

# Lawn Wizards

## Complete sustainable lawn service

### Abstract

Statistics and research have shown that there are a tremendous amount of resources, especially water, being wasted in maintaining lawns. More and more people are concerned about wasting water while current technology, which can alleviate this problem, is not affordable or easily accessible. Our project is to find a way to combine available devices into a more effective and approachable lawn irrigation system, making it easier and more cost effective for customers, providing them with optimal performance and water conservation. Our project is not only environmentally and economically valuable but also filling the gap between technology and society, resulting in sustainable design.

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## Executive Summary

The EPA estimates that 50% of water used outdoors for residential lawn irrigation is wasted due to inefficient irrigation practices.<sup>1</sup> Suburban residents put a high priority on a lush green yard, without understanding the complexity of the system and simply overwater in order to solve any dry spots or other issues. Overwatering can cause runoff that not only then has to be treated by the town facilities, but can also end up in surrounding lakes and rivers with harmful toxins from fertilizer applied to these same lawns. These toxins have a large effect on the ecosystem of the water. Meanwhile, it is estimated that 5.3 billion people will suffer from water shortages by 2025.<sup>2</sup>

Depending on the region of the United States, homeowners use 30-60% of their household consumption of water outdoors<sup>1</sup>. In particular, there are large peaks in consumption during summer months when the irrigation needs of a lawn outpace the typical rainfall received. From our research, we determined that 20% of American households irrigate their lawn excessively<sup>3</sup>, however, the majority of wasted water is a result of automatic sprinkler systems that are not properly utilized. Automatic sprinkler systems waste water because they do not consider weather or lawn conditions and cause runoff and evaporation.

For the concept generation phase, we looked into the different ethnography studies conducted throughout the project term and multiple surveys we designed for our personas. Keeping in mind that customer needs are of higher importance than environmental sustainability, the requirements and specifications were created based on brainstorming sessions that were driven towards addressing the customer needs through several concepts that are environmentally superior when compared to