Thirsty Runner—A Hydration Mapping Tool for Distance Runners

by

Andrew K. White

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Greg Walsh, Thesis Advisor

_____

Greg Walsh, Committee Member

Abstract

Millions of Americans participate in long distance running as a form of exercise and recreation each day. For these runners—and any other athletes—maintaining proper hydration is essential for one's health in preventing cramps, heat exhaustion, and heat stroke. Many cities and suburban areas across the country have publically available drinking fountains. Designing an application to provide the locations of these drinking fountains could help address the issue of improper hydration for runners. Research on a characterization of the typical runner showed that this potential user had a broad range of age, was more likely to be female, highly educated, and very dedicated to his or her sport. The distributed nature of drinking fountains means that an application can not only provide these locations but allow them to be uploaded by its users. In this paper, I present the results of the process of designing *Thirsty Runner*—a mapping website for runners to find and add locations of drinking fountains—through user-centered design methodologies. The design evolved from feedback provided by long-distance runners during hour-long individual interviews and guided usability test sessions. Not only did the final design allow users to accomplish primary tasks of building running routes and submitting fountain locations, but it also took steps to address issues with collecting volunteered geographic data, including data credibility and data accuracy. Beyond that, my research provides observations on runners' mindset regarding planning a run and view of hydration. Finally, I conclude by discussing the limitations of my proposed design and the research needed to refine *Thirsty Runner* further.

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Chapter 1: Profile of Long-distance Runners

Introduction

At the 1972 Olympic games in Munich, American runner Frank Shorter took home the gold medal in the marathon event. With this momentous achievement, he started the "running boom", or the rapid growth of distance running across the United States. This growth has continued into the 21st century, inciting millions of Americans to begin running for recreation and fitness (Borzi, 2012). In 2015, competitors in road races eclipsed a participation total of 17 million ("2016 State of the Sport - U.S. Road Race Trends," 2016). This total does not even include the more casual runner who does not enter organized running events. Sales of running shoes exceeded 3 billion dollars in 2013, further demonstrating the large segment of the population that participates in distance running in the United States ("2014 State of the Sport - Part II," 2014).

A 2005 report by the Institute of Medicine of the National Academies defined the Adequate Intake of water for men to be 3.7 L/day and 2.7 L/day for women. According to this report, "physical activity and heat strain can elicit high rates of total water loss via sweat loss" (Institute of Medicine of the National Academies, 2005, p. 127). For those individuals who are active—including distance runners—proper hydration is necessary, especially during the summer months. Because of this and the popularity of distance running, I wished to develop an application entitled *Thirsty Runner* to allow runners to find the locations of publically available drinking fountains. A public drinking fountain can be considered in the traditional sense, such as an outdoor fountain in a park; but also a water source (indoor or outdoor) provided by a specific individual or business with the aims of helping runners. An example of the latter could be a runner-friendly store, such as a local running shoe vendor. My aim is to make the locations of fountains searchable so that runners can plan their route around periodic water stops.

This paper presents the process for designing a mapping tool to find and add public drinking fountains. The following chapter explores the needs and motivations of distance runners in conjunction with their use of technology, all of which provided the foundation for designing the *Thirsty Runner* application.

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Hydration During Exercise

Recommended Hydration Guidelines

During exercise and periods of intense cardiovascular activity, body temperature rises and sweat glands secrete perspiration in response so the body can cool once the sweat evaporates. This can be exacerbated during periods of extended exercise and when the ambient temperature/humidity is elevated. If this water lost in the form of sweat is not replaced, it can have adverse affects on one's exercise performance and health (Sawka et al., 2007). People should not only replace these fluids during and after exercise, but should also hydrate beforehand in preparation for the increased activity. The American College of Sports Medicine recommends hydrating 2–4 several hours before exercise begins.

Many factors can influence the rate at which one loses water during exercise, including sex, age, body weight, ambient temperature/humidity, and exercise intensity. Sawka et al. (2007) demonstrate this range by predicting the sweat rates for runners can vary from .43 L/hr. (50 kg individual at 8.5 km/hr. in a cool temperature) to 1.76 L/hr. (90 kg individual at 15 km/hr. in a hot temperature). Similarly, the range at which runners should rehydrate during exercise can vary greatly. However, the authors state that drinking .4-.8 L/hr. is "satisfactory for [all] individuals participating in marathon length events" (Sawka et al., 2007, p. 385). Another guideline for hydration during exercise provided by the American Counsel on Exercise recommends drinking 7–10 ounces of water every 10–20 minutes ("Healthy Hydration," 2016). This is roughly the same as the guideline from the American College of Sports Medicine as it equates to approximately .6–1.2 L/hr.

Water Intake of Runners

Sawka et al. (2007) performed a study where they observed the sweat rate of male cross-country runners during the summer, which ranged from .99–2.55 L/hr. This, compared to the observed voluntary rate of fluid intake (0–1.33 L/hr.), demonstrates that runners are losing more water than are consuming. Not only that, but researchers from the University of Alabama showed that this "inadequate fluid intake during and between runs may stem from underestimations of sweat losses" (O'Neal et al., 2012, p. 353).

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The aforementioned study compared runners' estimated and actual sweat loss after one-hour runs during mornings and evenings in the summer. The results showed that on average, runners underestimate their sweat loss by half. This underestimation was consistent across both men and women. Researchers stated that often runners exhibited the phenomenon of "voluntary dehydration" in which they replaced their fluids at a slower rate than at which they were lost. This can be attributed to both an underestimate of fluid loss but also because running with a large amount of water could cause stomach discomfort (O'Neal et al., 2012). Steps should be taken to address this disparity between water loss and water intake, as dehydration can lead to cramps, heat exhaustion, and possibly heat stroke.

In a similar study, a population from Arkansas, representing recreational distance runners, were surveyed regarding their hydration habits and the impact of dehydration on their bodies. Researchers found that a "large number of runners…believed that performance decrements and heat-related illness symptoms were caused by inadequate fluid intake" (O'Neal et al., 2011, p. 587). In this study, 45% of runners surveyed reported they had experienced heat-related illness as a result of dehydration. Runners with better hydration habits are those with higher running abilities and runners in the days leading up to a race. Above all, the most important finding was that monitoring fluid intake and using established hydration guidelines was not commonly done. Interpersonal contacts between runners was the primary source of hydration technique. Researchers recommended that runners need to be better informed about hydration and implement better techniques for hydration during runs (O'Neal et al., 2011). The aforementioned research shows the widespread issues in hydration among runners. In turn, access to the locations of public drinking fountains may help mitigate this problem.

Characterization of Runners and their Behavior

Designing an application for runners to locate public drinking fountains can only be successful if it accurately addresses the characteristics, behaviors, and needs of its potential users. The following sections illustrate the profile of those who might use such an application.

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Runner Demographics

Distance running continues to be very popular, with the National Sporting Goods Association (NSGA) estimating almost 42 million people in the United States went running at least six times in 2012 ("2014 State of the Sport - Part II," 2014). Of these runners, 24% can be described as "Frequent" runners (running more than 110 days/year), 46% are "Occasional" runners (25–109 days/year), and 30% are "Infrequent" runners (6–24 days/year).

While the the data provided by the NSGA classifies all types of runners, another major source of information on runners is Running USA's *Annual Runner Survey,* which categorizes more frequent runners. The *2016 Annual Runner Survey* had over 10,000 respondents, the majority of which are "core runners", or adult participants who "tend to enter running events and train year-round" (Running USA, 2016). Of those surveyed, 14% described themselves as a "Serious/Competitive Runner", 65% as a "Frequent/Fitness Runner" and 20% as a "Jogger/Recreational Runner" (Running USA, 2016). It should be noted that Running USA cautions that the results of their survey, while accurate, may not be representative of the running industry as a whole.

Gender. The population of runners skews female, according to data provided by both NGSA and Running USA. In 2012, females represented 52% of all runners in the NGSA dataset and represented 63% of those surveyed by Running USA ("2014 State of the Sport - Part II," 2014, Running USA, 2016). This is skewed even further when considering those of Millennial age (18-34 years old). Running USA sponsored a study documenting trends and behaviors of Millennial runners which stated that 73% of those surveyed were female (Achieve Agency, 2016). While research maintains that women participate in running more than men, this is even more the case for the portion of the population is more serious about the sport.

Age. The population of runners grouped by age is distributed fairly normally. Based on data from NGSA, 62% of runners are between the ages of 18 and 44. The largest grouping of runners fall into the 25–34 age bracket with 24%, followed by those 18–24 and 35–44 at approximately 19% each ("2014 State of the Sport - Part II," 2014). The more serious running population surveyed by Running USA skews somewhat older

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with 36% and 26% of runners encompassing the 35–44 and 45–54 age brackets, respectively (Running USA, 2016).

Education and socioeconomic level. The core runners surveyed by Running USA are highly educated, with 42% of respondents having earned a degree from a 4-year college and 37% having earned a graduate-level degree. This in turn has translated to most core runners being employed full time (87%), and more than 63% earning a salary of over $50,000 annually. While running does not require much equipment, road races such as marathons can be expensive. An article from 2013 reported that the average cost of a marathon is $112, a 35% increase since 2007 (Marcus, 2013). Not only that, but the *2016 Annual Running Survey* asserts 52% of runners exercise with a Global Positioning System (GPS) item or sports watch, which can also be pricy.

Runner Attitudes and Mindset

As one might expect, runners are focused on their wellbeing and try to live a healthy lifestyle. This is evidenced by the fact that "staying healthy" and "staying in shape" are some of the primary motivators for one to continue running (Running USA, 2016). Not only that, but runners are more likely to be of a normal weight, be a nonsmoker, and wear a seatbelt, compared to non-runners of a similar age and gender (Heath & Kendrick, 1989). While runners typically do not smoke, alcohol use in men was similar to that of non-runners and higher in women. Researchers also showed a relationship between participating in sports and a high life satisfaction for men (Varca, Shaffer, & Saunders, 1984). This same relationship did not exist for women.

Runners typically prefer to engage in their sport alone, compared to running with a partner or a group. According to Running USA, 49% of the core runners surveyed prefer running alone and among Millennials, 45% are not interested in in-person training groups (Achieve Agency, 2016, Running USA, 2016). Not only that, but only 20% of core runners would prefer to participate in an event as a group versus individually. This is supported by research indicating runners are more introverted and "are not much concerned with other athletes" (Morgan & Pollock, 1977, p. 2). This solitary nature of runners is contrary to the fact that runners are active on social media and running networking websites. As of 2012, runners had shared over 2.4 billion miles on Garmin's

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website and DailyMile.com had 750,000 members sharing their routes and training goals (Trageser, 2012). Many runners also use Facebook and Instagram to share running photos and discuss events, particularly Millennials. In 2015, *The Atlantic* wrote that "80 percent of runners have posted race photos and 62 percent have shared results on social media" (Stahl, 2015).

Those who run are often dedicated and serious about the sport. Among the core runners surveyed, the majority run year-round and at least four times per week (Running USA, 2016). Running sees high rates of retention as well; many who run have done so for many years. Participants are also competitive, demonstrated by the statistic that when asked, only 16% responded "I don't care about my race time" (Running USA, 2016). Millennials love to run and challenge themselves. Even those that have recently begun running are dedicated "whether they are training for an event or not" (Achieve Agency, 2016, p. 8). One study evaluating the psychological profile of long-distance runners reported these athletes exhibit high levels of anxiety and are "moderately motivated" (Mohd. Kamil Khan & Joawad Ali, 2013).

Runner Experience with Technology

Those who run, especially Millennials, are adept at using technology (Achieve Agency, 2016, Running USA, 2016). Smartphones are very common, and 61% of core runners report running with one. Runners use their smartphone for a variety of running-related tasks, including tracking mileage and GPS. Not only that, but 40% stated that they use their smartphone to map their running route. While their smartphone is their primary device for running activities, many run with a GPS device or sports watch.

Millennials sign up for races most often over the internet and prefer to be contacted about races via email. As mentioned above, runners are active on social media sites. The *Millennial Running Study* reports athletes of this generation learn about running events "via social media and internet searches much more than any other type of medium" (Achieve Agency, 2016, p. 11). The use of running tracking websites is not exclusive to the most athletic and advanced runners. The average pace on the site Runkeeper—where over 50 million users record their workouts—is over 11 minutes per mile (Stahl, 2015). One thing of note for running websites and applications, among

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Millennial runners surveyed, 70% reported they would not be willing to pay for a running app. So while they are widely adopted, at least among Millennials, there is an expectation that they should be free (Achieve Agency, 2016).

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Chapter 2: Study of Running and Technology

Applications using Volunteered Geographic Information

Background

The undertakings of large corporations such as Google have helped foster an environment in which anyone with access to the internet can view detailed mapping data spanning much of the planet ("Map Coverage Details," 2016). This, in conjunction with the proliferation and wide-spread adoption of GPS-enabled smartphones, has expanded the opportunities in which millions of people can generate volunteered geographic information (VGI). VGI encompasses the "collection, contribution, maintenance, and processing" of mapping data by volunteers, typically those with little to no expertise in collecting this type of information (Schmid, Frommberger, Cai, & Dylla, 2013, p. 1). In essence, VGI contributes to "geography without geographers" (Flanagin & Metzger, 2008, p. 139). VGI is closely associated with neogeography, or the "practices that operate outside [of]…the practices of professional geographers" ("What is Neogeography," 2016). The guidelines and best practices of neogeography and VGI are central to my design of an application to locate drinking fountains. Because the location data is not documented in any consolidated source, success of the application relies heavily on runners to find and log the fountains themselves.

Often VGI data are displayed and used in "mashup" applications (Flanagin & Metzger, 2008). According to Flanagin and Metzger (2008) mashups are "web applications that combine data from multiple sources to form a new integrated resource" (p. 138). In the context of a fountain application, the mashup would be the combination of a popular mapping service such as Google Maps and the additional layer of the fountain locations. Examples of mashup applications include a site with an embedded map to share biking routes or Yelp, a popular website used to find local businesses ("Yelp," 2004). Another popular example of a mashup application that relies heavily on VGI is Waze, which provides drivers with real-time updates on traffic accidents, police stops, and other traffic data ("Waze," 2016). In these examples, the burden of collecting the mapping data is shared by the large user base.

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Design Considerations using VGI

Prior to designing an application that accepts volunteered drinking fountain locations, I wanted to review some of the more common issues with VGI data and explore the design considerations needed for a successful implementation.

Credibility. The very nature of VGI and how it can be provided by anyone with appropriate access, invokes questions about its credibility. In these applications, "users play roles of both information consumer and information provider" (Flanagin & Metzger, 2008, p. 137). In the role of the consumer, users are expected to assess the information and determine its meaning and credibility themselves, which can be a large burden.

Credibility is thought of as believability, which can be further broken down into trustworthiness and expertise. One of the major issues with VGI is that data collection is done without any professional control standards or gatekeepers. This can be a hurdle when users view the volunteered data. Paradoxically, in spite of the lack of an authoritative oversight in VGI applications, this credibility issue can be remedied when the data is continually verified by a network of individuals. This principle is put into practice with Wikipedia and OpenStreetMap. Not only that, but research has shown that when users repeatedly use a source of VGI, they begin to see it as credible (Flanagin & Metzger, 2008).

In order to address the credibility barriers, Flanagin and Metzger offer several recommendations. Above all, as with many applications, credibility of the data is bolstered by focusing on professionalism and ensuring that the pages are laid out cleanly and are easily navigable. Omitting any commercial content and conveying objectivity will have a favorable impact on the user's impression of credibility. The authors also recommend that "social endorsement" is important towards VGI credibility (Flanagin & Metzger, 2008). They cite other studies detailing how one's judgment of data online is influenced by others' evaluation of said data.

Accuracy. Drinking fountains are usually very small and occupy only a very small physical footprint. Because of this, providing a solution that enables the data to be accurate as possible is essential. This is one way in which having geographic data come from the users can be more accurate than an official mapping organization. According to

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Fonte et al., volunteers often have an intimate local knowledge and "can lead to highly accurate and current local map results" (Fonte et al., 2015, p. 318). The authors go on to state that the quality of this volunteered data sometimes can be higher than the experts.

In addition, the method by which the geographic data is collected has an impact on its accuracy. A 2013 study at the University of Bremen assessed the methods by which volunteered location data can be ascertained. According to the authors, "the success of VGI critically depends on the users being equipped with tools matching their expertise and technical skills" (Schmid et al., 2013, p. 1). These four methods include Geotagging, GPS Waypoints, Satellite Imagery Annotation, and What-You-See-Is-What-You-Map (WYSIWYM). Each of these methods is described in more detail in the table below.

Table 1

Methods of Collecting Volunteered Geographic Data

VGI Collection Method	Description
Geotagging	Volunteer uses text entry to add GPS coordinates to non-spatial media, such as an image or a Tweet. This method has a very high ease of use but is inaccurate.
GPS Waypoints	Volunteer collects GPS coordinates by physically walking around the object to collect a series of GPS points. The data is analyzed and then its location is mapped.
Satellite Imagery Annotation	Users look at satellite imagery and use text entry or some other means to indicate the GPS coordinates of the location.
What-You-See-Is-What-You-Map	A type of application in which the user uses his/her smartphone to photograph the location and then uses his/her finger to trace the outline of the location, such as a building.

In this study, users were asked to map the location of rectangular buildings with each of the aforementioned methods. The results showed that the GPS Waypoints and WYSIWYM methods were the most accurate and quickest in mapping the locations.

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While the WYSIWYM method was slightly more accurate than using GPS Waypoints due to issues securing a consistent GPS signal, it should be noted that this may not be applicable to mapping the location of a drinking fountain. In the study, mapping the perimeter of a building required a continuous GPS signal. The location of a drinking fountain is different form that of a building in that it is small enough that it would require only one GPS marker (Schmid et al., 2013).

Fonte et al. (2015) state that collecting high quality VGI could be facilitated by "including corrective feedback provided by experts" (Fonte et al., 2015, p. 318). The authors also recommend that applications collecting VGI institute controls over multiple users submitting the location of the same item (Fonte et al., 2015).

Motivation. When designing an application to display and collect volunteered geographic data, I must work to encourage participation and provide proper motivation for its use. The researchers from the University of Bremen argued that users will not contribute to the dataset unless they understand the value of the data (Schmid et al., 2013). Research asserts that a motivating factor for contributing this type of data is for "protection or enhancement of a personal investment" (Coleman, Georgiadou, & Labonte, 2009, p. 343). According to Coleman et al. (2009), users are motivated when contribution addresses a shared problem and they receive "immediate payback for participation through shared improvement of a common resource" (p. 343).

The process in which one contributes VGI can be tailored so it is not demotivating to the user. Contributing data should be task-driven and broken down into appropriate steps: capturing the data, identifying what it is, and then ultimately publishing it (Schmid et al., 2013). Too much detail in the instructions can be demotivating. The application must include instructions with the appropriate level of detail so that the task is not confusing, but not so much that it would not be a burden. Finally, having the data available in real-time helps drive motivation. Users may be dissuaded from adding data if there is a delay between when it is added and it is accessible.

VGI on mobile. As stated earlier, a large portion of runners exercise with with their smartphone. Not only that but as of 2014, 60% of online web traffic came from smartphones and tablets (Hessinger, 2014). These two data points indicate that

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considerations should be made to optimize the drinking fountain application for mobile use. Nielsen Norman Group (NNG) evaluated the use of mashup applications on mobile devices and concluded that the map functionality introduces some usability issues (Bedford, 2014). For one, NNG states that when websites and applications using a design with search results on a map, the maps often "end up on the lower half of the screen…and extend below 'the fold'" (Bedford, 2014). When this occurs, users scroll to find a results list and inadvertently trigger the map's panning feature. This can be addressed by having the ability to show and hide the map or including gutters to the left and right to help "mitigate gesture ambiguity between scrolling…and panning" (Bedford, 2014). Finally, NNG also recommends the map be displayed at the proper level of zoom when there are many different icons to display. When map icons are placed too close together, users can inadvertently tap the wrong one.

Academic Studies on Running Technology

Social Fabric Fitness

Researchers from the University of Maryland performed a study on technology aimed at supporting group performance, as opposed to performance at the individual level (Mauriello, Gubbels, & Froehlich, 2014). The technology under review is called Social Fabric Fitness (SFF), which consists of a rectangular display of either flexible e-ink or LEDs. In this study, pace leaders in a running group wore the SFF display on the back of their shirts to communicate group running statistics to other members. These statistics—pulled wirelessly from the runner's mobile phone—included average pace, distance travelled, and comparisons to a preset goal pace. On the whole, this study explored the impact of SFF on group dynamics and motivation, as well as a comparison to other running technologies.

Mauriello et al. performed the study with 10 running groups and 52 total participants (19 wearers and 33 non-wearers). Results of pre- and post interviews showed that in both wearers and non-wearers, SFF "improved their awareness of their group's performance, helped motivate them to run at the group-set target pace, and helped keep the group together" (Mauriello et al., 2014, p. 3). The SFF technology leveraged data from the wearer's Runkeeper (see page 16) account on their Android smartphone and

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cycled through a display of pace, duration, distance, and heart rate. Of these data points, runners felt that using the e-fabric display to show the group's average pace was the most important. In addition, 65% of the respondents stated that the SFF motivated them to run faster than the group pace. One reason for this is from a sense of accountability and belonging, as one runner stated "it made me feel that I had a responsibility to run a target pace for the group" (p. 7) Among the three SFF form factors (e-ink and the two LCD displays) the field study did not provide any measurable difference.

RUFUS

A study from the University of Gothenburg in Sweden looked at unique running technology to take the normally solitary sport and increase its social component. This research team explored methods in which supporters (friends, family, etc.) of eighteen long-distance race participants shared their support during a race, and how this technology benefitted the athlete (Woźniak, Knaving, Björk, & Fjeld, 2015). Researchers examined this with technology they call RUFUS—or Runner Feedback and Ubiquitous Support—which uses ambient light and vibration to communicate to the runner. The RUFUS device is rectangular with four LED lights and is worn on one's wrist. This device also has vibration sensors to deliver haptic feedback. The RUFUS is connected via Bluetooth to the runner's smartphone and Runkeeper application.

In this study, "spectators" are defined as friends and family who did not attend the race but received updates on Runkeeper. During the race, they used a webpage to communicate one of three cheering options ("Thinking of You", "C'mon!", and "GoGoGo!") with their friend or family member. When spectators selected one of these phrases, a different light and vibration signal was sent to the RUFUS device. The runners were informed ahead of time what each pattern of lights and vibrations corresponded with each message. Upon receiving a cheer message, runners then acknowledged it by pressing a button on the RUFUS.

Overall, researchers found that the RUFUS device enhanced the runners' experience of the road race. In follow-up interviews, several of the participants shared that knowing someone was watching their progress increased their motivation to do better. With a device that provides vibrational and visual feedback, there is risk that it

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could be a distraction to the race participants; however, most runners indicated that the RUFUS device did not interfere with their focus. In terms of the race supporters, many wished to have additional messages and types of communication with the runner. While supporters needed "enough nuanc [sic] and information to feel that they [could] contribute meaningfully to the experience", Woźniak et al. concluded that the three signals included in the RUFUS were sufficient such that the complexities of the communication did not hinder the runners' performance (Woźniak et al., 2015, p. 8). This study shows that minimally invasive vibrations and lights can provide benefit to runners. While the RUFUS is not a smartwatch in itself, its design and functionality could easily be incorporated into smartwatches in the future.

Performance of Heart Rate Monitors and Sport Watches

In their 2015 paper, researchers Jakob Tholander and Stina Nylander reviewed the role heart-rate monitors and sport watches play in engaging runners and other athletes with their sport. They state that while many other studies showed motivational benefits of play and gamification on running, their research showed that some users instead wish to have technology that stays "within the boundaries of the sport…and the sports performance it involves" (Tholander & Nylander, 2015, p. 1). During this study, Tholander and Nylander conducted in-depth interviews with ten athletes (three elite and seven recreational) to gather qualitative results on the athletes' experience with the technology. Nine of the participants used a GPS-enabled watch with a heart rate monitor, while the other participant only used the GPS watch.

These technologies provide runners with real-time feedback of key metrics for measuring performance, including pace, distance travelled, and one's current heart rate. A major finding from this study is how runners and athletes evaluate these data and define success of a workout. The researchers claimed that during an exercise, perception of one's performance takes two forms—a measured sense of performance and a lived sense of performance. The measured sense of performance is a more objective, pragmatic approach using the biometric data available from the sport watch and heart rate monitor. In this instance, the readouts of pace, etc. push athletes to work towards an improvement in these metrics. During the interviews, some participants shared how "painful elements

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such as fatigue and lactic acid gave them a sense of achievement that were central to their enjoyment of the sport" (Tholander & Nylander, 2015, p. 9). The lived sense of performance is the observation of these subjective feelings and using biometric data as motivation towards achieving that exhaustion, pain, and exertion.

Essentially, researchers showed that objective, raw data such as pace and heart rate are not the only factor athletes use to judge the success of a workout. If this were the case, a neutral observer could compare one's performance to a baseline and make a determination on one's running performance. However, a runner could have the same average heart rate during two runs, but judge them differently due to the effect of the personal factors and lived sense of performance. In terms of running and athletic technology, designers should recognize these two senses of performance and identify ways to capture these subjective results. Not only that, but the importance athletes place on achieving that sense of pain and exhaustion demonstrates that running should not be trivialized by making aspects of it game-like. Finally, the data and technology itself should not determine if a workout is a success; instead, designs should support users to create "their own meaning from biodata" (Tholander & Nylander, 2015, p. 9).

Industry Review of Running Technology

Fitness Wearable Devices

The wearable fitness device market is relatively new to consumers. This burgeoning sector started to see growth in the late 2000s with the Nike+iPod fitness tracking device. Early in 2009, FitBit introduced a device intended to be strapped to one's belt, which uses an accelerometer to measure the user's steps (Winchester, 2015). Today, FitBit and other companies including Garmin, Polar, and Suunto develop watches that leverage not only an accelerometer but GPS and heart rate monitors. These running watches collect and provide data to the runner during a run, such as pace, heart rate, and distance travelled. Modern smartphones have GPS and accelerometer features, so similar data can be displayed on a web interface. Some fitness watches and smartphones can also provide alerts to the runner if he or she does not meet a set pace (Jensen & Mueller, 2014).

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MapMyRun

The website MapMyRun is owned by athletic company Under Armour and is part of the "world's largest digital health and fitness community, Under Armour Connected Fitness" ("MapMyRun," 2016). MapMyRun allows users to create a daily journal of their distance runs. Users are able to search a catalog of routes logged by users and view start points, end points, and mile markers—all displayed on an instance of GoogleMaps. MapMyRun also collects volunteered geographic information by providing a tool for users to click along the path of the running route (Appendix A). This VGI collection is slightly different than how it would be done in a drinking fountain application in that MapMyRun collects a path of GPS coordinates instead of only one location.

MapMyRun also has an iPhone and Android application (Appendix B) with many useful features that can be applied to a drinking fountain location application (*Run with MapMyRun*, 2016). The interface and functionality is slightly different in the mobile application compared to the desktop site. For one, all search results are displayed in a list compared to on a map. One can view a running route on a map only after selecting it from the search results. The desktop site displays the results in a map and then provides a list underneath. The search options are different between the two form factors. On the desktop, users can search by route name, city, neighborhood, and search radius (with a default of 3 miles). In the app, users can only search by routes they've created, routes they have marked as favorites, and within a radius of their current location. These search options are more limiting in the mobile view; however, this indicates that designers assumed if one were searching routes on a phone, the user would likely be running with that device. Finally, the MapMyRun smartphone application provides the ability for pairing with a fitness device so that the user can view mile markers on his or her wrist.

Runkeeper

Runkeeper is similar to MapMyRun in that allows the user to maintain a daily running journal. When the user first enters the application, he or she has the option of setting a target pace, distance, or choosing from a more tailored long-term running plan. However, in order to do this, one must be actively carrying his or her smartphone and using its GPS functionality to track the run. Runners can set goals, challenge other users,

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and receive reminders to stick to their running plan. The main feature of the Runkeeper application is its use of the street map (Appendix C). When the application initially loads, the street map occupies a large majority of the screen.

Runkeeper has many of the same functionality as the MapMyRun smartphone application. The one drawback is that Runkeeper does not have a desktop site to complement the smartphone app. Because of this, the user does not have any alternative to running with the smartphone application open. One other difference from MapMyRun is Runkeeper's focus on the social aspect of running and the community feel of the product. In fact, on the Runkeeper website, the tag line for the company is "Everyone. Every Run." (Fitnesskeeper, 2017). The home page shares runner testimonials and greets the user by saying "Welcome to the Community!"

Under Armour Gemini 2 Running Shoe

In early 2016, Under Armour released the Gemini 2, a running shoe with their "Record Equipped" technology that tracks information about the wearer when he or she runs. Using a chip inside the sole of the shoe, the technology uses an accelerometer to calculate distance and pace (Beverly, 2016). One benefit of this technology is that it does not require the runner to carry any device with them such as a smartphone or fitness watch. Not only that, but the battery of the chip is expected to last over three years, which is typically longer than the life of a pair of running shoes. The shoes begin tracking a run when the chip senses the wearer is moving faster than eleven minutes per mile. This can be seen as a drawback as it would not work for walkers or runners who exercise at a slower pace.

While the shoes do not require any supporting technology, the user can pair them with the MapMyRun application. By doing so, the application downloads the data collected by the shoes and adds it to the user's running log. To help the wearer determine if his or her shoes need replacing, the application maintains a tally of miles accumulated. Even though pace and distance data can only be added to the app after a run, Beverly (2016) sees this as a plus. This modality of data collection allows the user the peace of mind that the information is being calculated without the mid-run distractions.

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Strava Heatmap

Strava is a smartphone application for athletes that has many of the same features as MapMyRun and Runkeeper. It connects runners through a social network and tracks runners using GPS to collect metrics and performance data (Strava, 2017). This data collection requires the user to be carrying his or her smartphone while exercising. Strava Labs, a subsidiary of Strava, leverages these data to build a heatmap plotting the most frequent streets and paths used for exercise (Appendix D). On the map, the routes with a brighter color correspond to those run the most frequently. As of 2014, the site had collected data from over 19 million runs and 77 million bike rides to plot route data (Mach, 2014). The differing volumes of runners and bike riders at locations across the city can illustrate running trails and common running routes to users of the heatmap. This could be beneficial to not only residents but runners visiting an unfamiliar city.

Drinking Fountain Location Applications

WeTap. WeTap is a smartphone application (Appendix E) that uses VGI of drinking fountain locations and aggregates them on a map for viewing on your smartphone. Although it hasn't been updated since 2014, the WeTap application contains locations of drinking fountains all across the United States (*WeTap Drinking Fountain Finder*, 2014). While the collection of drinking fountains is large, the interface and functionality available in the application is minimal. The application does not provide any ability to search or view the fountains in a list. Instead, the main screen starts with a map focused on the user's location and one must pan and zoom when finding drinking fountains.

Users can add drinking fountains to the list of available locations; however, this functionality is limited. Users do not have the flexibility to indicate the fountain's location. Instead, a fountain must be added directly where the user is standing. Adding a fountain gives the user the opportunity to add metadata including a picture of the fountain and flags if the fountain is working and if it has a specific spot for refilling a water bottle. A drawback of adding fountain VGI is that the data cannot be added anonymously; users must register for an account and log in prior to contributing data (*WeTap Drinking*

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Fountain Finder, 2014). This could dissuade users from contributing because of this extra hurdle.

Choose Tap. Choose Tap is an application for smartphones (Appendix F) that allows users to locate drinking fountains in Australia, all while focusing on health and environmental activism (Yarra Valley Water, 2015). When one opens the application, users are presented with a map centered on their current location (*Choose Tap*, 2016). If you are not near any drinking fountains (referred to as "taps" in the application), a prompt appears informing you to zoom out and look elsewhere. When the zoom level is low enough, rather than displaying all of the fountains in an area, the map consolidates them into one location marker containing the total. While this practice can eliminate the issue of displaying too many icons, NNG contends that this can be confusing to the user when the map simultaneously displays consolidated icons and individual markers (Bedford, 2014). On the map zooming and panning are the only methods one can use to locate fountains. A list is available with all of the nearest drinking fountains and the distance of each from your location.

Adding drinking fountains is very straight forward. The first third of the screen shows a map in which you zoom and pan to find the exact street location of the fountain. Simply pressing and holding a finger on the proposed fountain location drops a marker. The name of the fountain then becomes the approximate street address. Finally, the user can describe the fountain location using free-form comments. Users can also indicate if the location contains certain features, such as a restroom and if it is pet-friendly. While adding these features can be done by simply tapping an icon, there are not any labels and what each icon represents is not clear (Yarra Valley Water, 2015).

TapItDC. TapItDC is a network of business in the Maryland, Virginia, and Washington, DC area that provides free public tap water (Metropolitan Washington Council of Governments Community Engagement Campaign, n.d.). Once a business registers its location with the TapItDC website as a participating partner, that business will become searchable in the TapItDC smartphone application (Appendix G). While this application only displays business locations and not public drinking fountains, its search functionality is an analog to *Thirsty Runner* (*TapIt Metro DC v2.0*, 2015). Upon logging

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into the application the initial screen presented to the user is an instance of Google Maps, centered on the user's location. To locate free tap water locations, the user can zoom and pan the map or switch to the search functionality. The application has options for searching by location/neighborhood and by business name. Because the user may not know the names of businesses offering free drinking water, the location search is the most practical; however, I could not get the search to return any results, no matter what search term was entered. Either the search is not functioning or its instructions are unclear.

A drawback of the TapItDC map function is that its default zoom level is so low that when you initially view the map over Washington, DC, or any area with a high concentration of TapIt businesses, most of the map is obscured by the map markers. If one prefers, the application gives the user the option to view nearby businesses in a list view. Once you click on a tap, the application presents a snapshot of the business. Tap details include the business name, address and distance from your location, and a description of the type of drinking water available. Additional features include the ability to add the location as a favorite, retrieve directions to that business, and social media integration with Facebook and Twitter. Finally, the only method to add a business is to go to the TapItDC website and use a Google form; adding a location using the application itself is not possible.

Role of Running Technology Research on *Thirsty Runner* Design

The preceding sections detail research that may be applied to the design of the *Thirsty Runner* application. I reviewed best practices and academic findings in conjunction with existing examples from industry to develop a comprehensive picture of the fitness and running technology landscape. In doing so, my intent was to understand what has been done previously so that it might be incorporated in my final design approach. The aim of this research was not to simply identify successful design decisions and replicate them in my application; rather, all aspects must be evaluated separately within the context of the tasks of finding and adding drinking fountains. Something that worked for one application does not mean it would necessarily work for *Thirsty Runner*.

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This research on running technology pairs well with research presented in Chapter 1 on who runners are and characteristics of my target audience. A review of potential users and their challenges in hydration and running demonstrated a need for an application such as *Thirsty Runner*. My hypothesis for an application to find and add drinking fountains is it would be accessed using both desktop and mobile form factors. I propose that runners would use *Thirsty Runner* on a computer prior to runs, for run-planning purposes. This use case would be complemented by a mid-run use case, in which runners would receive real-time updates on fountain locations via a smartphone or fitness watch. This mobile use case is supported by research in Chapter 1 about the prevalence of runners exercising with their smartphone. *Thirsty Runner* could adopt some of the features of running applications on smartphones and/or smart watches by providing alerts if the runner gets close to a nearby fountain or determining if the user is thirsty using pace and biometric data.

My research on running technology provides guidance for how I could incorporate the collection of drinking fountain VGI. In particular, the design should be such that data collected is credible and accurate. As mentioned earlier, users feel that data is less biased when it is contributed by a many people. One way credibility could be conveyed in my design is to allow all users to contribute and to show an edit history for the fountain metadata. The fountain application could also include a "check-in" feature to allow runners to explicitly indicate when they visit a fountain. As part of this feature, the application could display the total number of visits and the most recent date/time a user checked in. I could also include a star rating system for each fountain or incorporate social media integration to leverage credibility through social endorsement.

Results from the study on methods for collecting VGI (page 10) demonstrate that for my fountain location application, I should rely on either the GPS Waypoints method or the WYSIWYM methods due to their accuracy. As an alternative, the task of adding a drinking fountain could utilize a combination of the two methods. When adding a fountain, the application could capture a user's single GPS marker and optionally request a picture of the fountain. *Thirsty Runner* could combine this GPS marker with the user's tracing of the fountain. The photos taken on many modern smartphones also have

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embedded location metadata and this could be used in place of a tracing (Lefebvre, 2014).

Accuracy could be addressed by having experts or local government representatives provide quality control by reviewing the drinking fountain location after it had been submitted. Each fountain could be searchable in the application but would be listed in an "unverified" status. Not only that, but if a user attempts to add a fountain with GPS coordinates similar to one already in the system, the application could display a message asking "Did you mean…" to help minimize duplicate data from being logged. The task of adding fountain locations must be robust enough so that as soon as a user adds one, it is immediately searchable. Knowing there is a delay between adding a fountain and it being available in the search may dissuade runners from contributing.

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Chapter 3: User-centered Design Methods for *Thirsty Runner*

Introduction to User-centered Design

User-centered design (UCD) is a set of methods of design and development focusing on the people that will be using the final solution or product (U.S. Department of Health and Human Services, 2015). UCD processes can address problems across all industries, but often the final products resulting from user-centered methodologies are software solutions. For practitioners engaged in user-centered design, common phases of the process include identification of who will use the product and what tasks they will accomplish; creation and design of the solution through rapid, iterative versions; and evaluation of the proposed design through usability tests with representative users.

All too often, projects fail because of a knowledge gap between the design team and the user group. According to Jakob Nielsen, "designers are not users" (Nielsen, 2008). Without engaging users—as is done in user-centered design—a project team cannot be completely certain a product will address the needs and challenges of the intended audience effectively. In designing *Thirsty Runner,* I worked with users throughout the process to gather feedback to minimize the knowledge gap between myself and the user. While the user-centered design discipline encompasses a wide variety of methods, my process consisted of first conducting individual interviews, then iteratively designing an interactive prototype, and then finally facilitating guided usability tests of said prototype.

Individual Interviews

Background and Goals

The first phase of my user-centered design process was as mentioned above—identifying who my users are and how they would use *Thirsty Runner* to locate and add drinking fountains. In Chapter 1, I presented research based on a review of academic studies and other published literature to characterize runner demographics, needs, motivations, and mentalities. Upfront individual interviews supplemented this literature research with first-hand data. Not only that, but research gained from individual

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interviews provided information specific to the the problem of designing a site to locate public drinking fountains.

An individual interview is a qualitative research method with one participant that typically lasts between thirty minutes and an hour. During these interviews, facilitators "probe…attitudes, beliefs, desires, and experiences to get a deeper understanding of the users who come to your site" (U.S. Department of Health and Human Services, 2013a). In a long-form one-on-one setting, researchers can learn much about a user, including insights, customer validation, and clarity of the overall approach to a solution (Bluestone, 2013). Above all, individual interviews are beneficial when you want to "explore users' general attitudes or how they think about a problem" (Nielsen, 2010). In these type of exploratory interviews, one should ask users about times in which something worked especially well or went especially wrong. These types of events are often more memorable to the user. Nielsen also states that because users are "pragmatic and concrete", they cannot speak to how they would use technology purely on its description; however, having a sketch or something tangible will allow users to provide meaningful feedback (Nielsen, 2010).

Interviewers conduct the discussions using an interview protocol, or a guide of initial questions and follow-up probing questions. Interviewers should work to keep the participant relaxed and at ease. These interviews are intended to be conversational and an opportunity for the participant to share openly. While the protocol serves as a baseline for the interview structure, the conversational nature of these interviews means that certain topics may be covered out of order or not at all. This type of research method can be a counterpoint to surveys with a rigid, pre-defined structure (U.S. Department of Health and Human Services, 2013a).

At the end of a round individual interviews, the goal is to have detailed notes and/or recordings from which the project team can draw conclusions and use as a basis for a design. UCD practitioners also can use interview results to develop personas, or realistic representations of a website's major user group. These personas can then be used as part of the design process in helping prioritize features and functionality (U.S.

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Department of Health and Human Services, 2013c). The results of the *Thirsty Runner* individual interviews, including personas, can be found in Chapter 4.

Interview Structure

As stated above, the purpose of conducting individual interviews is to speak with users first-hand and understand how they think about solving a certain problem. Specifically, I wanted to interview long-distance runners to understand their behaviors and thoughts on using an application to locate public drinking fountains. Over the course of six weeks, I conducted ten hour-long individual interviews with runners of varying backgrounds and demographics. Each interview session was held remotely using the Zoom video conferencing software. Remote discussions had both audio and video components in order to simulate an in-person interview.

I recorded the audio and video of each interview so that I could reevaluate participant responses at a later date. In the days prior to the interview session, I provided each participant with an informed consent document to review. This document—found in Appendix H—outlined my study and explicitly stated that I would be recording each session, data would be kept anonymously, and that participation is voluntary. Since I conducted my interviews remotely, participants were not able to physically sign the informed consent document; however, at the beginning of each session, I asked each user to consent verbally.

Interview Protocol

I developed a standard interview protocol for facilitating each interview session. This interview protocol can be found in Appendix I. During the interview, the user and I went through four sections: project background, use of technology and running, hydration practices, and a discussion about a specific solution for finding public drinking fountains.

The project background section was an opportunity to set expectations and provide context for the discussion. During this time, I provided background information on myself and the *Thirsty Runner* project, my goals for the interview, and how the interview fit in my overall design process. I then clarified my expectations for the user and asked him or her to be honest and forthright. Before continuing to the next section of

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the interview, I asked the user to verbally consent to the study and provided the user with the opportunity to ask any questions before we began.

The purpose of the running and technology portion of the interview was to understand the user's running habits and speak about how he or she used technology in conjunction with running. I started this part of the interview with the following questions:

- What is your age?
- On average, how many miles do you run per week?
- Do you run year-round?
- How often do you run in the city?
- Do you have a smartphone, and if so, do you run with it?

To understand each user's relationship with technology and running, I asked the participant to walk me through how he or she uses technology before, during, and after a run. For each scenario, I asked the user to describe the tasks accomplished with the technology. I left the definition of "technology" to the discretion of the participant; however, I defined running technology as any website, smartphone, smartphone application, or wearable device used to assist in any part of the running process. The running process includes, but is not limited to, planning and preparing for a run, the act of completing the run and monitoring one's performance during the run, and then any post-run activities, such as journaling and/or reflection on one's performance. If the interview participant used technology in any of the aforementioned scenarios, I asked probing questions about the strengths and weaknesses of that specific technology solution.

Much like the questions about running and technology, during the running and hydration portion of the interview, I asked users questions about how they hydrate before, during, and after a run. Topics for this section included how much water each participant consumes at each stage of the running process and any equipment used for water consumption. Hydration equipment during a run includes carrying a hand-held water bottle, a running belt, or a running vest (Jhung, 2012). Finally, I asked questions about water fountain specifics, including if the user stops for water, and if so, the circumstances in which he or she stops.

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Finally, I asked the interview participants questions about how a website and/or application to locate public drinking fountains would function. At the start of this portion of the interview, I asked users to describe their vision and how they would expect to use a hypothetical *Thirsty Runner* application. Next, using the Zoom video conferencing screen-sharing capability, I showed the interviewee some hand-drawn sketches of my preliminary ideas. The initial wireframe sketches (see page 45) showcased three different webpages: *Thirsty Runner* homepage, a fountain search result page, and a page allowing the user to add a fountain. Questions about the sketches included how the design meets the user's expectations, how the user would improve the overall design, and what components he or she thought were missing and/or unnecessary. In addition, I asked users if, knowing that the locations of drinking fountains were crowd-sourced, to what extent they would trust the information and how my proposed design could be improved to build that trust.

I concluded each interview by thanking the user and providing an opportunity for the participant to clarify anything we had discussed. I then provided a recap of how the interview fits into my overall design process.

Participant Recruitment

Because the majority of public drinking fountains are located in major metropolitan areas, I wanted to focus my research on runners who run primarily in Baltimore City. In order to do this, I recruited interviewees by engaging running communities associated with Baltimore City. The ten participants were recruited from four separate Baltimore running communities—runners of the 2016 Baltimore Marathon, staff of the Falls Road Running Store, members of the Baltimore Road Runners Club Facebook page, and members of the Baltimore Pacemakers running group.

I recruited the majority of my participants through face-to-face meetings. For instance, major running events, such as the Baltimore Marathon, often have an expo or running festival on the day prior to the race. I attended this expo and gathered names and email addresses of race participants. Falls Road Running Store is a major vendor for running shoes and running apparel in northern Baltimore. I visited this running store and met several of their staff members who volunteered to participate in my study. The

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Baltimore Pacemakers running group holds weekly long distance runs on Saturday mornings. I recruited several of my participants by attending one of these meetings. The one recruitment method that was not face-to-face was using social media. I posted a brief description of my personal background and my study on the Baltimore Road Runners Club Facebook page and received responses of runners willing to help. Finally, I found several interview participants via referrals from other participants identified using the methods above. A summary of each participant and his or her recruitment method is shown below.

Table 2

Individual Interview Participant Recruitment Methods

Participant Number	Recruitment Method
P1	Baltimore Road Runners Club Facebook page
P2	Baltimore Marathon Running Expo
P3	Referral by Interview Participant
P4	Falls Road Running Store
P5	Falls Road Running Store
P6	Baltimore Pacemakers
P7	Baltimore Pacemakers
P8	Baltimore Pacemakers
P9	Referral by Interview Participant
P10	Baltimore Pacemakers

Participant Demographics

As shown in the runner demographic research detailed in Chapter 1, those who participate in long distance running varies across age groups and genders. I selected interview participants such that this variety of ages and genders were accurately

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represented. I interviewed six men and four women, spanning from age 24 to 67. While I sought runners that routinely run longer distances (approximately ten miles or more), a high weekly mileage total was not a requirement for participation in my study. Users that participated in the individual interviews run from 11–20 miles per week to over fifty miles per week. All participants run year round and ran the majority of their runs in Baltimore City. Specific age, gender, and mileage totals of interview participants are shown below.

Table 3

Individual Interview Participant Demographics

Participant Number	Age Range	Gender	Average Weekly Mileage
P1	31 to 40	M	31 to 40
P2	21 to 30	M	50+
P3	31 to 40	M	31 to 40
P4	51 to 60	M	31 to 40
P5	21 to 30	F	50+
P6	61+	F	31 to 40
P7	61+	M	11 to 20
P8	21 to 30	F	21 to 30
P9	31 to 40	F	31 to 40
P10	41 to 50	M	11 to 20

Iterative Application Design

Background and Goals.

Developing the design of the *Thirsty Runner* application relied heavily on the UCD principle of iterative design. Iterative design is defined by the evolution and refinement of a user interface (UI) based on feedback received from user testing and

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other evaluation techniques (Nielsen, 1993). The application design phase in developing *Thirsty Runner* included creating the site information hierarchy, interaction components, and visual design of the user interface. I accomplished much of the application design in the second phase of my overall process; however, in order to iterate effectively, designing *Thirsty Runner* was not simply one step in a linear process. Iterating and obtaining feedback from the users meant that I designed the UI throughout my *entire* process—prior to the individual interviews, after these interviews and before guided usability tests, and after the guided usability tests.

Continual feedback from users throughout the design process can improve usability significantly. Wireframes are a common tool for communicating design ideas and eliciting feedback from users. Wireframes can take many forms, from a hand-drawn sketch to polished mockup in an image editing software such as Adobe Photoshop. In designing the user interface of *Thirsty Runner*, I created both "low-fidelity" and "high-fidelity" wireframes. Low-fidelity wireframes start with a design containing only the high-level components (e.g. site navigation, page structure). At this stage, details including typography, imagery, and color are not necessary. Later in my design process, I included more specific details, including branding, color, and site copy, to build high-fidelity wireframes. High-fidelity do not have to have color and imagery, but should at least have specifics surrounding site interaction and behavior (U.S. Department of Health and Human Services, 2013b). Users evaluated both low-fidelity and high-fidelity wireframes for *Thirsty Runner*. Gathering this iterative feedback is central to user-centered design and allows project teams to save time by addressing issues as soon as possible.

Low-fidelity Wireframing

A primary benefit for starting my application design process with low-fidelity wireframes was I could rapidly generate ideas without much time commitment. In the context of designing the user interface for *Thirsty Runner,* low-fidelity wireframes intentionally lacked detail (specific content items) and styling (imagery and color). This provided me the opportunity to gather my ideas and solidify a general approach before proceeding. I developed all of my low-fidelity wireframes using the same steps:

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1. Conceptual Modeling –For each page, I created a list of all the high-level content items and tasks available to the user. I then put together a larger model of how each page would connect and the methods for doing so.
2. Initial Sketching–Initial sketches included drawing more complex content items, such as a search result widget or a pop-up box. I created various ideas for the layout of the content items before placing them within the context of a whole page.
3. Wireframing–The final step was to consolidate all content items and tasks into a cohesive webpage.

All of the conceptual models, initial sketches, and wireframes were hand drawn in ink on 8 ½″ x 11″ sheets of paper. Using this medium meant that ideas for the user interface could easily be changed with minimal effort.

In iteratively designing *Thirsty Runner*, I used low-fidelity wireframes in two instances. During individual interviews I obtained feedback on a preliminary version of low-fidelity wireframes and my initial approach. After the ten individual interviews, I consolidated feedback on the application design and refined my ideas into a new set of low-fidelity wireframes. This additional version served as the basis for the high-fidelity wireframes.

High-fidelity Wireframing

After developing a low-fidelity design and iterating with users, I completed a high-fidelity version of the site for gathering additional user feedback. The high-fidelity prototype built upon my initial design and expanded the application into a version that was more recognizable as a final product. My intent with high-fidelity design was to create a version that both looked and behaved as a functioning website. The high-fidelity wireframes were still very much a draft version and major capabilities were not yet in place; however, upon completion of the high-fidelity wireframe, a user could interact with the site using his or her computer and accomplish high-level tasks of finding and adding water fountains. This was so users could provide feedback on a version that was closer to a final product. I developed the high-fidelity wireframe using Axure Rapid Prototyping software. I chose Axure because this software has capabilities for designing

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the visual aspects and building interaction components (Axure Software Solutions, 2016). Examples of interactions in the high-fidelity wireframe include working links and buttons.

Guided Usability Tests

Background and Goals

In designing *Thirsty Runner,* I conducting guided usability tests to once again solicit feedback from potential users. This was also the final phase of my user-centered design process. There are many benefits to conducting usability evaluations, including informing design, rectifying "usability deficiencies existing in products…prior to release", and eliminating "design problems and frustration" (Rubin & Chisnell, 2008, p. 22). Usability tests must be conducted with representative users. In the context of *Thirsty Runner* and locating public drinking fountains, this meant testing with not only with runners, but those that hydrate during runs.

Data obtained in usability evaluations can be both qualitative and quantitative. According to Jakob Nielsen, the majority of user research results should be qualitative (Nielsen, 2012). Qualitative results focus on the major insights that drive and improve the overall design. Quantitative results are usability statistics, often included as supporting evidence for the qualitative results. Nielsen continues that most major usability issues can be uncovered by conducting usability tests with five participants.

According to Usability.Gov, moderators of usability tests can gather information from users by utilizing either "concurrent" or "retrospective" questioning techniques (U.S. Department of Health and Human Services, 2014). The concurrent technique involves asking the participant questions during his or her use of a product; in the retrospective technique, the moderator solicits feedback after the session is completed. During both the concurrent and retrospective test types, moderators can use "think aloud" and "probing" questions. The think aloud questions are designed for the user to "keep a running stream of consciousness while they work". Probing questions obtain additional information about a user's behavior or about an answer to a think aloud question. Concurrent tests can be beneficial for eliciting real-time qualitative feedback while the retrospective format can be better for quantitative results; often concurrent questions can

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interfere with collection of usability metrics (U.S. Department of Health and Human Services, 2014).

Whether using the concurrent or retrospective method, facilitators of guided usability tests use a test protocol outlining the think aloud and/or probing questions. Just like in individual interviews, moderators should work to keep the participant relaxed and at ease. At the end of a round usability testing, the goal is to have findings—both positive and negative—to support design refinements. In designing a tool for locating public drinking fountains, I used these findings to iterate my high-fidelity wireframe further and drive the final product toward meeting user needs.

Usability Test Structure

The goal of the guided usability tests was to develop qualitative results and identify areas in which my design could be improved. In conducting a guided usability test, I sought to gather feedback on the information presented on the screen and how the user accomplished the major tasks of searching for and adding a fountain. Beyond this, I wanted to observe the user's process when planning a long run. What factors do users consider when looking for fountains? What are the methods by which a runner searches for a fountain? Does the site provide the flexibility for the invariably different means for approaching this complex task? How does the application facilitate the collection of crowd-sourced location data? These are the types of questions that served as the goals for my usability evaluations.

As a result, I used the concurrent test structure with both think aloud and probing questions. In the individual interviews, users provided feedback on how they might use *Thirsty Runner* when presented with the low-fidelity wireframes. In the guided usability tests, I evaluated users' *behavior* by observing participants as they searched for and added drinking fountains in the high-fidelity prototype.

I conducted seven guided usability tests over four weeks. The format of these tests was similar to the individual interviews. A major finding from the individual interviews (see page 37) was that users would not search for drinking fountains during a run; because of this, I had participants use the site in a planning capacity. The tasks for the guided usability test were done remotely and did not involve any actual running.

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I facilitated these tests using the Zoom Video Conferencing software, which provided both audio and video capabilities to simulate an in-person interview. Participants shared his or her screen while using the high-fidelity prototype so that I could observe the his or her behavior in real-time. I recorded the audio and video of each guided usability test. Just as in the individual interviews, I provided the users with an Informed Consent document (Appendix H) to review. The guided usability test did not begin until the participant verbally consented to the contents of the document.

Usability Test Protocol

Also similar to the individual interviews, I developed a protocol for facilitating the test. This protocol contained several sections: a high-level background on the project and the test goals, setting the user's expectations, and the test scenario/tasks. I began each test by explaining who I was, what I hoped to accomplish with the usability test, and how the results would be used in my overall design process. Before the participant used the application, I ensured that he or she was familiar with the test guidelines. These guidelines were to put the user at ease. These guidelines and the full test protocol can be found in Appendix J.

After reviewing the guidelines with the participant, I gave him or her an opportunity to ask any questions before the test started. Next, I set up the test by describing the test scenario. The scenario for this test was as follows:

> Imagine it is Saturday morning in August and you just woke up in your Mount Vernon row home. Today is your long run day, part of your training for the Baltimore Marathon in early October. You want to get in about a 15-mile run. You also want the run to end in Patterson Park since you are meeting some friends there for a game of Ultimate Frisbee before going to brunch.

I then asked the user to complete two different tasks. The first task was to use the site to plan the aforementioned 15-mile run. The second task was to if, during the run, the

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user encountered a fountain that was not found on the site, how he or she would submit a fountain to *Thirsty Runner*.

I wrote the think aloud and probing questions to understand the user's thought process in planning the run and adding a fountain. On the whole, the questions were written to understand the user's expectations and gather feedback on ways in which the site could be improved. For each participant, I made note of how he or she searched for the fountains.

Usability Test Participants

I solicited the help of guided usability test participants from many of the same people that volunteered to help with my initial research in the individual interviews. In recruiting participants, I was careful to solicit runners that fit into both the "planner" and "non-planner" personas, developed as a result of my individual interviews (see Chapter 4). Five of the seven users evaluated in a guided usability test participated in an individual interview. I recruited the other two participants using the Baltimore Road Runners Club Facebook page. For these two runners, prior to scheduling the usability test, I issued a brief screening questionnaire in which they provide me with their age, weekly mileage, hydration habits, and their running routine. This enabled me to help categorize these users as either persona. A summary of the guided usability test participants and the recruitment method can be found in the table below.

Table 4

Guided Usability Test Participant Recruitment Methods

Participant Number	Recruitment Method	Individual Interview Participant?
P1	Baltimore Marathon Running Expo	Yes
P2	Referral by Interview Participant	Yes
P3	Referral by Interview Participant	Yes
P4	Baltimore Road Runners Club Facebook Page	No
P5	Baltimore Road Runners Club Facebook Page	No

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P6	Baltimore Road Runners Club Facebook Page	Yes
P7	Baltimore Pacemakers	Yes

The demographics of the usability test participants were similar to those that participated in the individual interviews. Guided usability test participants were a mix of both men and women and those with varying weekly mileage totals. One slight variation between the population of interviewees and usability testers is the user's age. Additional details on my interview findings can be located in the following chapter; however, one specific takeaway from these interviews was that participants in their late 40s and older used very little technology when planning runs. For this reason, the usability test participants were runners from 20 to 40 years old. A summary of the guided usability test participants and demographics is shown below.

Table 5

Guided Usability Test Participant Demographics

Participant Number	Age Range	Gender	Average Weekly Mileage	Persona
P1	21 to 30	M	50+	Planner
P2	31 to 40	M	31 to 40	Non-planner
P3	31 to 40	F	31 to 40	Planner
P4	31 to 40	M	50+	Planner
P5	21 to 30	F	21 to 30	Planner
P6	31 to 40	M	31 to 40	Planner
P7	21 to 30	F	21 to 30	Non-planner

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Chapter 4: Results of User-centered Design

Individual Interview Results

The upfront individual interviews with representative users influenced the design of *Thirsty Runner* heavily. Upon completion of ten hour-long interviews, I reviewed the notes and audio/video recordings to develop a list of major findings to apply to the design. After speaking with runners about their running routine, how they use technology, and how they hydrate during runs, I had gathered enough information to also create personas, detailing who my users were.

User Personas

A user persona is "fictional, detailed user model", intended to represent archetypical users (Blomkvist, 2002, p. 2). Personas capture the needs, motivations, and behaviors of users, based on information obtained during the research phase of a project. According to Blomkvist (2002), user personas are not real users nor are they average users; instead, they are models of users with concrete goals that drive the design of an interface. Because the abstract "user" can be difficult to conceptualize—especially during communication of a design—personas are given realistic details including a name, photograph, and a personal story.

After reviewing the results of the individual interviews, I defined two user personas: Bradley Powell and Claire Warren. While each have their own specific goals and motivations, on the whole, Bradley can be considered the "planner" persona and Claire can be considered the "non-planner" persona.

Bradley is serious about his hobby. He is methodical about planning workouts by using mapping tools to plan routes a day to a week in advance. He monitors his pace and heart rate using his Garmin GPS watch and keeps an online journal of his workouts. Bradley carries water with him year-round on runs lasting over an hour; on warmer days, he monitors the weather before he begins and will often plan his route knowing he will need to stop at a public drinking fountain to refill. Bradley's primary goal is running three to four marathons per year, using any information and data available to achieve peak performance.

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Claire is a social runner. She attends the Saturday morning long runs organized by the local Baltimore running club and runs with a few club members several days a week, in the evenings after work. She tries to run all year to keep in shape, though she will skip an occasional run if the temperature looks too cold. When Claire runs, the routes she takes are either planned in advance for her by running club leadership or are one of the three routes she knows from experience of exploring the neighborhoods near her home. She will occasionally check her FitBit or Nike GPS at the end of a run to see how quickly she finished; however, she does this more casually, as a mental note. She reluctantly carries two eight-ounce bottles of water when she runs over ten miles. Just like running with water, she dislikes stopping during a run to hydrate, but will if needed. Claire's primary goal is to simply run and be finished. While running is one of her favorite activities, she is not as devoted as some of the other club members. Additional details about Bradley and Claire are shown below.

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Table 6

Planner Persona: Bradley Powell

Bradley Powell	
Overview	Bradley is a 29-year-old male, living in Fells Point. His is recently married and is employed full-time at a digital marketing firm. While he lives in the city, he travels frequently for business.
Running History	He has been running for 19 years, since he started high school. Bradley runs year-round, with an average of 40 miles per week. He typically participates in 5–6 races per year, including at least several marathons. Usually Bradley runs alone.
Running Routine	Bradley's running routine includes: • Researching routes a day or more ahead of time • Actively monitoring his pace and splits • Immediately after a run, he takes a moment to check to see how he feels • He finishes by logging workouts into a journal
Hydration Routine	Bradley's hydration routine includes: • Planning out hydration in detail, including where to stop • Checking the weather and making adjustments • Varying the amount of water and number of stops depending on the distance • Carrying water year round on long runs

Note. Image from van der Sluijs, Peter. (Photographer). (2012, December 17). *Black man are good runners* [digital image]. Retrieved from https://commons.wikimedia.org/wiki/File:Black_man_are_good_runners.JPG

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Table 7

Planner Persona: Claire Warren

Bradley Powell	
Overview	Claire is a 38-year-old woman, living in Roland Park with her husband of 12 years. She is employed full-time at a non-profit in Washington, DC
Running History	She has been running for 8 years and tries to run year round. On average, Claire runs 25 miles per week. She has run one marathon but her favorite distance is the 10K. The majority of her runs are done with a local running club
Running Routine	Claire's running routine includes: • Meeting with running club members every Saturday morning • Running with a few club members twice a week in the morning, often in a route around her house • When training, she will carry a GPS watch, but only informally to keep track of the pace • She very seldom prepares prior to runs
Hydration Routine	Claire's hydration routine includes: • She hates carrying water, but will on long runs in the summer • Claire has a set group of indoor and outdoor fountains from which she will drink • She will drink a glass of water when she gets up

Note. Image from Rebler, Claus. (Photographer). (2009, July 11). *Christina* [digital image]. Retrieved from https://www.flickr.com/photos/zunami/3712960556/in/photostream/

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Key Interview Findings

Context of use. The biggest finding from the individual interviews was the method by which runners would use an application such as *Thirsty Runner*. At the onset of these interviews, my hypothesis was that runners would use the application both before and during runs. Literature research (see Chapter 1) showed that a large portion of Millennial runners exercise with their smartphones; however, of my interview participants, only P8 stated that she carries her smartphone. Not only that, but she only carries her smartphone when training for a race.

The primary implication from this finding is that *Thirsty Runner* should be considered more of a "planning" application compared to a "running" application. Users stated that they would use *Thirsty Runner* to plan a route either immediately prior or a day or two in advance. In general, interview participants agreed that they would use the locations of drinking fountains as supporting information for planning a route. As a whole, the runners I interviewed consistently responded that they would not stop during a run to locate where drinking fountains are located.

This finding is significant because of its impact on the design of *Thirsty Runner.* At the end of Chapter 2, I describe my hypothesis for how runners would use the application in both a desktop and a mobile form factor. I also provide ideas for real-time alerts using runner biometric and pace data. This finding demonstrates that these mid-run capabilities should not be my priority. Not only that, but this also implies that a smartphone form factor in general is less important (only three participants indicated they would access the application via smartphone). Instead, my design should focus on addressing the challenges and needs planning a run. Because of this finding, I changed my hypothesis to state that runners would use *Thirsty Runner* solely in a planning capacity and access it most often using a computer. This hypothesis would be further validated during my usability evaluations.

Another finding regarding context of use was that in Baltimore, many runners recognize that at least when it comes to outdoor drinking fountains, the available options are limited. Because of that, users indicated that *Thirsty Runner* would not be a site they checked very often. Runners were excited about being able to see the location of the

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available water stops; however, once they had committed them to memory, they would not have incentive to return to the site. While this would be drawback for a site reliant on community participation, P1 and P10 participants indicated that *Thirsty Runner* would be especially beneficial for when one is away from home. Much like looking for nearby restaurants when on vacation, *Thirsty Runner* could provide value for those runners who want to exercise in an unfamiliar city.

Importance of hydration. As detailed in both user personas, research showed users understand the benefits of being properly hydrated. For instance, P6 said, "where to get water is very important to me"; P9 went further to say, "I try to be as hydrated as possible." Unanimously, all interview participants prepare by planning to hydrate mid-run. While certain runners make more of an effort than others, everyone stated they carry a water bottle or fuel belt and/or plan to stop at a water fountain to refuel. Generally, users brought water or planned to stop during runs that were longer than an hour or over approximately eight to ten miles. For many, this benchmark held true independent of the season. Even during cold winter runs, several interviewees stated they would still bring water with them on their long runs. Despite this, runners that carry water with them view this as an annoyance. P10 claimed "I grudgingly run with my water bottle." When referring to an application such as *Thirsty Runner*, P6 said she would consider not carrying water with her if she knew where it was available on her route. As a result, these findings confirm that an application showing the location of public drinking fountains would provide value to the running community.

Running technology. During the individual interviews, I spoke with participants on their use of technology as it related to their running process. The users I interviewed owned a variety of products to track pace, distance, and heart rate and accessed different products to plan and journal their progress. The general sentiment on this technology across runners was of ambivalence. A quotation from P1 best captures this feeling when he said he is "not tech heavy [and uses] just enough [technology] to be comfortable." P3 only uses his GPS on long runs and P5 does not use a GPS watch at all because she likes to "get lost in the run." Over the years, P4 has owned a number of different watch models, but likes his FitBit best. P2 and P9 like their Garmin GPS watch and each use it

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to monitor their performance during the run. Users P1, P3, and P4 all use MapMyRun to plan specific training routes. However, on the whole, while runners felt that running technology was helpful, many did not express strong feelings about any particular product or website. Several of the older participants barely used technology at all. If they did, it was very casually or a device with fewer features such as a FitBit or digital watch.

Volunteered geographic information. During the individual interviews, I spoke with participants about the idea of volunteered geographic information, in particular how they viewed its accuracy. Eight of ten runners—all interviewees other than P1 and P4—expressed sentiments that they would trust the locations of the drinking fountains due to the fact the data was curated by the running community. According to P3, "runners sympathize with each other's position." P10 said "the running community is a good community and people are very friendly." P6 stated that she would "trust another runner." The idea that *Thirsty Runner* would provide a service *for* runners, *by* runners, was seen very favorably. Several interviewees did state that their trust of the information would be lost if they visited a fountain after using the site and that fountain was missing or broken. Even though runners said they would trust the data, multiple participants indicated they would like to see additional data to confirm the site's accuracy, such as the most recent date it was visited (P8).

Participants also stressed the need for making the process of adding fountains as simple as possible. For instance, four users suggested when specifying a fountain's location, they would like to "drop a pin" by clicking on a map rather than entering an address (P1, P2, P5, and P9). P5 also commented how she would not want to type any information about the fountain. Her vision for adding the fountain would be to use a series of "checkboxes" to enter fountain details. She justified this by citing the online running log, Running2Win, which she said forces users complete too many steps. Several participants stated that they would not upload a picture of the fountain.

Responses were mixed on whether those interviewed would add water stops to *Thirsty Runner*. P3 and P4 explicitly stated they would not add fountains to the website. P6 said she would add fountains, P1 said he would if he were referred by a friend, and P2 said he would if he were provided with a reward. Because interviewees held the running

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population in such high regard, one way to facilitate use of the site and to help grow the community is to show that it does, indeed have a community. Upon launch of the site, I could personally add a group of fountains to serve as a baseline. Not only that, but I could reach out to running groups in the city to help grow the user base.

User mental model. Conducting the individual interviews gave me insight into users' mental model for locating public drinking fountains. According to Ballav (2016), a mental model is "a person's intuitive understanding of how something functions based on his or her past encounters, exposure to information, and sound judgment" (Ballav, 2016). Major usability issues can occur when the model and approach of solving a problem in an application differs from the user's mental model. Feedback on runners' mental model for *Thirsty Runner* served as the foundation for the prototype.

My initial idea for *Thirsty Runner* was an embedded geographic map with an overlay of fountain markers. The map would also have all the standard features of a map application, including zoom and pan. The interviews with runners validated this approach for displaying fountain information. However, the interviews revealed that using a map was even more important to the user's mental model than I had anticipated. When asked to share their vision of how one might locate public drinking fountains, most immediately responded to use a map. The sketches I shared during the interviews showed a map occupying approximately one third of the page and a detailed search results list occupying the other two thirds. Feedback from P5 indicated that this was not enough focus on the map and that it should be "front and center." P9 said that the "results [list] works, but I want the map first." She continued to make the argument for a map by stating "I wouldn't know where the fountain is…using a list." These responses show that the map must be the primary feature of *Thirsty Runner.*

Regarding how users searched and found the fountains, I can conclude that the final design must allow for searching by multiple methods. The users' idea for method of search was varied, including searching by: destination, street corner, address, neighborhood, and searching near the one's current location. Several runners expected the experience to be "similar to Yelp" (P3) or "kind of like you're looking for a coffee shop" (P7). Two users indicated that they would want to use the map to build a route,

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similar to MapMyRun (see page 16). However, P1 said he would not use it to build a route, but would go to MapMyRun first; P2 echoed this sentiment by explaining that he would use the data found on the fountain map to cross-reference with other maps. These varying results, while important to note, can be explored further with behavioral research in the guided usability tests.

Site content. Overall, users did not expect to see many details regarding each fountain on *Thirsty Runner*. Six of the participants claimed that after its location, if the fountain is working was the most important information about each fountain. Several runners related similar experiences with running in Baltimore city and seeing fountains either turned off in the winter or not functioning. Users shared that a fountain star rating and a "verified" status—initial ideas contained in the sketches—were unnecessary. My initial approach for this site was to focus the locations of the outdoor, public drinking fountains, but several users who occasionally stop indoors would like to see those locations as well. Four participants (P2, P7, P9, and P10) wanted to see locations of bathrooms in addition to water stops.

As detailed above, I found that runners recognize the importance of drinking during a long run. The initial wireframes contained a section on the home page entitled "Why Hydrate". This was intended to convey the benefits of hydration but also to provide context to why one would use *Thirsty Runner*. Feedback from the interviews was that this is unnecessary. For instance, P5 shared that she did not "need to be lectured."

Iterative Application Design Results

Initial Wireframes

As I mentioned, for the individual interviews, I created initial wireframes to share with the participants and gather feedback their vision for *Thirsty Runner*. I created six different wireframes—a *Thirsty Runner* home page, a search results page, and an add fountain page, each with a desktop and mobile version. These wireframes were developed before I conducted any of the individual interviews; their purpose was intended as a tool to which interview participants could react. Since they were designed to simply elicit discussion, they were intentionally lacking in detail and focused primarily on the core

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user tasks of searching and adding fountains. The mobile form factors of the initial sketches can be found in Appendix K.

***Thirsty Runner* homepage**. The homepage initial wireframe had the following major sections: page header, with buttons for "Search Near Me" and "Add a Fountain"; information about the purpose of *Thirsty Runner;* information on the importance of hydration; current weather; and "My Favorite Fountains".

My initial concept was to have the core user tasks accomplished using buttons at the top of the page. My assumption was that the primary use case for searching for a water fountain would be for the user to search near his or her location. If the user wished to search using a different method, he or she could use the search link in the navigation. The other content items on the home page were intended to provide context to the application. Specifically, I included the "About" and "Why Hydrate" sections to illustrate the value of the application and drinking water in general. The current weather section also supported this overall theme. Finally, I included "My Favorite Fountains" in this sketch as a way to show the user that he or she could potentially customize *Thirsty Runner* to one's own specifications.

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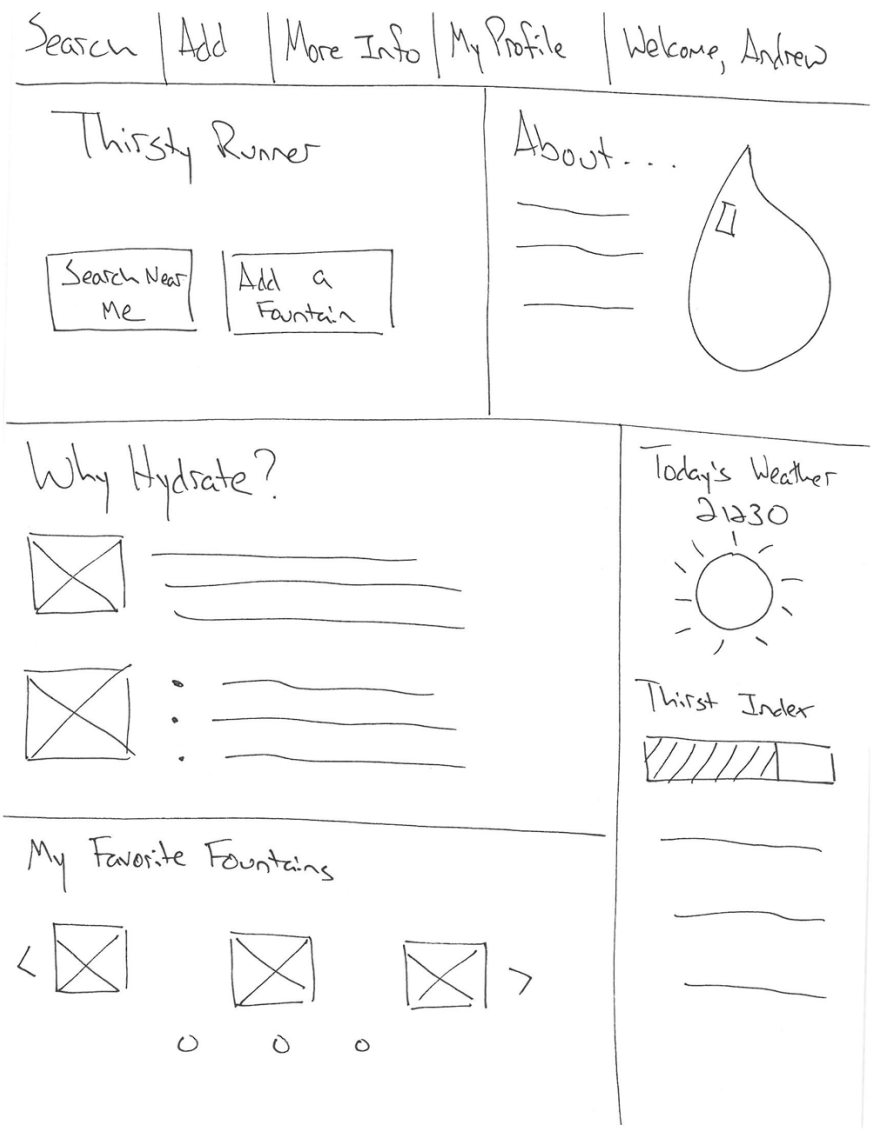

Figure 1: Initial wireframe of the *Thirsty Runner* homepage

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Search Results page. The focus of the initial wireframe for the water fountain Search Results page was a list of water stops. The list contained all of the water fountains in ascending order based on distance from the runner. In addition to showing distance from the user, each search result widget had a title, the date it was last visited, the total number of visits, a rating, and a check mark to indicate it was "verified". The user could accomplish three tasks in the search results section: get directions, add the fountain to his or her list of favorite fountains, and to check-in, to indicate if he or she had visited the water stop during a run. Other content items on the search result page included a map, which showed a visual representation of each fountain's location, search result filters, and a link to the Add a Fountain page. When developing this wireframe, my intention was to showcase the various metadata and user tasks in each of the search results instead of having the street map be the prominent feature.

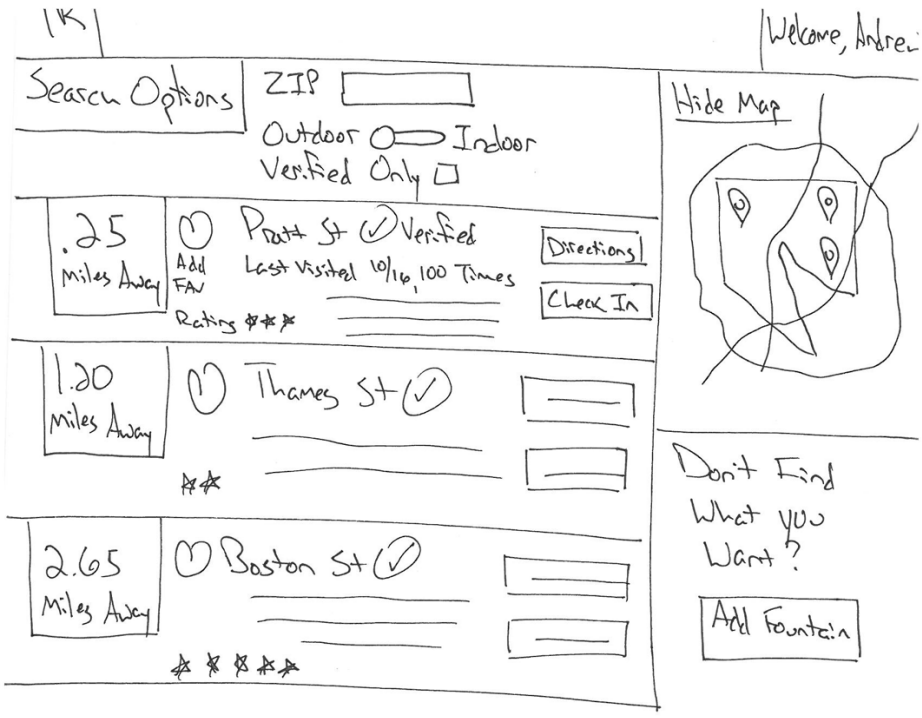

Figure 2: Initial wireframe for the Search Results page

Add a Fountain page. The initial wireframe of the Add a Fountain page contained a section with a description and instructions on adding a fountain, a large street map, and a section at the bottom with the different form elements needed to submit a fountain to *Thirsty Runner*. My initial approach for adding a water stop to the web site

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was to ask users to enter the minimum amount of information. The form in the initial wireframe had users enter a description of the fountain, add a photograph, and then mark if the fountain was outdoors, had cold water, and was working. Finally, the Add a Fountain page allowed users to rate the fountain from one to five stars. The only task available on this page was to submit a water fountain.

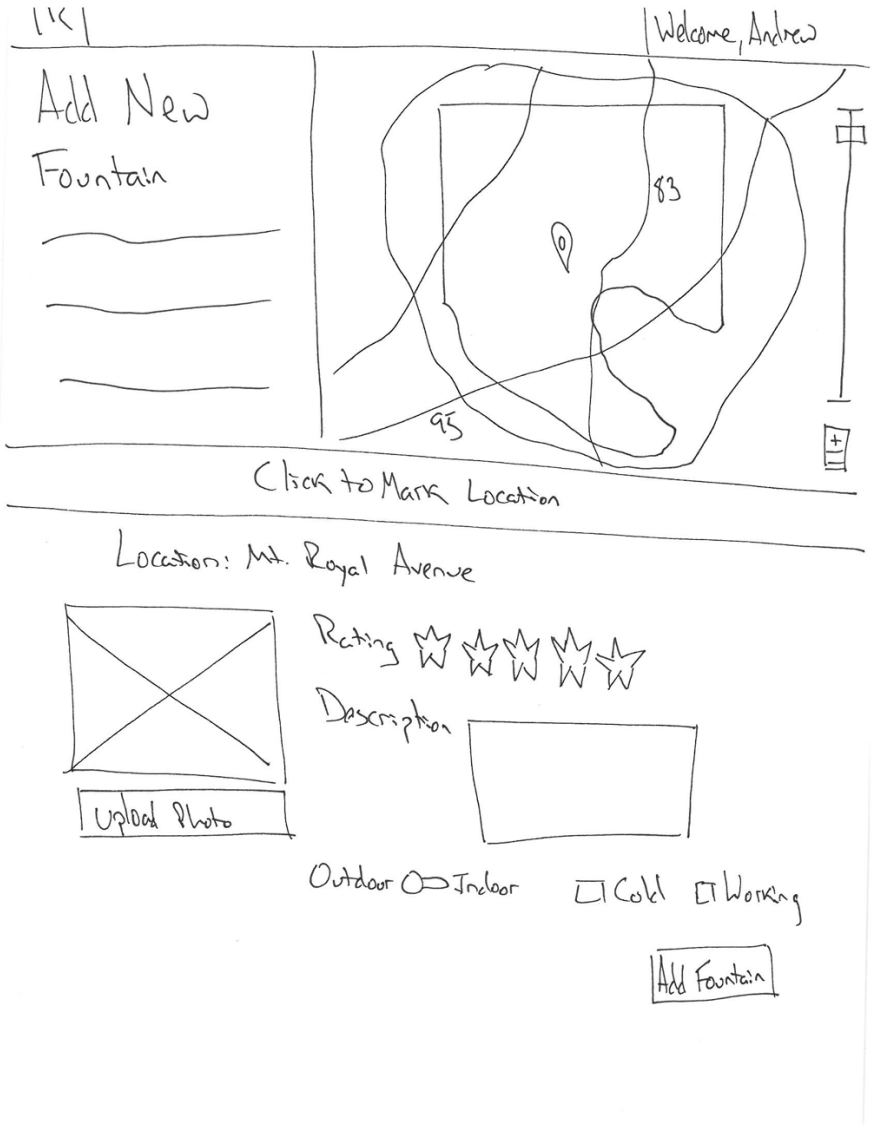

Figure 3: Initial wireframe for the Add a Fountain page

Low-fidelity Design

At the conclusion of my interviews, I applied all of the feedback received on my initial wireframes to iterate and develop additional low-fidelity wireframes. These low-

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fidelity wireframes were the next step in iteration towards the final design. While I used the initial wireframes as a tool for generating discussion, I created the next set low-fidelity wireframes to refine my ideas further and to serve as a model for the high-fidelity prototype. One major change from the initial wireframes was that going forward, I would only focus on the desktop form factor. This was based on feedback from the interviews regarding runner's context of use (see page 67).

Conceptual Modeling. During the conceptual model step of creating the low-fidelity design, I developed a list of pages and a preliminary site map for *Thirsty Runner*. The list of core pages I considered for my site map included: *Thirsty Runner* home page, the Search Results page, the Add a Fountain page, a page specific to each fountain, and a My Profile page. The site map also contained secondary pages and/or variations of the core pages. These secondary pages included: edit a fountain, edit success, add a fountain success, check-in to a fountain, check-in success, add a favorite success, and get directions. The site map for *Thirsty Runner* can be seen below.

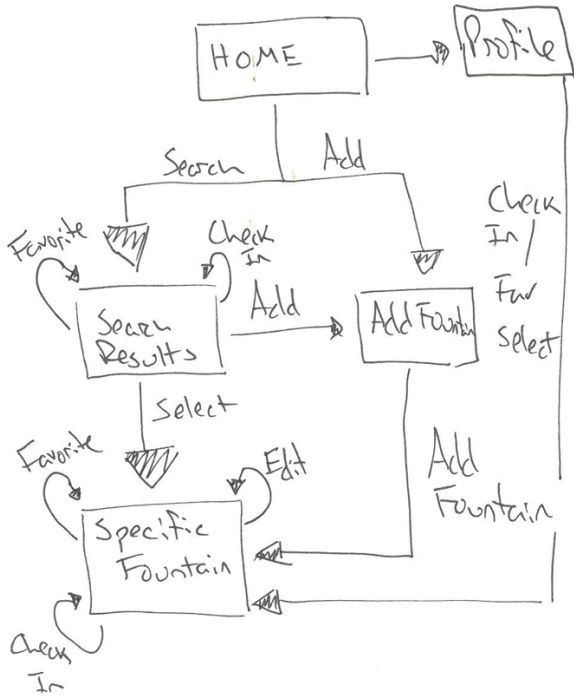

Figure 4: *Thirsty Runner* site map

***Thirsty Runner* homepage**. In iterating the design of the *Thirsty Runner* homepage, I removed the "Search Near Me" button and replaced it with a search field

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and search button. Interview participants shared a variety of methods by which they would search for water fountains; to support this, the homepage in the low-fidelity wireframe had a universal search. If the user wished to search near their location, they could search by their neighborhood, their address, or ZIP code.

I also removed the "Add a Fountain" button from the home page and placed a link to the Add a Fountain page in the primary navigation. I decided that the task of locating a drinking fountain was higher priority than adding a fountain and thus wished to only feature the search on the home page. I changed the homepage to also have a large hero image to communicate the purpose of *Thirsty Runner* visually. On the initial version of this wireframe, I devoted a large section of the page on the importance of hydration. In the second iteration, I removed this section and replaced it with more details about the aim of the application and how it is supported by the running community.

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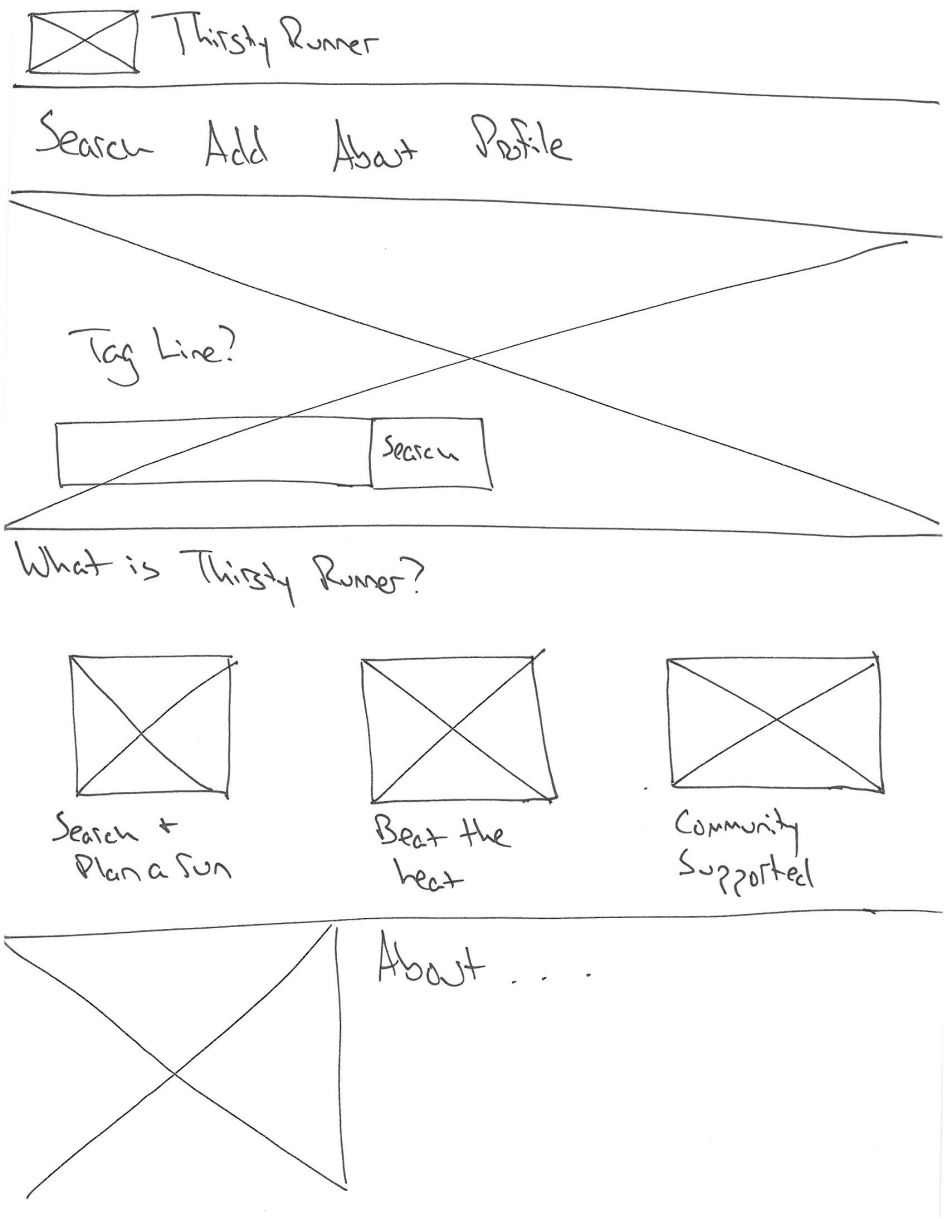

Figure 5: Low-fidelity wireframe of the *Thirsty Runner* homepage

Search Results page. Building upon the first draft, this version of the low-fidelity wireframe still had the same three major sections sections: search filters, search result list, and the interactive map. The biggest change to the Search Results page between my initial wireframes and the next version was the focus on the street map section. Feedback from the interviews showed that users wished to see the map as the primary fixture on this page. Because of this, much of my effort in designing this search page was to refine the search results widgets to showcase certain fountain-specific metadata and actions. If

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the map occupied a larger portion of the screen, then that meant that the search results section had to be more constrained and I needed to limit the amount information displayed in each search result widget.

For this version of the wireframes, I also brainstormed ideas for info windows to show fountain-specific information directly on the map itself. Each info window would be shown when the user moves his or her cursor over the map marker. With this mouse-over approach, *Thirsty Runner* could display additional fountain information within the geographic context of the map; but by having it hidden the majority of the time, the user could remain focused on using the map to locate fountains.

At this stage of the design, I had different concepts for the search results widgets. Most of my ideas allowed users to complete the same tasks as were in the initial wireframes: get directions, check-in, and add the fountain as a favorite. The data describing the fountain changed significantly. I removed the "verified" water fountain concept and the star rating. Instead, I added the neighborhood and ZIP code, if it was working, if it was outdoors, and if a bathroom was located nearby. Sketches for the info windows contained much of the same information. The second version of my low-fidelity wireframes are shown below. Additional sketches of the search results widget and the info window can be found in Appendix L.

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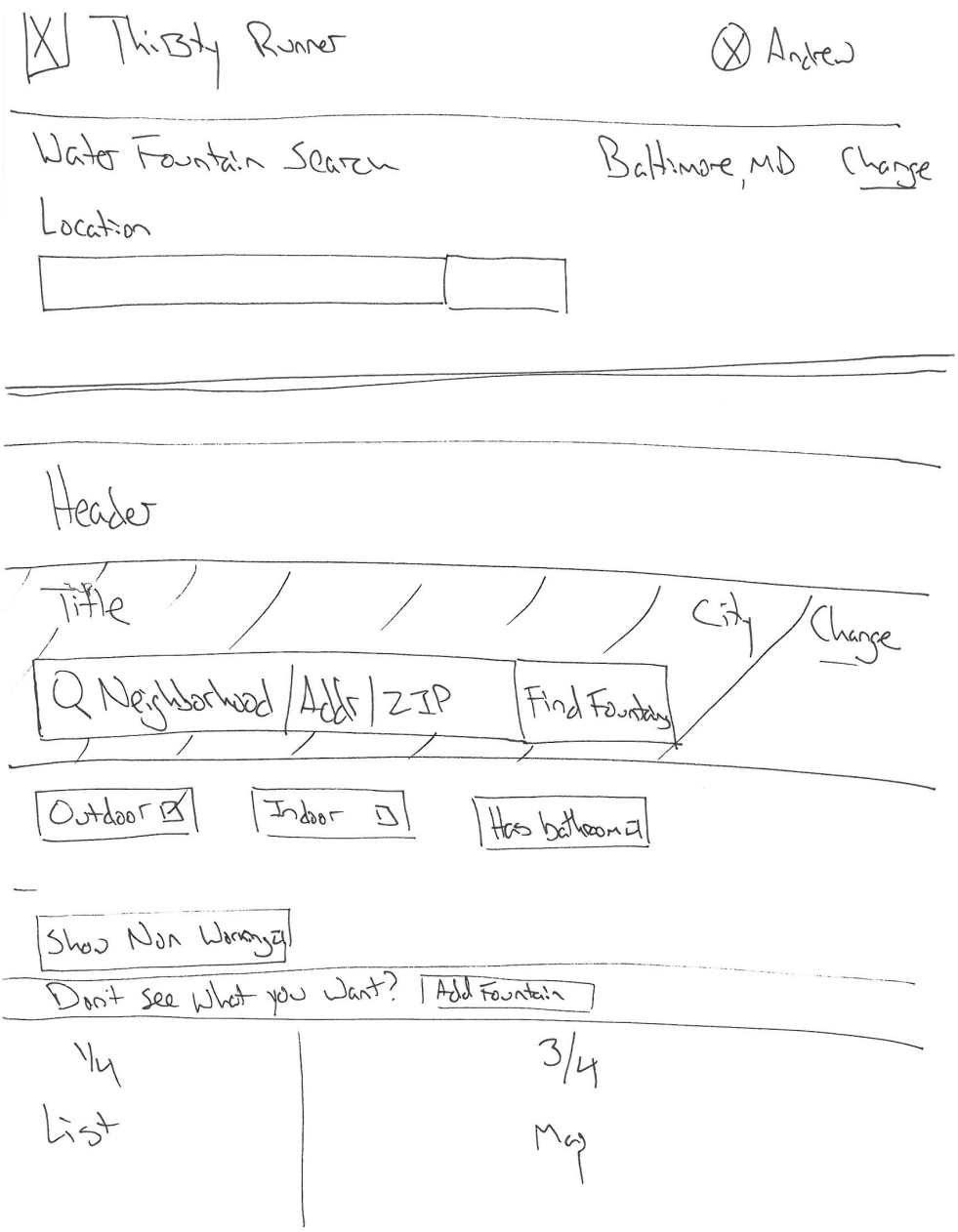

Figure 6: Low-fidelity wireframe of the Search Results page header

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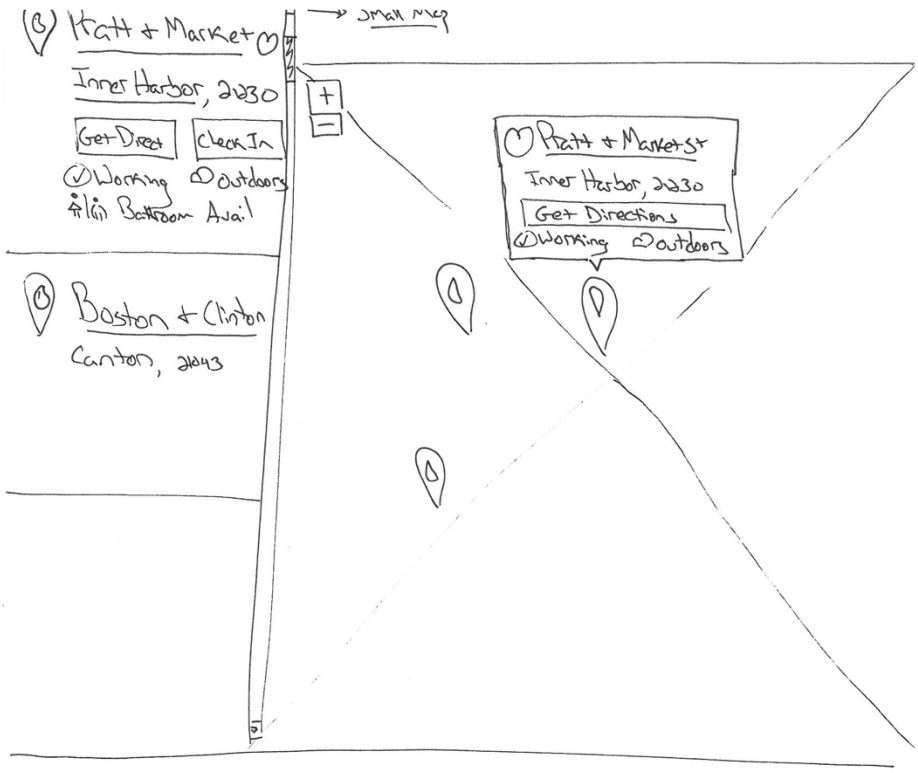

Figure 7: Low-fidelity wireframe of the Search Results list and map

Fountain Details page. The Fountain Details page was not part of the initial wireframes that I shared during the individual interviews. This was new page designed to provide specific information about each water fountain that could not be included on the Search Results page. While this page contained the same information and tasks as in each search result widget, this page also contained data about its submission to the website. This includes which user added the fountain (anonymously or not), the date on which the fountain was added, and how many runners had checked in to the fountain. The Fountain Details page also showed a description and any comments entered by users of the website. I kept the total check-ins and most recent date of check-in to help reinforce the accuracy of the VGI.

In an effort to make the street map the focus of the application, the low-fidelity wireframe of the Fountain Details page also contained an embedded street map. This map displayed the location of the water fountain centered and at an appropriate zoom level to show the fountain's exact location.

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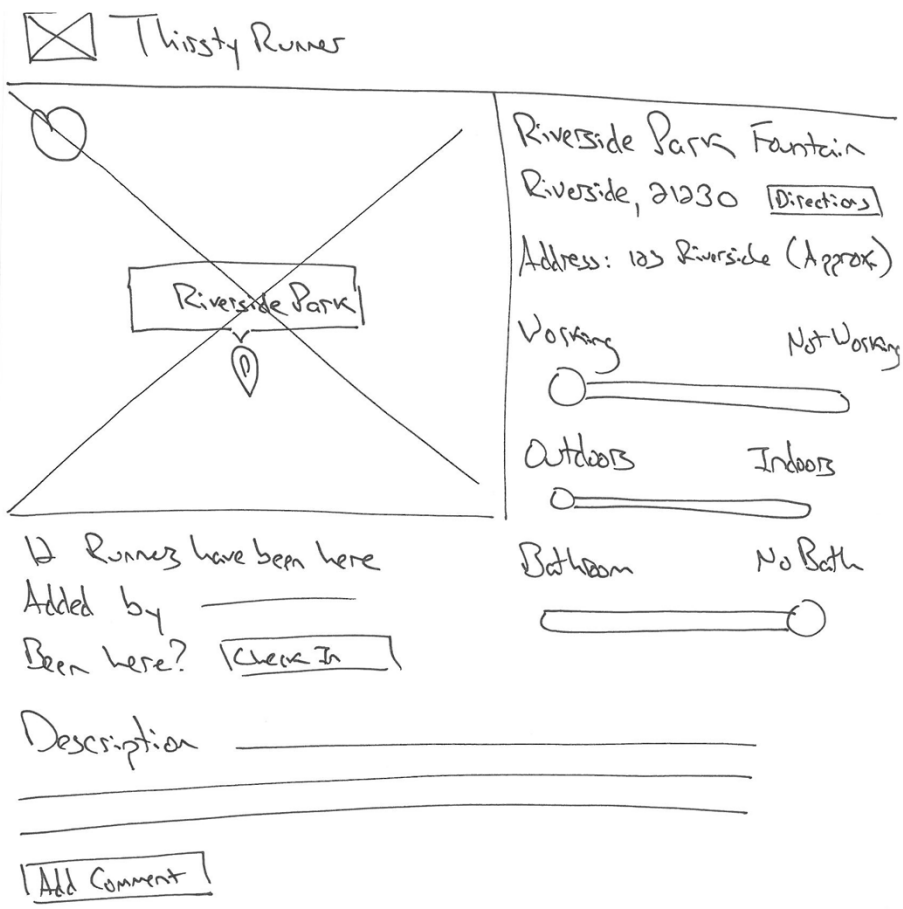

Figure 8: Low-fidelity wireframe of Fountain Details page

Add a Fountain page. I made only minor changes to the Add a Fountain page between the initial wireframe and the next low-fidelity version. Interview participants responded positively to the dropping a pin method of indicating a water fountain's location. For this second version, when adding a fountain, the user had to enter a fountain name, a description, and then answer three questions: is the fountain working, is it outside, and is it near a bathroom? Users could respond to these questions using a yes/no radio button.

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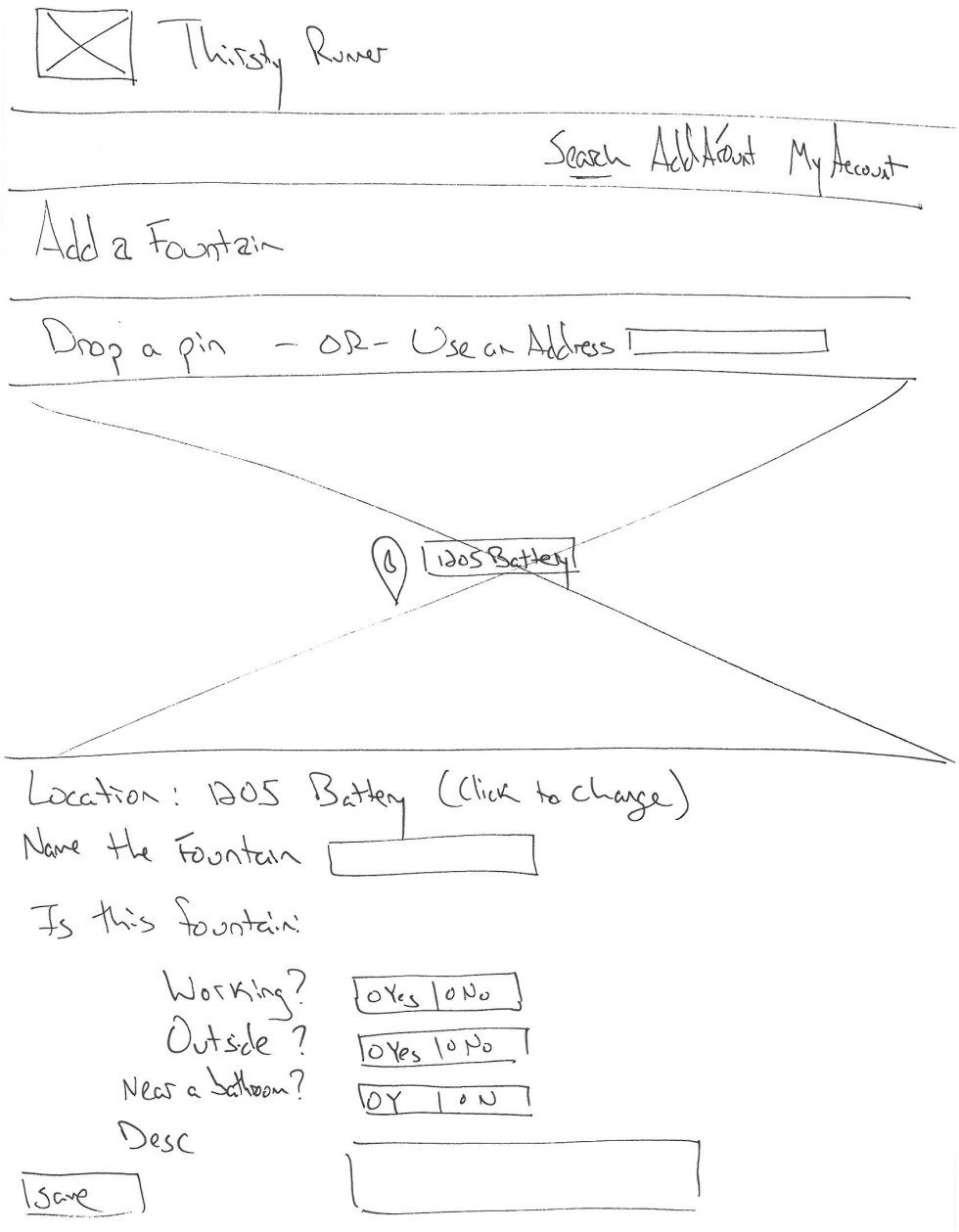

Figure 9: Low-fidelity wireframe of the Add a Fountain page

High-fidelity Design

As previously mentioned, I designed the high-fidelity wireframes by iterating upon my low-fidelity design using the Axure Rapid Prototyping software. Since I wanted my high-fidelity prototype to mimic a real website, not only did I need the design of the interaction elements, but I also needed to design of the visual elements, including typography, color palette, and overall aesthetics. One common method of designing the

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visual elements of a website is to use a style guide and a pattern library. Style guides establish the "root of the visual presentation" while a pattern library encompass the "static web UI elements" (Cook, 2016). Often these two frameworks support and complement each other.

Rather than design my own, I sought to leverage an existing style guide and pattern library. In designing *Thirsty Runner*, I selected Google's Material Design, which contains both a style guide and a pattern library (Google, 2016). Material design is the basis for all of Google's web applications. I felt that Material Design would be appropriate for *Thirsty Runner* because of the ubiquity of Google's suite of applications (and in turn, examples of Material Design) and interviewees mentioned Google Maps specifically when describing their vision for the site.

Even though Google's Material Design is rather strict in terms of customization, when building a site using this framework, web designers have the freedom to select a high-level color palette. I chose blue as the primary color scheme because of its association with water and orange as an accent color because of its complementary nature with blue. Other visual design elements including typography, grid system, margins, and padding are included with the Material Design style guide.

All imagery in *Thirsty Runner* was used under the allowable guidelines. All photographs on *Thirsty Runner* were purchased for reuse from Adobe Stock or are permitted for use without credit based on the Creative Commons license. Site icons are included for free use as part of the Material Design style guide. The three illustrations on the *Thirsty Runner* home page were selected from FlatIcon.com. I was authorized to use and modify these illustrations under the Flaticon Basic License (Graphic Resources S.L, 2017). I found all other images on Google Maps and were cited appropriately.

Photographs and illustrations were intended to convey a feeling of running and hydration; the hero image was of a runner refilling her water bottle, as an example. In the process of adding fountains to *Thirsty Runner*, I wanted users to be able to upload photographs of the drinking fountain to assist others in locating the water stop. If a water fountain did not have an uploaded photo, I had the default picture to be of running water to establish that sense of hydration.

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***Thirsty Runner* homepage**. On the homepage of my high-fidelity design, the major change from the low-fidelity wireframe was the adjustment to the site header. Previously, the *Thirsty Runner* primary navigation was divided into "Search", "Add a Fountain", "About", and "My Profile". This next version of the navigation had the same sections; however, I changed the label of "Search" to "Fountain Map". I did this to show users they could browse fountains instead of searching.

The other change made to the site header was to make the search box persistent at the top of the page. Even though this iteration of the *Thirsty Runner* site map was not very deep, I wanted to allow users to be able to complete the primary task of locating water stops across all pages of the site. The search box also has the hint text "Neighborhood, Address, or ZIP Code…" to communicate that this search can be used for a variety of search terms. Finally, in the site header, I provided a label identifying the user's current city to reinforce the scope of the map is limited to Baltimore. If this site were completely functional, this would automatically use the runner's location to identify the nearest metropolitan area and adjust the search accordingly.

Underneath the site header, I included a large hero image of a runner refilling her water bottle in the middle of a workout. I included this large image with the tagline "Find Fountains. Don't Run Thirsty" with the intent that together, they would clearly communicate the goals and functions of the site.

Underneath the hero image, I created a small weather widget with the current temperature and the temperature at each of the next two hours. Below the weather widget, I provided a section with three blurbs further detailing the purpose of the site. Both of these two sections had been included in all previous iterations of the homepage.

On the initial wireframe, I had a large section on the importance of hydration, but removed it from the subsequent version. For the high-fidelity design, I condensed the "Why Hydrate" section into a brief "Did you know?" fact underneath the three blurbs and illustrations. Similar to my selection of site imagery, I wanted the entire site experience to speak to the concepts of running and hydration. Finally, at the bottom of the site I provided a footer stating that *Thirsty Runner* could be used to find drinking fountains in other major cities.

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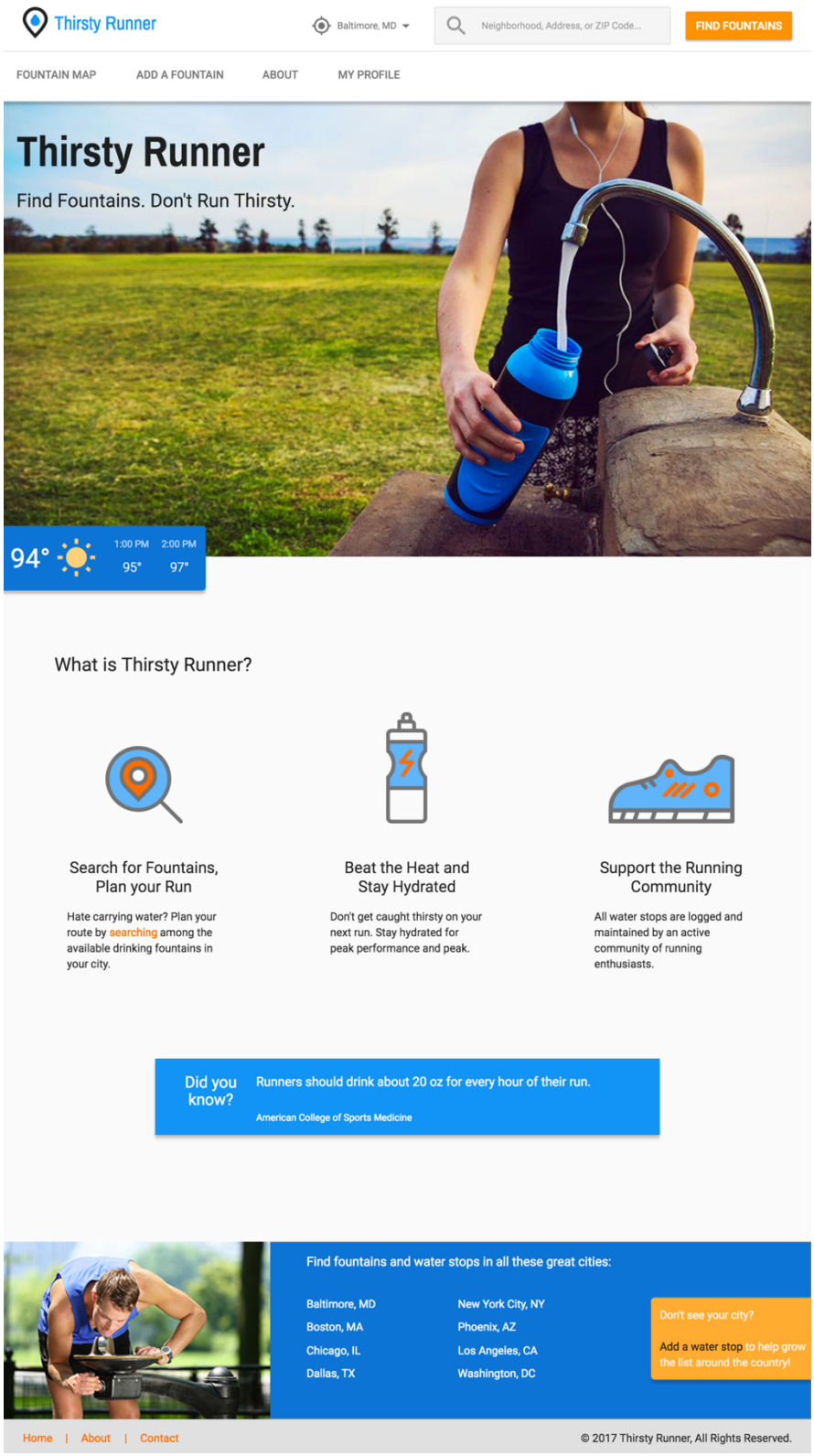

Figure 10: High-fidelity wireframe of the *Thirsty Runner* homepage

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Fountain Map page. The high-fidelity wireframe of the Fountain Map page (formerly Search Results) contained even fewer fountain-specific details than in previous iterations. The majority of the page still contained a street map, with the remainder of the page containing the search result widgets. From the previous version, I kept the fountain name, neighborhood, if it was working, if it was outdoors, if there were a bathroom nearby, and the ability to get directions. I removed the ZIP code label because I felt as though this information did not have as much relevance to runners as did neighborhood. I also added a photograph and the distance the fountain was from the user's location. The search results panel was scrollable within itself so as to maintain the user's focus on the street map. Having the search results list be its own scrollable panel prevented the user from scrolling and losing sight of the map.

At the top of the map, I included search filters based on working/not working, outdoor/indoor, and if the fountain was near a bathroom. By default, the Fountain Map page showed all fountains that were working, outdoors and indoors, and near a bathroom. On the map itself, I refined the data in the info window significantly. In a previous iteration, the info window had much of the same data displayed in the search result widget. To reduce redundancy, I altered the info windows to only show the fountain name, if it was outdoors, and an icon for adding it to one's list of favorite fountains.

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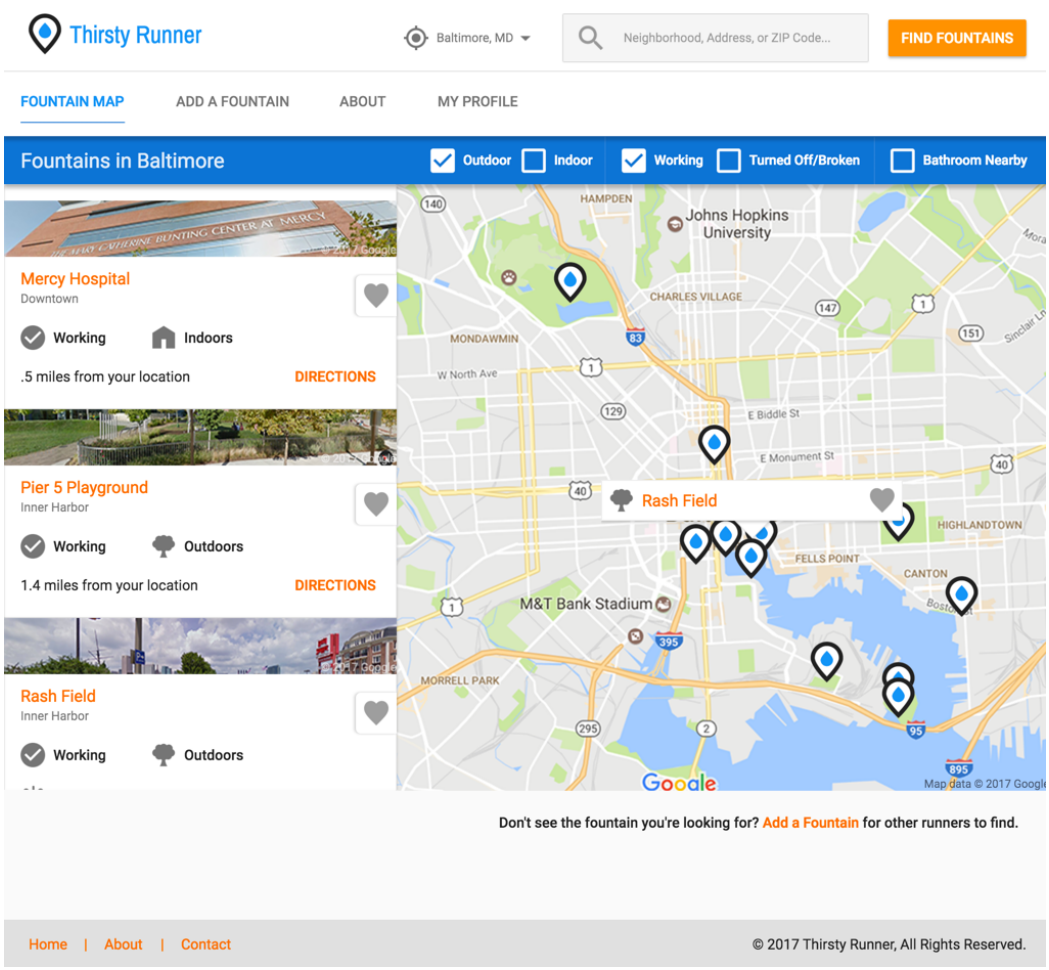

Figure 11: High-fidelity wireframe of the Fountain Map page

Fountain Details page. In a similar style to the design of the low-fidelity wireframe, the Fountain Details page developed in Axure had a two-column layout with the fountain metadata in one column and a street map in the other. The left side of the page showed if the fountain is working, outdoors, and was near a bathroom; the name of the runner who added the fountain, total runner check-ins, and the date of its last visit; and any comments left by the running community, sorted by most recent. At the top of the street map, I provided a banner with the address of the fountain. If this fountain was indoors, the address displayed would be the exact address of the building; otherwise, it would be listed as approximate.

Many of the user tasks available on this page were consistent with the previous version, including checking-in, adding a comment, getting directions, and adding the

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fountain as a favorite. I added one additional user task, which was the ability to edit the specifics of a water stop. Including this edit feature accomplished two goals: giving the user the flexibility to correct any mistakes made when adding the fountain, but also letting *other* users update any information that was incorrect or no longer valid.

Another change to the Fountain Details page was the inclusion of a photograph uploaded by the user. If the user chooses not to upload a photograph, *Thirsty Runner* would then use a picture of a generic fountain by default. Finally, in order to provide additional context to the location of each fountain, this page contained three "Nearby Fountains" at the bottom of the page.

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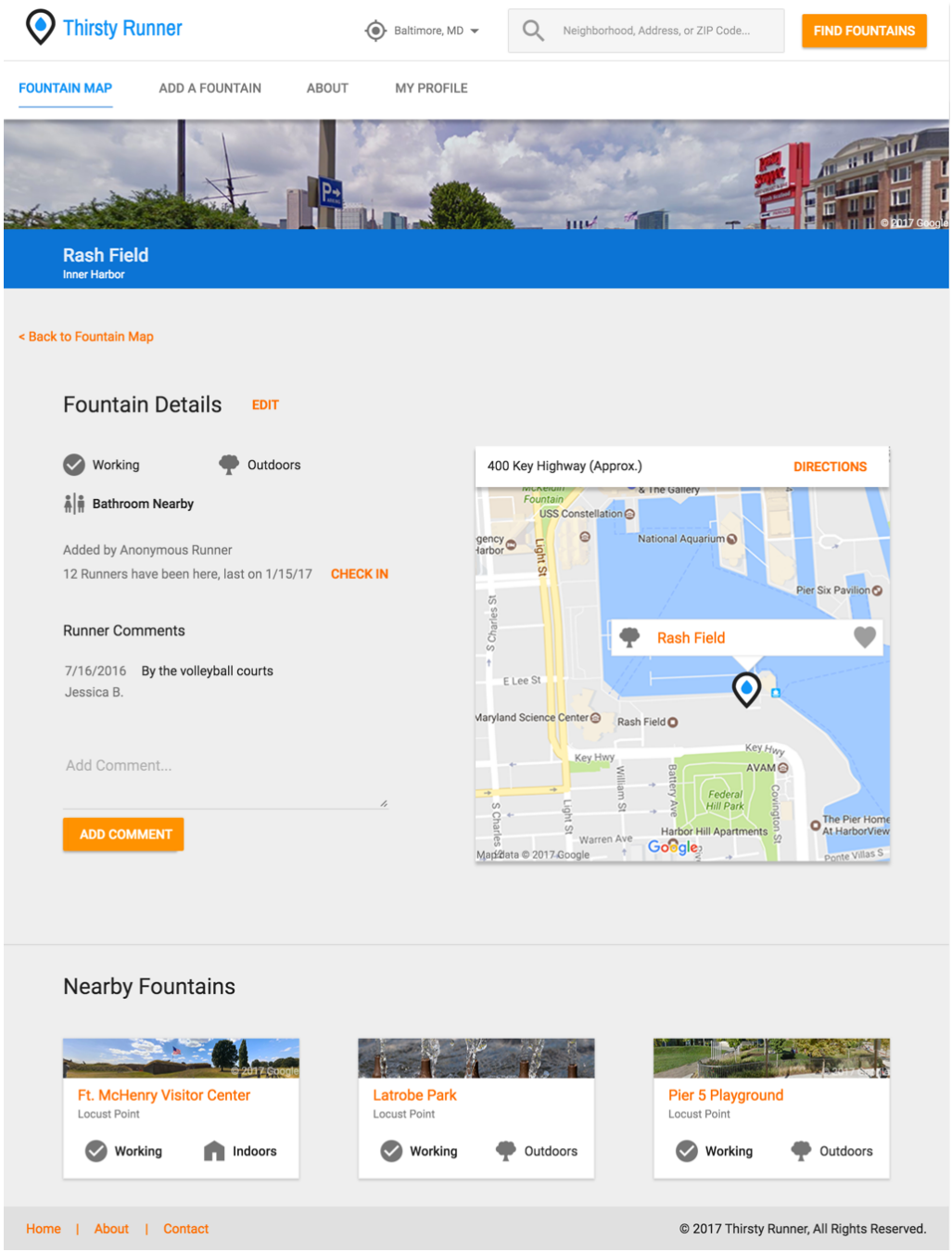

Figure 12: High-fidelity wireframe of the Fountain Details page

Add a Fountain page. Of the pages included in *Thirsty Runner,* the Add a Fountain page changed the least up to this point. The high-fidelity version of this page contained almost all of the same elements as were included in the low-fidelity wireframe. When submitting a new water fountain to the site, users must enter a fountain name, a

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fountain description, and answer if the fountain is working, outdoors, and near a bathroom. Changes between the low-fidelity wireframe and high-fidelity prototype included allowing users to upload a photograph and moving the map to the right side of the screen. I moved the street map to the right side for consistency with the Fountain Details page. I also added language at the top of the page to inform users that the fountain would be searchable on *Thirsty Runner* immediately after the fountain was added.

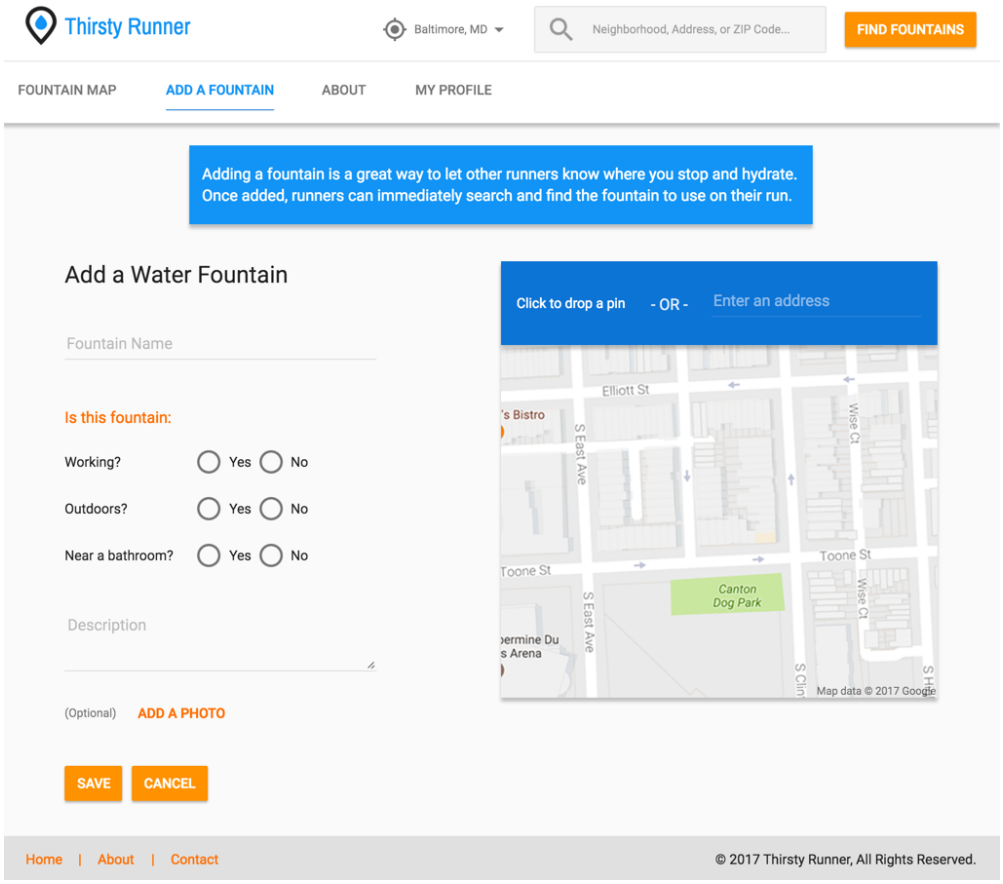

Figure 13: High-fidelity wireframe of Add Fountain page

Other supporting pages. While the primary tasks for my guided usability tests (see Chapter 3) involved searching and adding drinking fountains, I wanted the high-fidelity prototype to convey a cohesive user experience. To that end, I built the About and My Profile (Appendix M) pages not to be a focus of these evaluations but as a working section of the site, should the user happen to click the respective link.

The About page was an extension of the "What is Thirsty Runner?" section of the home page. This page expanded upon the goals of the site and provided a detailed

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overview about all of site functionality, including search versatility, indoor fountains, and the profile feature. This page was intended to describe more than what was displayed on the home page.

The My Profile page was intended to represent a profile similar to a profile on a social media site such as Facebook. This page had a picture of the user; his or her name; running club, if applicable; a section about the runner; and any *Thirsty Runner* "stats". These stats included the user's total check-ins, number of fountains added to the site, and the number of his or her favorite fountains. The list of favorite fountains was displayed underneath the picture and biography section.

Interactions for guided usability tests. While the Axure prototype is considered "high-fidelity", this version only had enough interactions necessary to conduct my guided usability test and gather feedback on the user's primary tasks. The intent of this prototype was not to mimic the application as if it were fully completed. Many buttons and links did not function properly, some of the water fountain data was fictional, and it did not draw from a real database of drinking fountains.

That being said, I used Axure to build website interactions similar to how the final product might function. The main interaction I simulated using Axure was the fountain search box at the top of the screen. The usability test task was to plan about a 15-mile run starting in Mount Vernon and ending in Patterson Park. The Fountain Map page had five different variations based on what the user entered. The user could search by "Mount Vernon", "Patterson Park", "Druid Hill Park", and "Ft. McHenry". The first two options were provided to the participant in the background task and the latter two options are common areas for runners. If the user searched by any other term, the Fountain Map would show a map of the entire city of Baltimore.

As mentioned in Chapter 3, one of major goals for the guided usability test was to observe users' thought process for planning a run and searching for drinking fountains. To support this, I created a Fountain Details page for thirteen different water stops. The locations of the fountains were all displayed on the map, shown across the city. On the map itself, when the user hovered their mouse pointer over any of the fountain markers, an info window displayed. The fountain name also served as a hyperlink to each of the

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Fountain Details pages. Users could access the Fountain Details page from the hyperlink in the info window or in the search results pane on the left side of the page.

Due to time and technical limitations, the map did not have the full functionality. The map in the prototype was a static image with the exception of a zoom out/zoom in control when the user searched for one of the neighborhoods mentioned above. For instance, if the user searched for "Mount Vernon", the search result page would show a map of the Mount Vernon neighborhood and any associated fountains; this image had a zoom out button that, when clicked, showed the fountain map for the entire city.

Finally, when adding a fountain to *Thirsty Runner*, the prototype allowed the user to click on a map of Canton Dog Park to drop a pin. Upon clicking the save button on the Add a Fountain page, the prototype then loaded a new Fountain Details page specific to Canton Dog Park, maintaining the user's entries for fountain name and description. My test protocol contained several questions about the user's understanding of the process of adding a fountain. I included the interaction of generating a new Fountain Details page with the hope that users would provide more valuable feedback when the process was fully simulated.

Facilitated Usability Test Results

Key Findings

Overall, the seven guided usability tests were very successful. Feedback was generally positive. For instance, at the conclusion of the test, P1 remarked that *Thirsty Runner* was "exactly what I'm looking for." P3 stated that it was "cute, casual and friendly … [and it] makes me want to use it." However, results from the evaluations showed that I could continue to refine *Thirsty Runner* to address runner needs and expectations.

Route builder functionality. Perhaps the most critical finding was that the water fountain search functionality only partially addressed users' mental model. Upon arriving at the search results page, users such as P6, stated that a large street map is what they expected. However, they expected *Thirsty Runner* to go even further and provide functionality for building a running route directly on the map. Several users expressed confusion when they were searching for a method to enter a start and/or end point for the

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hypothetical run. They also wished to click on the map (some actually did click on the map) and add waypoints. P2 said that he expected to see "MapMyRun, with water fountains."

This finding demonstrates that the high-fidelity design did not allow users to accomplish the task of planning a route completely. While the Bradley persona is focused on the planning and preparation aspects of running, users that fit into Claire persona shared the need to draw a route directly on the map as well. Six of the seven usability test participants either tried to click on the map and create a run or expressed the desire to do so. Only P1 indicated that he would not expect to be able to plan a specific running route using *Thirsty Runner.*

Volunteered geographic information improvements. As mentioned in Chapter 3, the second task for participants in the guided usability tests was to add a drinking fountain to *Thirsty Runner*. One of the probing questions that I asked was, "What would you expect to happen if you tried to add a fountain that already exists?". Five of the seven participants (P1, P2, P3, P5, P6) stated that if they were adding a fountain that was already in the application, they would have expected that fountain to be displayed in the embedded map on the Add a Fountain page. By doing so, this could prevent any errors in the VGI. Upon arriving at the Add a Fountain page, all users other than P6 immediately focused on the map and clicked to drop a pin. While P6 completed the form first, he also quickly understood how to add a fountain by dropping a pin. When P3 arrived at this page, she said, "I really like 'click to drop a pin'." This demonstrates that this method of identifying a location on a map is very familiar to users.

I observed confusion and concern from users on entering data describing a fountain. The form for adding water fountains had two text entry fields (name and description), three yes/no radio button groups, and an optional button to upload a picture. Of these inputs, the text fields caused the greatest hesitation. Testers P2 and P4 skipped entering a name entirely. Users P3 and P7 were uncomfortable with the idea of adding a name. For instance, P7 asked, "Am I allowed to name it whatever I want?" For fountain description, P2 said he would not fill it out unless there was something unique about this fountain; P3 said she has "no idea" what to enter in the description field.

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Users also hesitated when entering if the fountain was working or near a bathroom. The scenario for this task was that the user ran past a fountain on their 15-mile run to Patterson Park. Because the task did not have users stopping at the fountain, the runners did not know if the fountain was working or near a bathroom. P1, P2, P6, and P7 were uncertain on how to complete the form because they lacked necessary information. P1, P6, and P7 all said they would like an "I don't know" choice; P2 said he preferred that *Thirsty Runner* only allow yes and no because "you really shouldn't have people submitting fountains if they didn't test it out."

One of the biggest strengths observed from the usability tests was the participants' view of the site's trustworthiness. Users provided positive feedback on the aspects meant to convey trust and accuracy, including the ability to check-in, total check-ins, last date visited, fountain-specific comments, and site copy describing how it was maintained by runners. Overall, four of the seven participants provided feedback on how the site conveys trust and accuracy. P3 commented that knowing the application is maintained by runners "makes me confident it's accurate." P2 shared that it was helpful to see the total check-ins. These findings support the results of the individual interviews.

Street map improvements. As mentioned above, having a street map as the primary focus of the Fountain Map page met all of the user's expectations. While all users were able to navigate to the Fountain Details page from either the search results list or the info windows, four of the participants initially clicked on the map marker expecting to see more information. Users also seemed to miss the search results panel. Not only did P5 say she did not see the search results on the left side of the page, but once she did, she did not see the fountain's distance from her. Finally, three participants (P1, P2, and P6) wished to see an indication of their own location on the map.

Thought process of planning a running run. Results of the guided usability tests further demonstrate runners' appreciation for the importance of hydration and how it plays a role in planning long distance runs. Not only that, but runners all have very different strategies on how to incorporate water stops into their workouts. For instance, P2 started his run by going north where there was only one available fountain. His justification was that since he was just beginning, he would not need much to drink.

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When P4 runs long distances, he prefers to stop every two to three miles; therefore, his run was focused more in the downtown area because of the high concentration of water fountains. P7 started her run north towards Druid Hill Park and then also chose to run downtown, not because she wanted to stop often, but because of the many *opportunities* to stop. P5 decided to run two loops from Mount Vernon to Patterson park so that he could drink from the Patterson Park fountain both mid-run and at the end. Several users filtered the search results to only show the outdoor fountains. As a result, while the thought process of how one hydrated was different among users, access to water during a run was an important factor in planning.

One strength of the approach of the high-fidelity design was its flexibility for searching for water stops. Three users (P1, P2, and P7) all accessed the map by selecting "Fountain Map" in the primary navigation. Two participants began planning their run by searching near their starting point of Mount Vernon—one searched for Mount Vernon explicitly, another searched by a downtown ZIP code and wanted to use the map to pan and zoom towards Mount Vernon. Finally, P5 searched by her home address and P6 clicked a hyperlink to the Fountain Map page in the "What is Thirsty Runner?" section of the home page. This demonstrates that the site clearly conveys the flexibility and ease of locating water fountains.

Running technology. As mentioned in the individual interview findings (see page 41), those that I interviewed use technology to support their runs, but do not feel a strong affinity towards it. During the guided usability tests, I asked users how *Thirsty Runner* compared to other running websites and/or applications that they have used in the past. Results were mixed on if the site felt like a running application. Users P3 and P6 both said unequivocally, that yes, it did feel like a running site and they would not do anything to improve this feeling. P1 and P2 felt differently in that *Thirsty Runner* felt more like a map site. However, both participants said it was not an issue that it did not provide much of a running impression. P6 said for running webpages in general, "runners don't want it to shout it's a running site." He said that *Thirsty Runner* has a "comforting, modest" running feel. These comments from the users support the idea that running-specific technology is not a primary concern for users.

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Application to Final Design

As demonstrated in the findings above, the final design of *Thirsty Runner* should have capabilities to build a running route by clicking on a street map. This functionality would show the user's location, allow for a start and end point, and clearly display the distance to a fountain at any point while building the route. This additional feature is critical because despite different goals and priorities, test findings showed that the behavior of users in both personas was similar within the context of this application.

While the route builder capabilities would be utilized by both Bradley and Claire, I still wish to address their differences. The route builder functionality would supplement a section of the site where users could simply browse the list of fountains. This way, users that are less interested in planning could still find water fountains quickly. Aspects of the site such as the "Add to Favorites" functionality and creating a profile—while not required for site use—provide additional tools for those with character traits similar to Bradley.

On the Add a Fountain page, test results show that the final design should have an embedded map that is similar to the map used for locating drinking fountains. The embedded map used in the guided usability tests only had an address search and did not have the locations of existing fountains. Incorporating a full flexible search and the locations of existing fountains will aid in the process of collecting the water fountain VGI. Other improvements to the Add a Fountain page include making description an optional field and allowing users to enter "I don't know" when selecting if the fountain is working and near a bathroom. These "I don't know" statuses should then be reflected on the Fountain Map page.

To eliminate confusion regarding entering a fountain name, users should no longer be asked for this information. Mapping software such as Google Maps has the capability to preform reverse geocoding, or determining a street address from a latitude and longitude coordinate ("Reverse Geocoding," 2017). When the user drops a pin on the embedded map, the water fountain could then be named automatically based on the intersecting streets or nearby landmarks.

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On the Fountain Map page, the final design should reflect minor improvements to the street map, including adding a marker indicating the users' location, making the fountain marker clickable, and having only the outdoor water fountains be shown by default. The search results panel on the left side of the page should be emphasized more, without detracting too much focus from the map itself. Not only that, but the distance from the user's location to each a water fountain should be more prominent on the page. Several users showed difficulty in locating this information.

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Chapter 5: Final Design and Next Steps

Final Design

In summary, at the onset of this study, I wished to design an application to support long-distance runners' need to achieve proper hydration. Research shows the importance of maintaining a proper level of hydration on one's health and overall performance during exercise. I developed the design for this application—entitled *Thirsty Runner*—using processes within the user-centered design methodology. The final design for this application is a result of completing ten hour-long individual interviews, extensive iterative design of low-fidelity and high-fidelity wireframes, and seven guided usability tests. Integral to this process was the focus on potential users, their needs, goals, and priorities.

The final design approach to *Thirsty Runner* is an iteration of the high-fidelity design presented in Chapter 4. The revisions to that design included in the sections below are a result of observations and feedback from runners. The pages that did not change are the *Thirsty Runner* homepage, the About page, and My Profile page.

I did not make any changes to the homepage because I felt that it was successful in achieving site goals. All users were able to locate the Fountain Map page without any assistance; not only that, but many participants did so almost immediately. While several users commented that they would like to see more information on the homepage explaining the functions of the site and how to use the search, this uncertainty was not reflected in their behavior. For that reason, I felt that the homepage design (including the site navigation) did not warrant any major changes. One minor enhancement could be to have autocomplete capabilities when the user searches by landmark, address, neighborhood. By providing search assistance, this could help users further in identifying an area in which to search. I did not make any changes to the About or My Profile pages either. The primary reason for this is neither of these pages were included in the core tasks of the usability evaluations and I did not observe any behavioral feedback to justify changes. My changes to the Fountain Map, Add a Fountain, and Fountain Details pages are detailed below.

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Fountain Map and Building a Running Route

As mentioned previously, the final design of the Fountain Map page had to be refined to allow users to interact with the street map and build a running route. I included this functionality on the Fountain Map page to align the design of *Thirsty Runner* with runners' mental model. This route building functionality is very similar to what is available on MapMyRun. I reviewed the capabilities of MapMyRun on page 16 and adapted them for my application. My approach to incorporating the route builder functionality was to make it an addition to the Fountain Map page rather than its own page. Browsing the map of water stops and using the map to click along streets to create a running route are similar enough user tasks that I felt that they warranted being included on the same page. If they were located in separate sections of *Thirsty Runner*, I felt that users would have difficulty distinguishing the uses of each.

During testing, several users did not notice the search results panel. To address this, I changed the blue subheader that previously spanned both the map and search results so that it was shorter and only above the search results. In the high-fidelity wireframe, this subheader contained the search filter checkboxes. I added a floating panel in the top left corner of the map to accommodate these search filters and a new "Build a Route" button. When users select this button, the Fountain Map page would shift into the route building mode, the search results panel would collapse to the right, and the map would expand to fit the entire width of the page.

Next, users could click anywhere on the map to begin creating a running route. After the first click, an orange marker with an "S" would appear on the map. Clicking again would trace a line between the start marker and a new "E" marker. Each subsequent click would extend the tracing and move the end marker along the streets and pathways. In route building mode, at the top of the map, a new small panel would appear showing the total route distance, the nearest water fountain, and buttons to undo or redo route segments. When the user is finished building the route, they would click the "End Route" button.

To support the route builder functionality, I made a few additional changes to the Fountain Map page. For one, I added a marker indicating the user's current location.

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More than likely, this would often be the runner's starting point. In the info windows, I added a distance label that would show different values depending on the situation. When runners are simply browsing the map, this would be the distance from the user's current location. When in route building mode, this distance would change dynamically based on the the position of the "E" map marker. That changing distance would show the user how far away each fountain would be at any point while planning the run. Finally, I also removed the Directions button on each of the search results items. Since users were so vocal about using *Thirsty Runner* to build a route, I felt that getting directions was a lower priority and could be removed from this page. The designs for the Fountain Map page in browsing mode and route building mode are shown below.

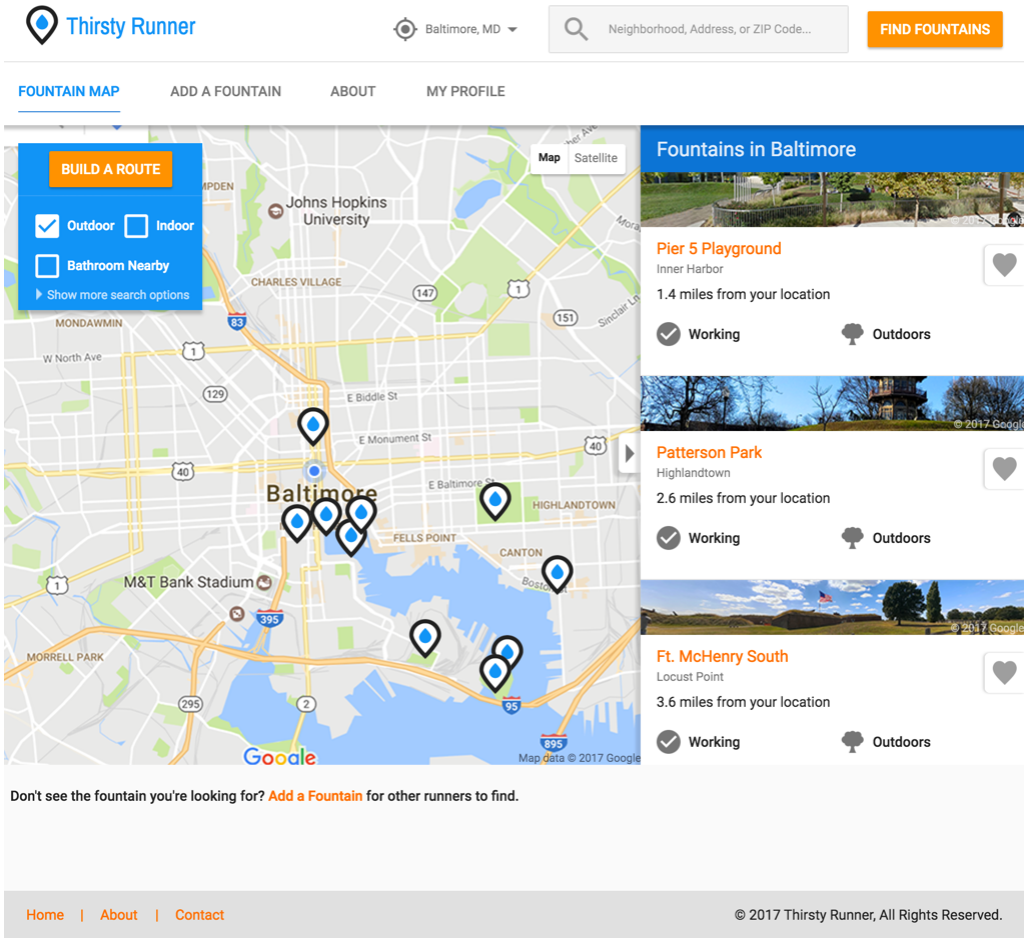

Figure 14: Final design for the Fountain Map page in browsing mode

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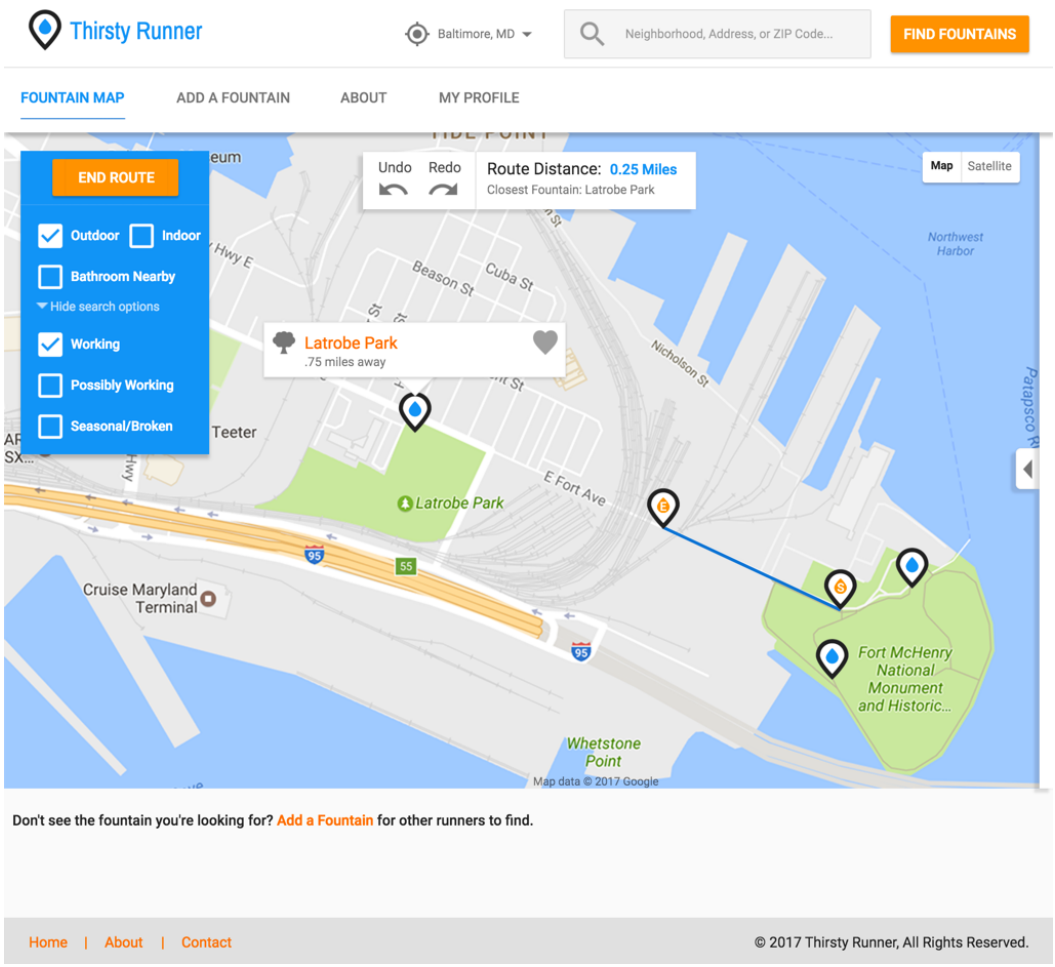

Figure 15: Final design for the Fountain Map page in route building mode

Add a Fountain Enhancements

I refined the design of the Add a Fountain page in order to address the hesitation users experienced when adding fountains. While letting users build a running route helps address gaps between *Thirsty Runner* and their mental model, this additional functionality is not required for users to sufficiently locate drinking fountains. The final design improvements to the Add a Fountain page were different from this in that without them, runners might not be able to add water stops confidently.

For one, I refined the design of the embedded map to be a more complete experience. On the Fountain Map page, users can search by a variety of terms and see all existing fountains relative to each other. I determined that these two capabilities should be available on the Add a Fountain page as well. By having a more robust search

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(previously this was only an address search), users could identify the location of a fountain quicker. In the interview findings section, I mentioned that users' context of use for *Thirsty Runner* was in a planning capacity; by extension, this means users would be physically located in their homes, workplace, or location different from the water fountain they wished to add. Because of this, users need the flexibility to search and navigate the map as they see fit. A less flexible map could be justified if users wished to add a fountain while on a run and near the fountain's location; but, this use case was shown to not be realistic in my interviews.

Accuracy of the water fountain VGI could be improved by also including all of the existing water stops on the embedded map on the Add a Fountain page. Questions arose if the user would be warned or notified if trying to add a water stop that already existed. This could be clarified by showing the user all of the water stops available in *Thirsty Runner* at the point of adding a new one. The intent for this improvement was for users to recognize that a fountain already exists by seeing it on the map when dropping the pin. This would not eliminate duplicate fountain entries but could curtail the majority of erroneous fountain uploads. To support this change, I changed the color of the user's dropped pin to have a gray center. This could help users distinguish their pin from the blue existing fountain markers.

Since I observed usability issues in completing the form, I made minor changes to the fields displayed on the Add a Fountain page. I made Description an optional field and removed the Fountain Name field. Rather than have users provide the fountain name, *Thirsty Runner* should use Google's reverse geocoding capabilities to name the fountain automatically. I also added a "Don't Know" answer for responding to if the fountain was working or was near a bathroom. This way if a runner sees a fountain while on a run but does not stop, he or she could still add it to the site.

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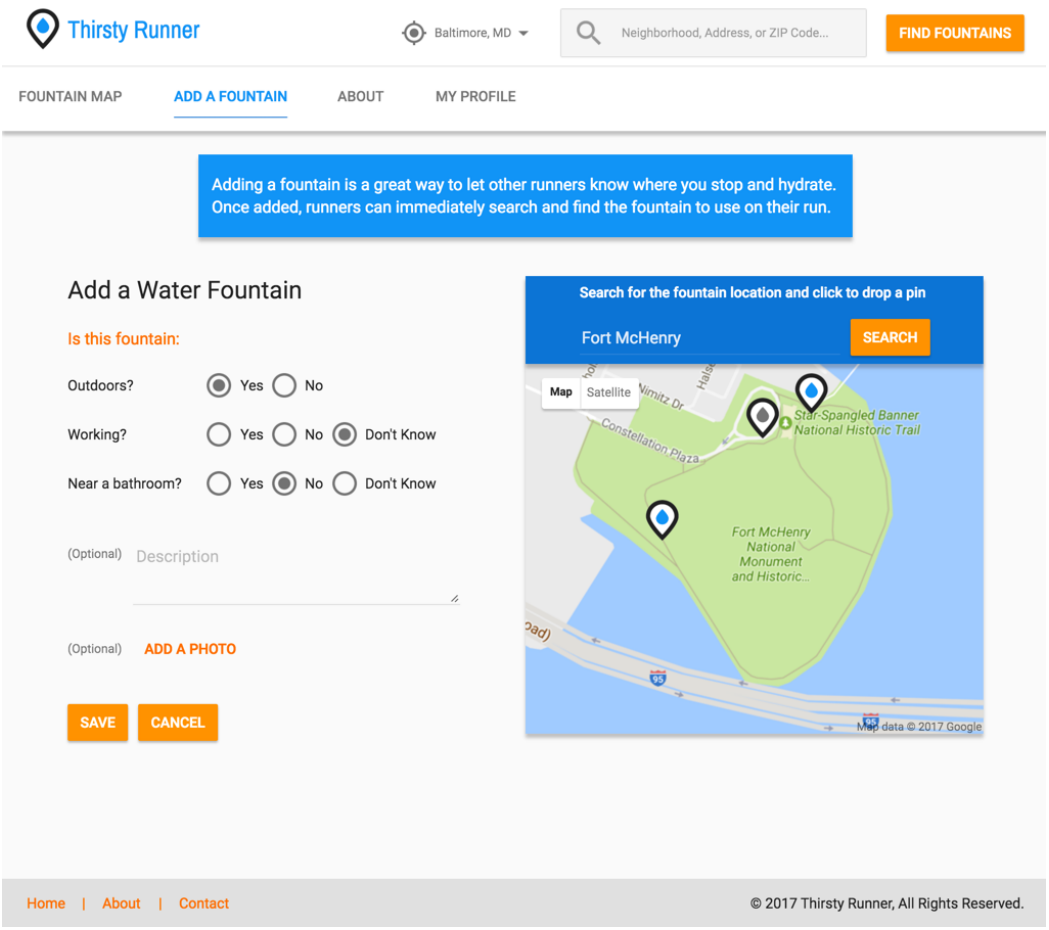

Figure 16: Final design for the Add a Fountain Page

Supporting Information for Finding Fountain Locations

I wanted to make refinements to my high-fidelity design that enabled runners to better understand where the water fountain was physically located. Runners will not be using the application while on the run, so the site needs to give runners the knowledge and confidence of being able to find the fountain while exercising. The majority of these improvements would be applied to the Fountain Details page.

In the usability evaluations, I received feedback and questions from users on making sure that the fountain is truly located where it is shown on the map. I improved the Fountain Details page to give users additional means of exploring where the fountains are found. This included the ability to switch from a street map a satellite view. Having the satellite view is beneficial for fountains located in parks or those not found on street corners. For these types of fountains, the street map provides limited value because it

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hides the details of running trails, grassy fields, and open city areas. The ability to toggle between street map and satellite view would also be available on the Fountain Map and Add a Fountain pages.

I also refined the Fountain Details page to place a greater focus on photographs. In the high-fidelity prototype, when users upload a picture it is displayed at the top of each Fountain Details page, above the Fountain's name. In the final version, I kept the picture at the top of the page, but it would instead be pulled from Google street view and be used for aesthetic purposes. In testing, several users either looked for a picture and did not see one in the page header, or did not make the connection that this header picture was intended to show the fountain's location. I created a section on the Fountain Details page devoted to fountain photographs. Uploading a photograph would still be optional, but if a picture existed, the Fountain Details page would display it prominently.

The Fountain Details page would also have to be updated to accommodate the aforementioned "Don't Know" answers. In my final design, when users do not know if the fountain is working, that fountain should have a "Possibly Working" status. I did not want these fountains to automatically default to either working or not working because that could introduce inaccurate data to the application. Fountains that are possibly working may have a different meaning to users and be treated differently when planning a run. For instance, fountains with this status might be included in a run as a backup option or if the runner wishes to have an option to stop earlier than necessary.

When users do not know if a bathroom is nearby, *Thirsty Runner* would simply show that it is not near a bathroom. The reason for this is even though I wish to display bathroom information, the primary focus of the site is hydration. Rather than add complexity with "unverified" or "possibly near a bathroom", I felt that not displaying anything at all would not detract from the user's experience.

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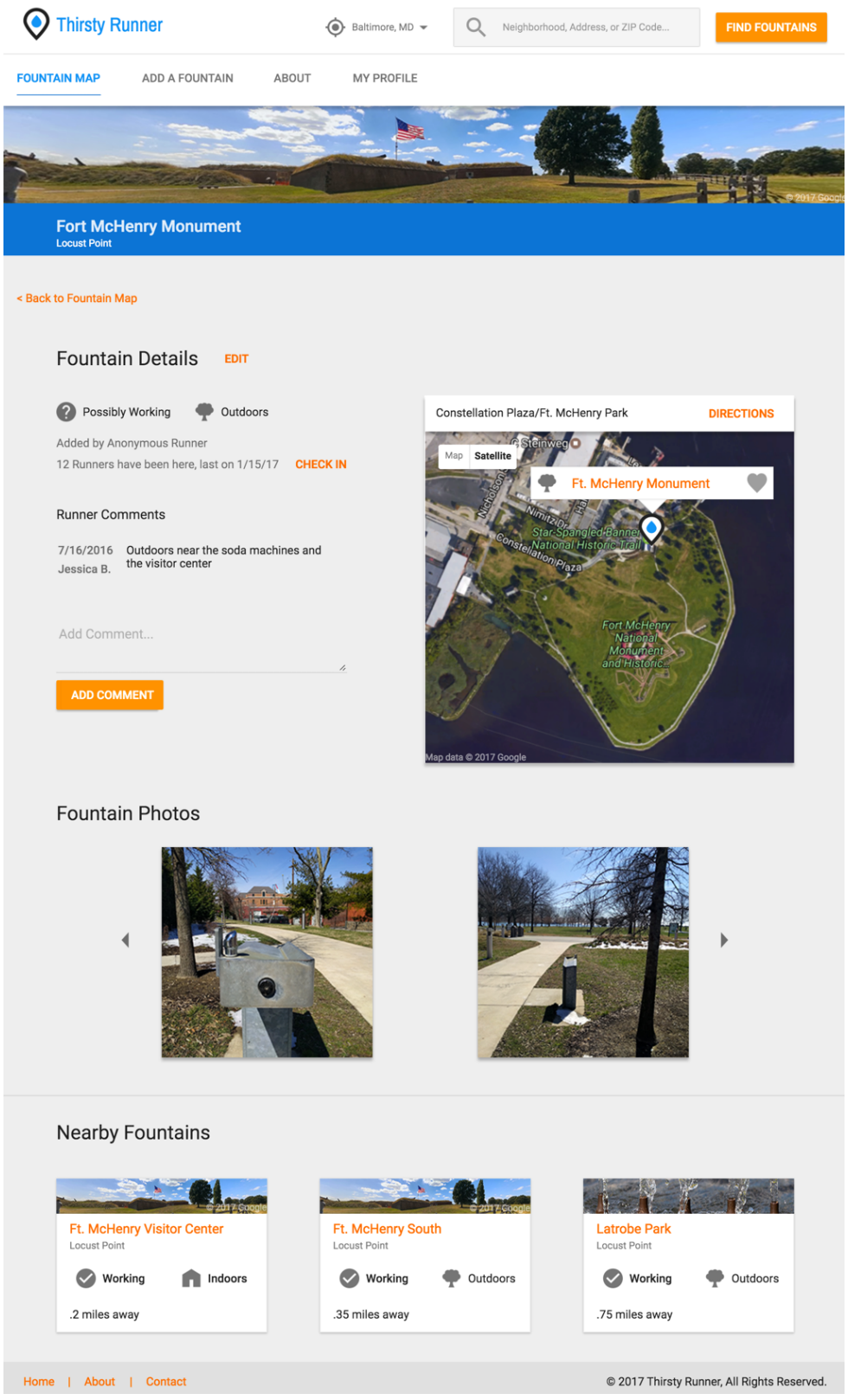

Figure 17: Final design for the Fountain Details page

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Further Research and Next Steps

Going forward, success of my final design is contingent on additional feedback from users. Above all, I would like to conduct additional usability evaluations to understand how runners use the route building functionality on the Fountain Map page. While I used the results from my guided usability tests and inspiration from MapMyRun for this additional feature, I cannot be confident this design is free from usability issues without verifying it with the user community.

In addition, I would like to test user comprehension and behavior when using *Thirsty Runner* with fountains that have a "Possibly Working" status. I could also expand the test to a wider pool of participants and test a version with a "Possibly Working" status and a version without a "Don't Know" option but has language dissuading users from adding fountains that they did not visit. The results of this two-part test could then confirm if permitting users to add unverified fountains is the correct design approach.

Independent of user-centered research, I would like to continue research on the capabilities of reverse geocoding. This technology is integral to my final design as it drives the naming convention for all submitted fountains. Should this functionality be incapable of providing descriptive and/or specific enough fountain names, I would need to change the approach for how the fountains are named. Instead, I potentially could have users enter a fountain name as in the high-fidelity design, but provide additional guidelines and help text to preemptively address users' issues.

From a design perspective, the next step for the user interface of *Thirsty Runner* is to apply the design to a mobile form factor. With the proliferation of smartphones and users accessing the internet from devices other than a computer, it stands to reason that *Thirsty Runner* should be adapted to handheld devices. The final design for this application does not consider a mobile form factor because of the planning nature of its use. While I feel that most runners would access this application using their computer, that does not mean that mobile devices should be ignored entirely. Offering access to *Thirsty Runner* using one's phone or tablet would give runners additional flexibility in locating water fountains.

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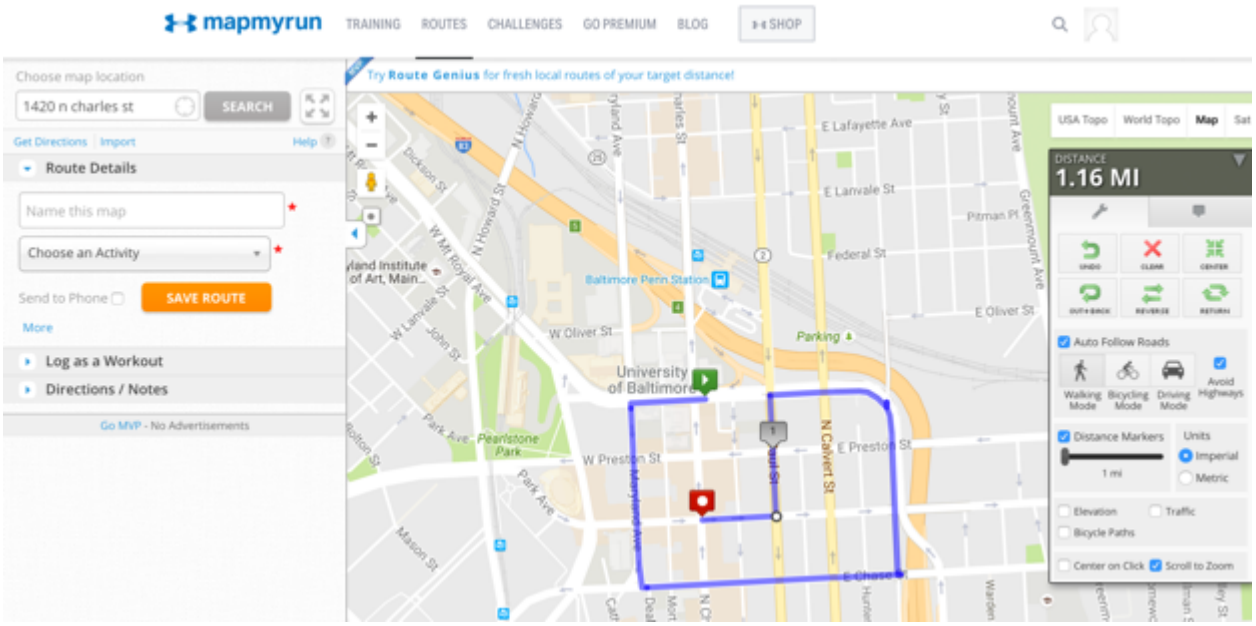
Appendix A: MapMyRun Web Interface



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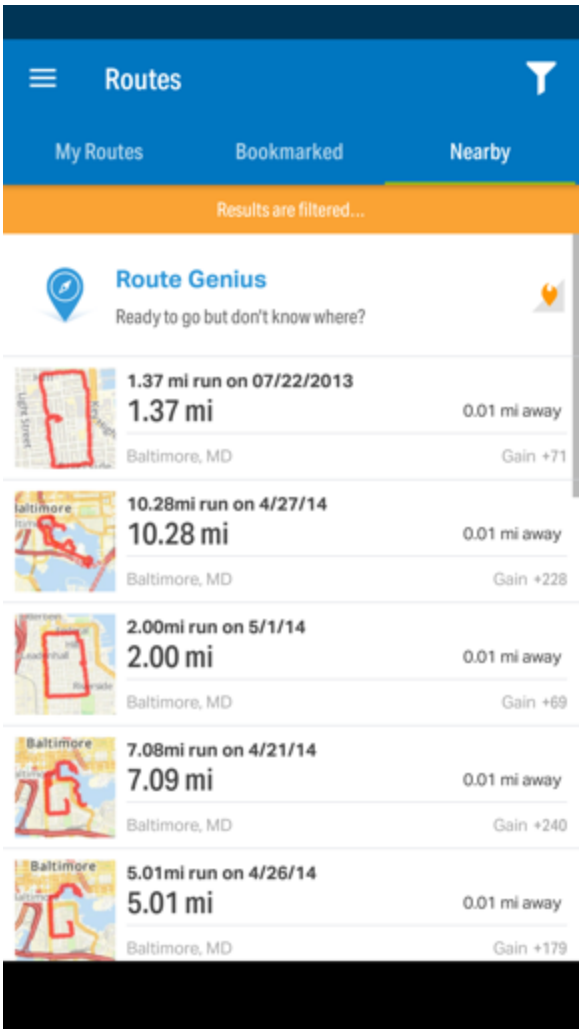
Appendix B: MapMyRun Android Application



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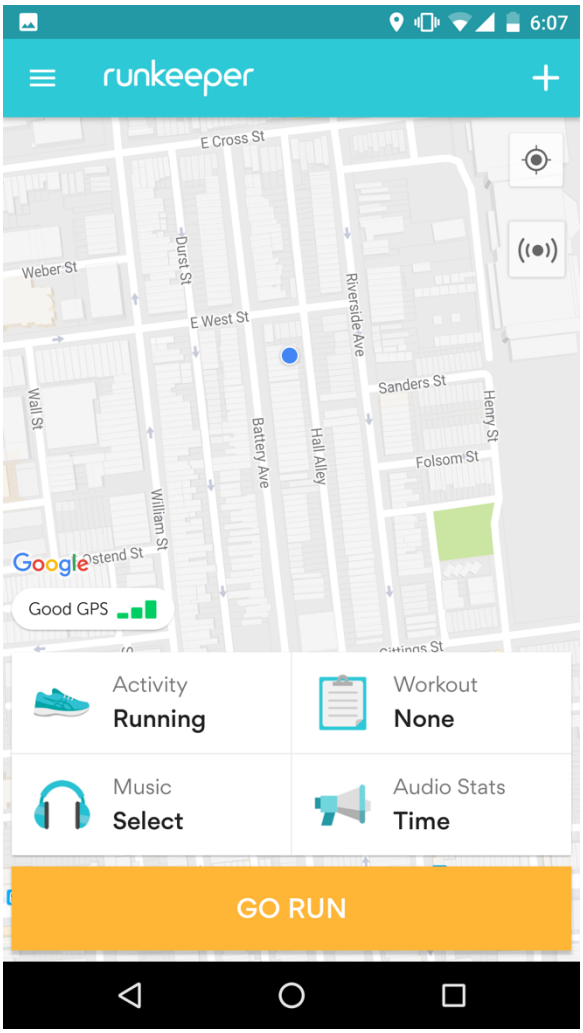
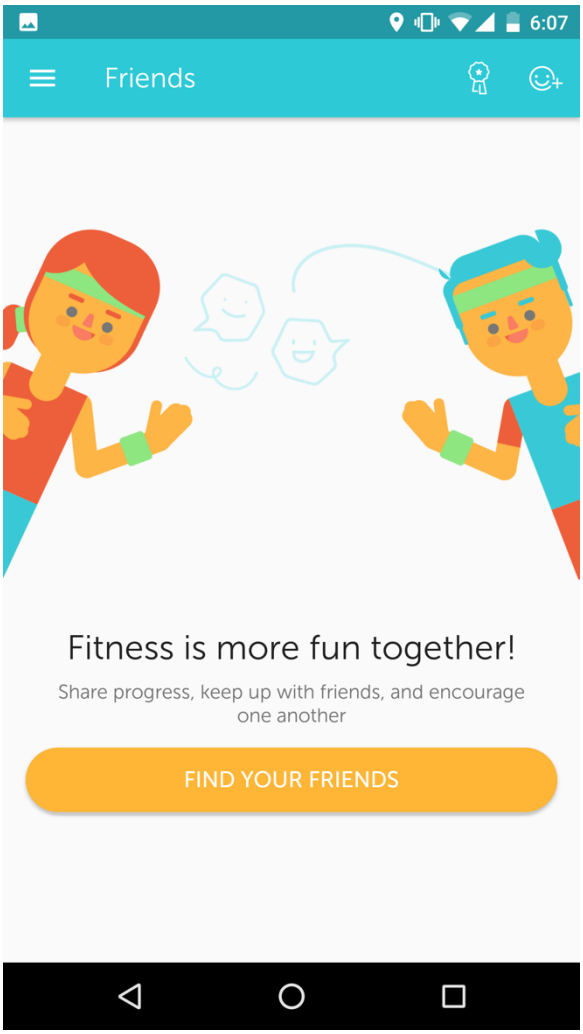
Appendix C: Runkeeper Android Application





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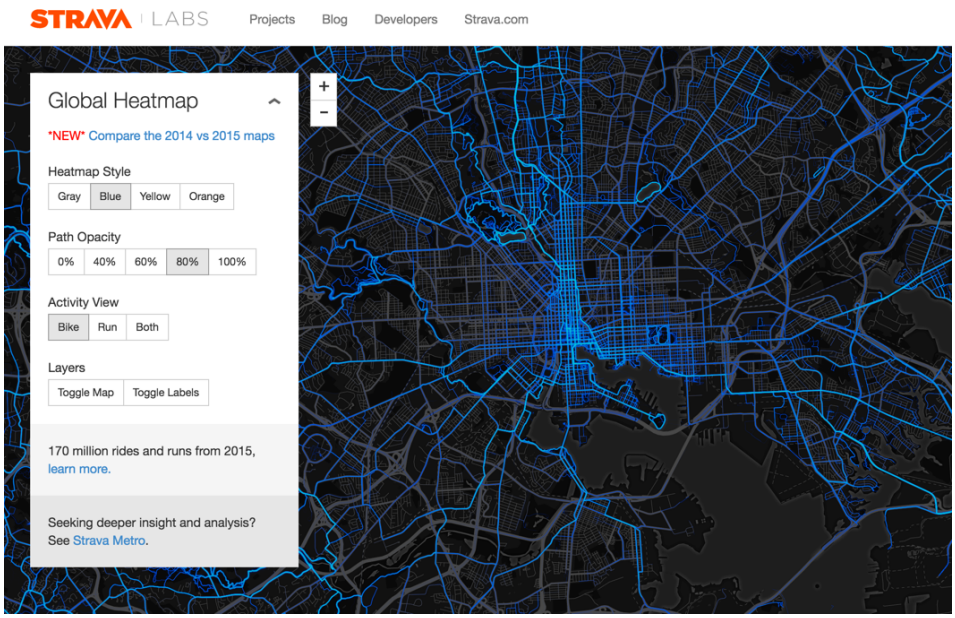
Appendix D: Strava Labs Heatmap



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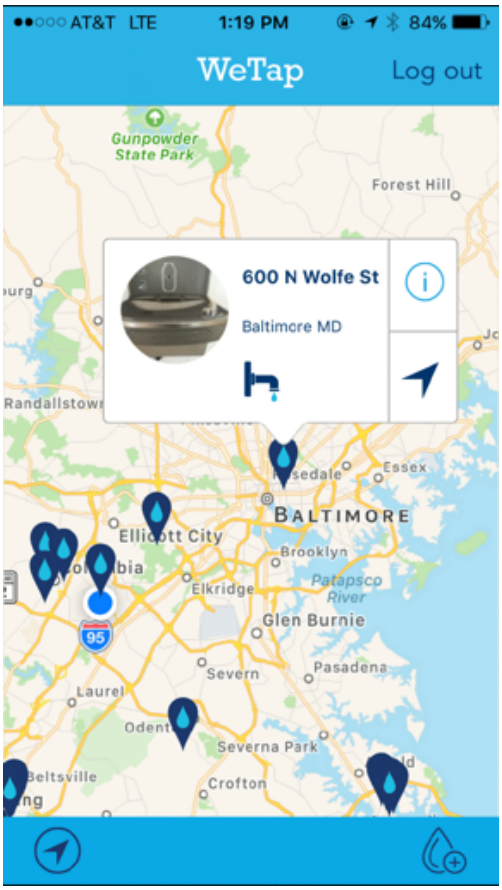
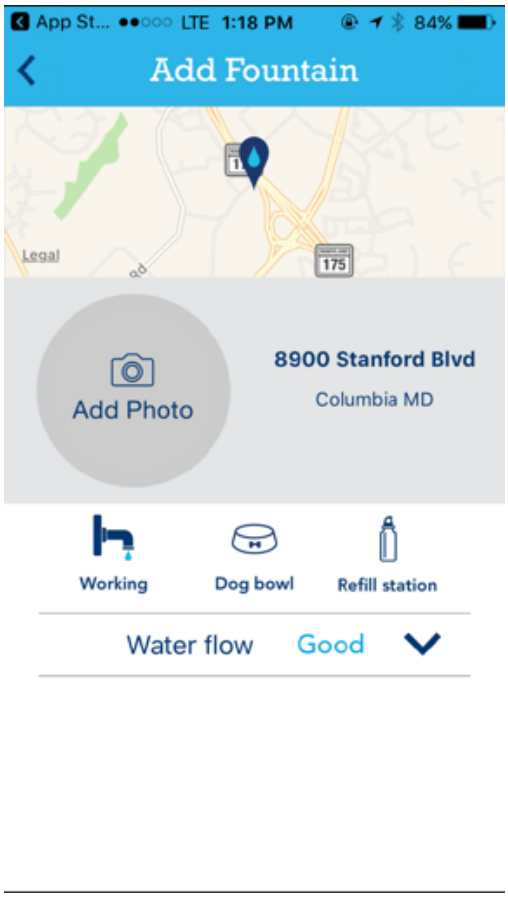
Appendix E: WeTap iPhone Application





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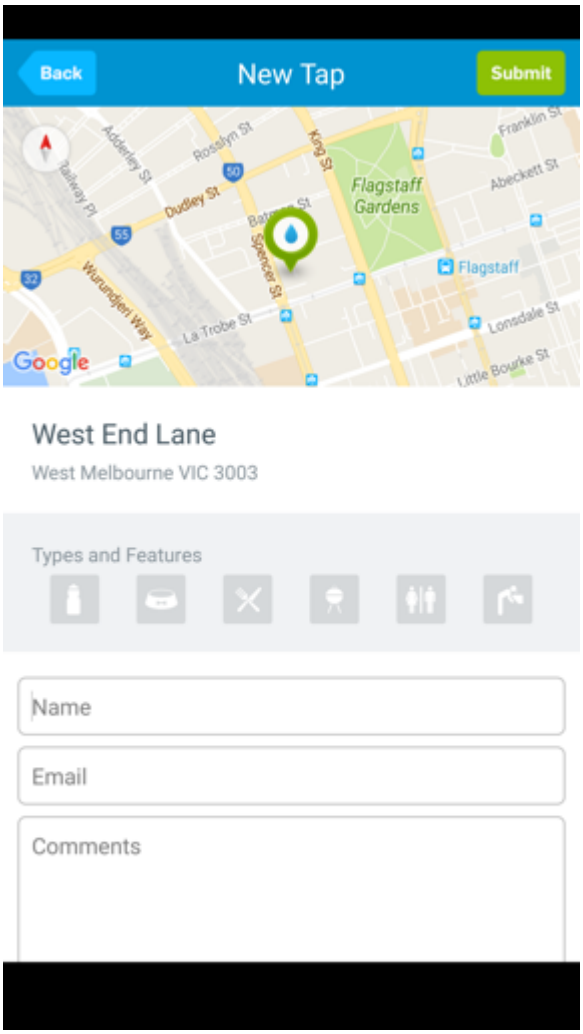
Appendix F: Choose Tap Android Application



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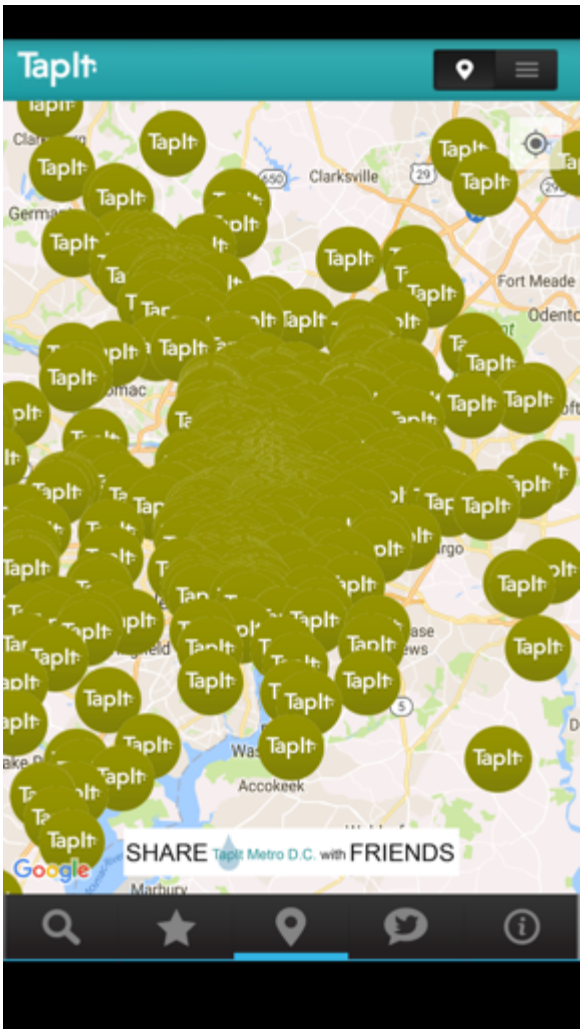
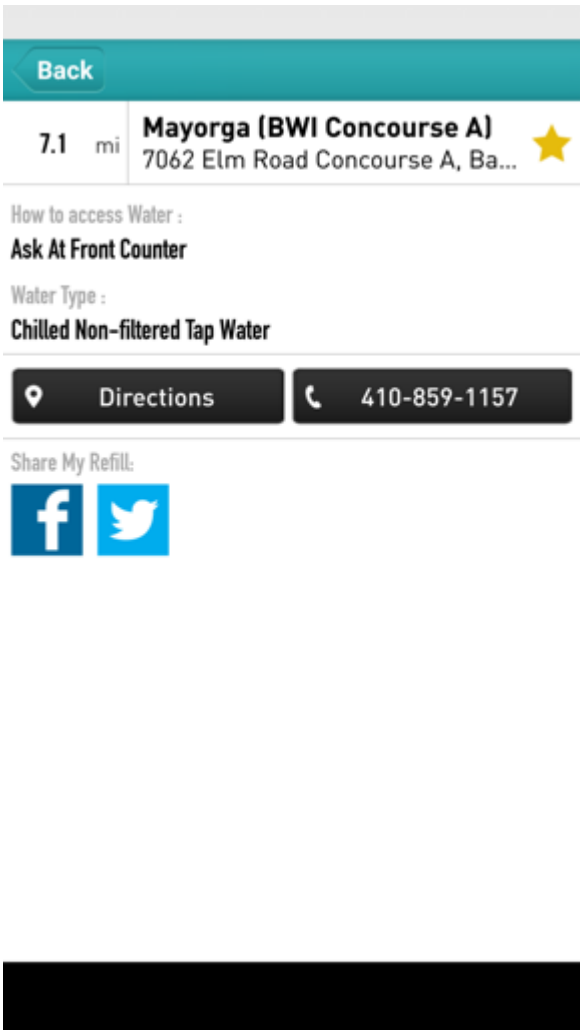
Appendix G: TapItDC Android Application





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Appendix H: Informed Consent Form

INFORMED CONSENT

What I'm Doing

I am looking to understand how users would interact with a website/app that allows users to find and/or add the locations of public drinking fountains. I am looking for honest feedback on how the system is designed and on how you would expect the system to behave. This is simply an information gathering activity and I am not evaluating you in any way.

How I'm Doing It

Each session will take approximately one hour and will be audio and video recorded. All recordings will be kept in a password protected computer and session notes will be kept in a locked cabinet. Prior to sharing responses and results with other individuals, all data will be anonymized with a participant number. I will remove any other information that could directly identify you from your responses. I will be the only person with access to information linking your responses to you.

What Happens to the Information I Collect

I am the only person who will view/listen to recordings or any other information collected as part of the evaluation that can be directly linked to you. I use the recordings primarily to document the information you provide regarding the drinking fountain website/app.

Risks

There are no known risks associated with this evaluation.

You Can Withdraw at Any Time

You can withdraw from the evaluation at any time for any reason. In addition, at the conclusion of the evaluation, you may see the information I have collected. If you decide to withdraw from this study, please notify me immediately. Otherwise, I might not be able to identify your information because of my efforts to ensure anonymity.

Voluntary Consent

By signing this form, you are saying that you have read this form. You are also saying that you understand the form and understand what I am asking you to do. In addition, you are agreeing to audio and video recording of the session.

By signing below, you are stating that you agree to participate in this evaluation. I can provide you with a copy of this form upon request.

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Questions/Concerns

If at any time you have additional questions or concerns following this evaluation, feel free to contact me, Andrew White, via email (Andrew.White@ubalt.edu) or phone (410-245-0970). Alternatively, you may contact the University of Baltimore Institutional Review Board at IRB@ubalt.edu or 410-837-6191.

SIGNATURE: _____

NAME: _____

DATE: _____

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Appendix I: Individual Interview Protocol

USER INTERVIEW SCRIPT

Introduction

Hi, my name is Andrew and today I'm designing a website for a project for the University of Baltimore. Today I will be asking you some questions about how you would use a website to find or add the locations of public drinking fountains along your running route. After, I will show you some rough sketches of a proposed design to get your initial impressions.
Thank you for volunteering to help me on this project.

Set User Expectations

- All information that you provide to me will be strictly confidential and kept anonymously. Nothing you say will be linked directly to you and I am the only one with access to your responses.
- I will be taking some hand written notes and may be recording your responses using an audio or video recorder. As I mentioned, any recordings will only be accessed by me.
- This interview is voluntary. You are welcome to stop at any time.
- Please read and sign this consent form acknowledging that you understand what we will be doing. Do you have any questions before we begin?

Interview Questions

1. I would describe "technology" as any website or app or any devices (including your smartphone, GPS watches, and any other smart bands/watches). How would you describe your use of technology and running?

2. When do you use technology with running – before, during, and/or after?

3. What are some of the typical things you do right before you start a run?

4. What type of planning goes into your running? Do you use any fitness apps, websites, or wearable devices to do this?

5. What information, if any, do you need while you are in the middle of a run? For instance, are you monitoring any data (ex. pace) while running?

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6. When you are in the middle of a run, do you use any fitness apps, websites, or wearable devices?

7. What are some of the typical things you do right after you finish your run?

8. Do you recap your runs (ex. journaling) after you are done? Do you use any fitness apps, websites, or wearable devices to do this?

9. If you were to use an app to find drinking fountains, when would you use it most? Before, during, after, or not at all?

10. If you were to use an app to add drinking fountains to the public list, when would you use it most? Before, during, after, or not at all?

11. Please describe your hydration routine when running, including before the run, during the run, and after.

12. Can you describe to me how you would use a website/mobile app to find a nearby public drinking fountain?

13. When would you use this application? Before a run? During a run? After a run?

14. What methods would you prefer to access and use this application?

15. How would you envision finding a drinking fountain using the app?

16. What types of information would you expect a site/app like this to show you about each water fountain?

17. How would you know that the locations of the fountains shown on the app are legitimate?

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18. What information would you need to see so that you'd know that the fountain listed is really there or is working?

19. Would you use an app/website to add fountains that you knew about?

20. How would you envision using an app/website to add fountains?

Sketch Review Questions

21. Take a look at the following sketches, let me know your initial impressions.

22. What information is not shown here that you would expect to see?

23. What information is shown here do you think is unnecessary?

24. What do you see as the most important information about each water fountain?

25. How would you improve the way you would use this site to find a water fountain?

26. How would you improve the way the water fountains are displayed?

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Appendix J: Guided Usability Test Protocol

USABILITY TEST SCRIPT – Thirsty Runner

Introduction

Hi, my name is Andrew and I am going to be walking you through today's session. Thank you for volunteering to help me on this project.

I am evaluating a website I designed for a project for the University of Baltimore. Today you will be looking at a number of screens of a website I'm calling "Thirsty Runner", which details the locations of public drinking fountains for runners.

I will be taking notes which I will then incorporate into refining my overall site design. I will also be recording your screen and voice. The recording, your name, and your comments will be kept confidential and will not be used by anyone other than me.

Set User Expectations

- This is a not a test of you or your skills and abilities. You are evaluating the application and helping me determine what works or does not work for you.
- I want to hear exactly what you think. I need to know is how easy or difficult you find these pages to use. Your honest feedback is the most important part of this evaluation.
- As we move through the tasks, I am going to ask you to think aloud, to tell me what is going through your mind. The most helpful thing you can do is tell me what you are doing as we go through these pages and WHY.
- This is a prototype, so not everything is going to work as it will in the final version of the software. If a link or something else does not work, I will ask you to tell me what you expect it would do.
- If you have questions, just ask. I may not be able to answer them until the end of our session. I will try to answer any questions you still have when we are finished.

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Scenario Background

Imagine it is Saturday morning in August and you just woke up in your Mount Vernon row home. Today is your long run day, part of your training for the Baltimore Marathon in early October. You want to get in about a 15-mile run. You also want the run to end in Patterson Park since you are meeting some friends there for a game of Ultimate Frisbee before going to Brunch.

Task 1: You log into the Thirsty Runner site and are presented with the screen that you see in front of you. Show me how you would use this site to plan your running route.

User access the Home Page

1. Let me know your initial impressions of this page. What do you think you can do here?

2. What would you do first?

3. For your long run, how would you use this site to find a water stop?

User accessed the map by:

☐ "Fountain Map" in the Navigation

☐ Searching Mount Vernon

☐ Searching Patterson Park

☐ Searching _____

User access the Fountain Search Page

4. Is this what you expected to see? What are your impressions?

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5. Which fountain(s) would you stop at? How did you make that decision?

6. Are there any drinking fountains that you would not stop at? Why?

7. What information about the drinking fountains stands out to you the most?

8. What information about a fountain did you expect to see that is not here? What information is unnecessary?

9. How would you improve this page, either the map and search options or the search results listing?

10. How would you find out any additional information about the drinking fountain?

User access the Fountain Info Page

11. Is this what you expected to see?

12. What information on this page would you expect to see on the map page?

13. Now that you have found a drinking fountain, what would you do next?

14. How would you improve the overall process of finding drinking fountains?

15. What did you like the most about the process?

16. Was there anything that you did not like or felt uncomfortable with?

Task 2: It is now Sunday morning on your rest day. On your way to Patterson Park during your run, you ran by Canton Dog Park and saw that there was a water fountain there. You may or may not have seen it when you were planning

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your run yesterday. You'd like to submit it to the website. Please show me how you would do this.

User access the Home Page

17. What would you do first?

User access the Add Fountain Page

18. Is this what you expected to see?

19. What do you think it means to add a water fountain? What do you expect to happen once you do it?

20. What information that you're asked to enter do you think is unnecessary?

21. How would you improve the process of adding a drinking fountain?

22. What did you like the most about the process?

23. Was there anything that you did not like or felt uncomfortable with?

24. How do you know that a water fountain has been added?

25. Now that a fountain has been added, what would you do next?

26. (If user does not try to search for the fountain) I noticed you didn't search for this fountain before you went to add it. Walk me through your thought process for this.

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27. What, if any, scenarios would you search for the fountain first?

28. What would you expect to happen if you tried to add a fountain that already exists?

Final Questions

29. How do you feel about the overall layout of the site?

30. How does this site compare to other running websites/apps you've used before?

31. How would you improve the feel of the site to make it more like other running sites?

32. Any other thoughts that you'd like to share?

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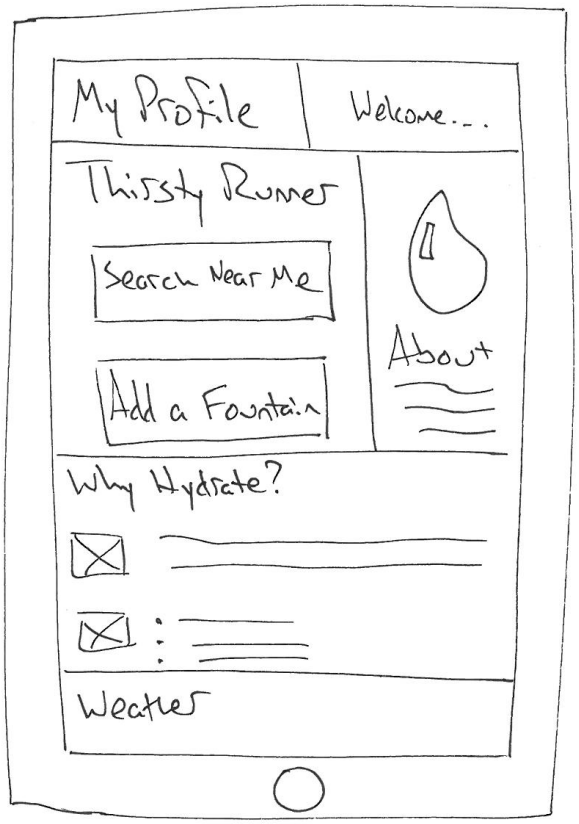
Appendix K: Initial Wireframes of *Thirsty Runner* for Mobile Form Factor



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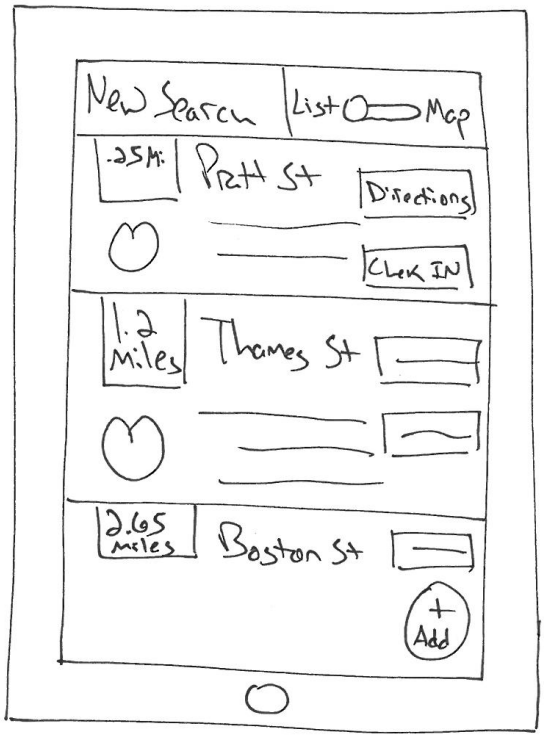

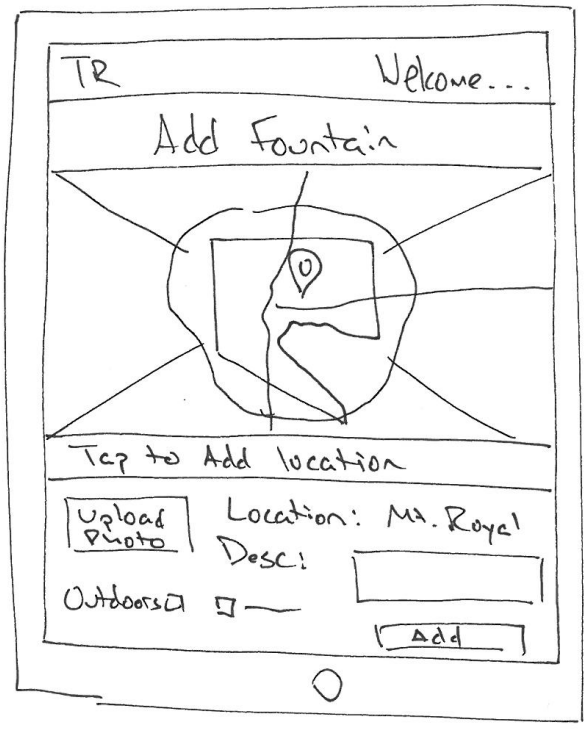

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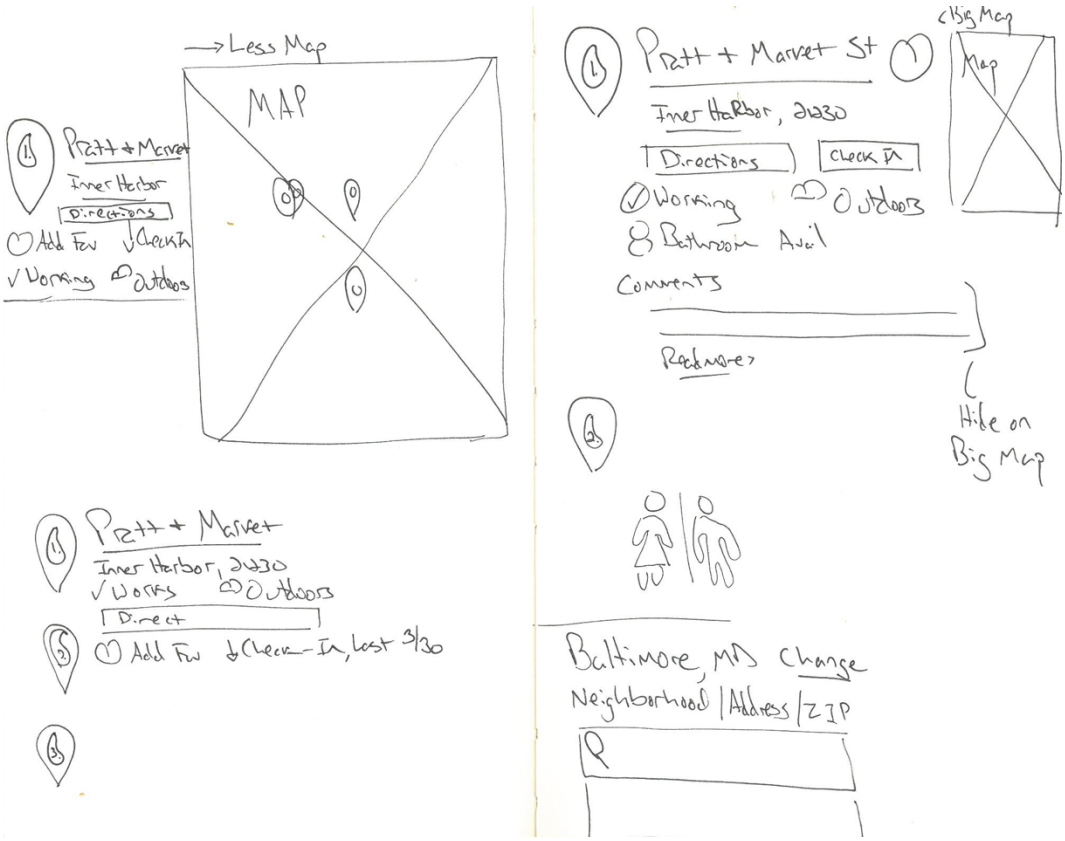
Appendix L: Low-fidelity Sketches of Search Results Page Components



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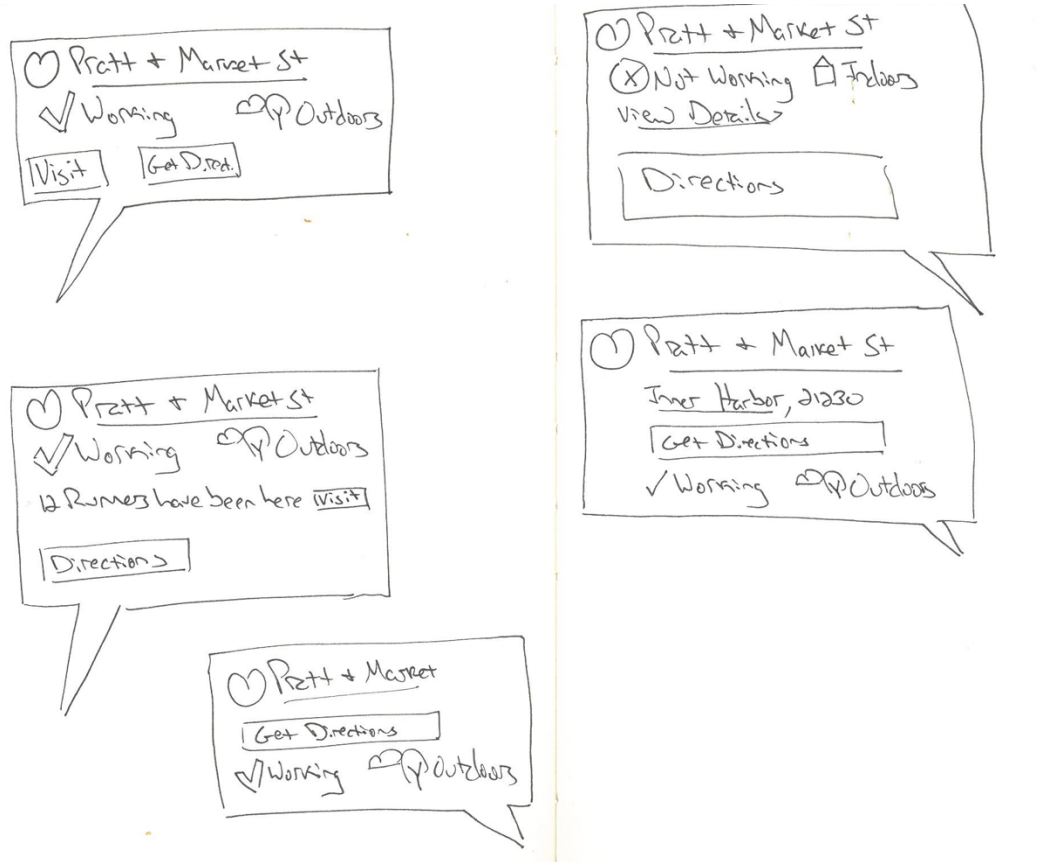

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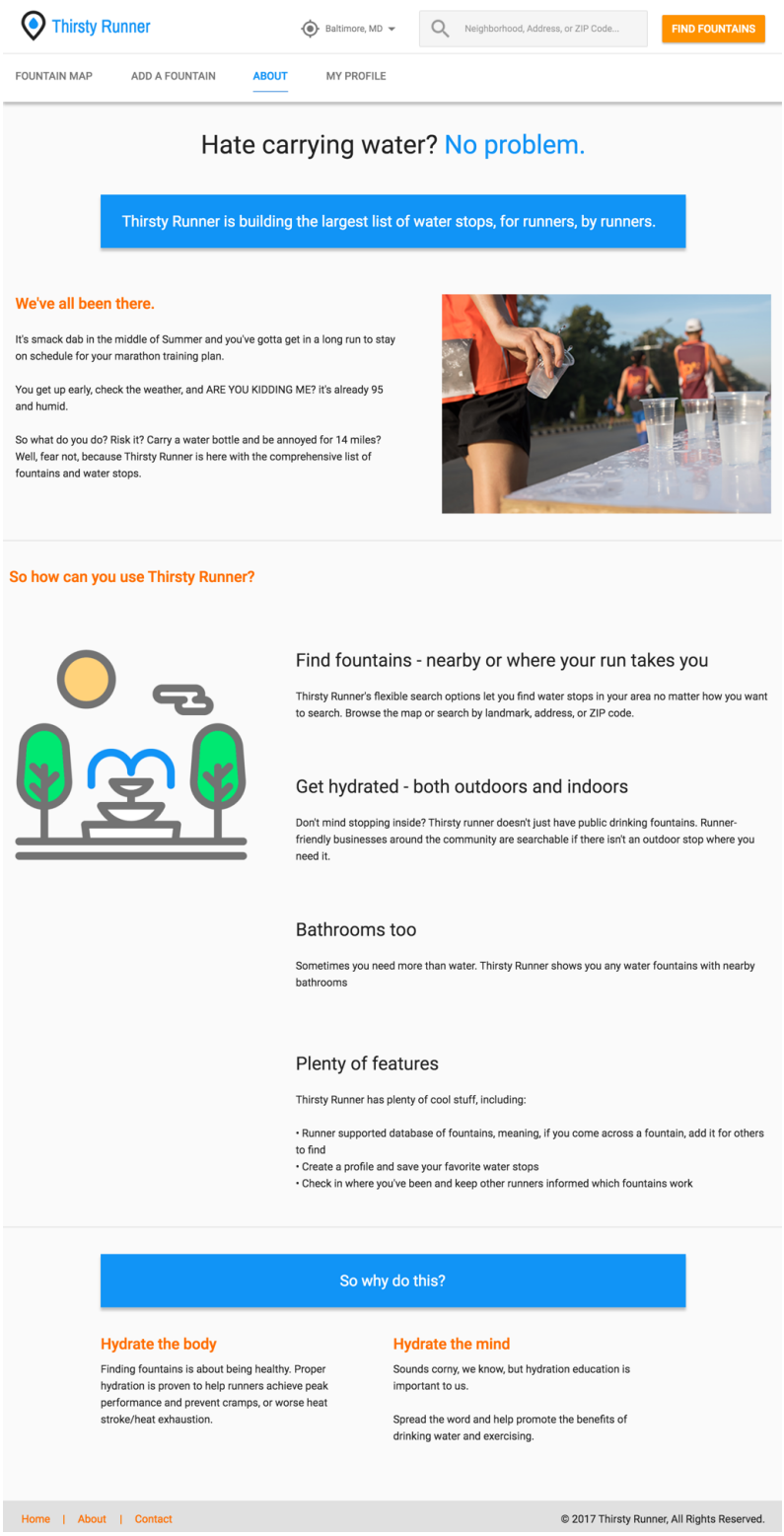
Appendix M: Additional High-fidelity Wireframes of *Thirsty Runner*



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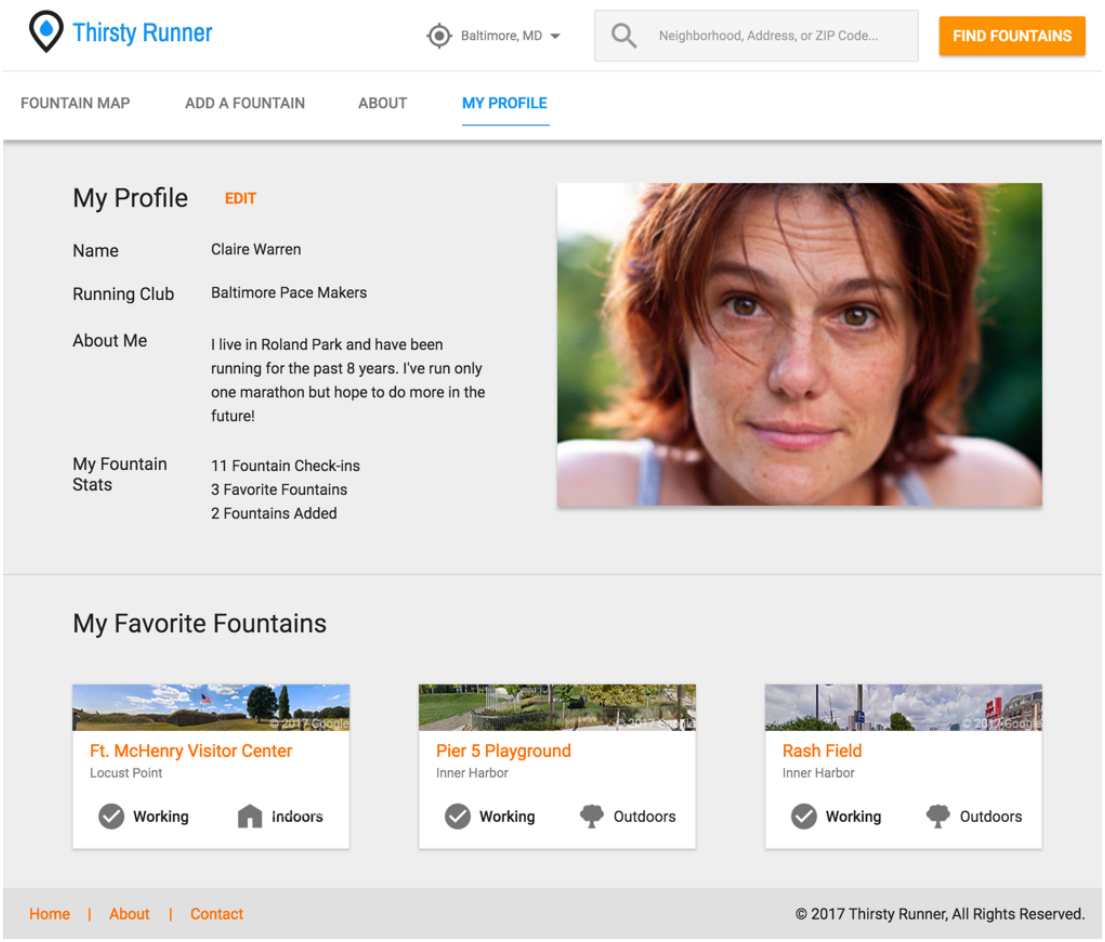

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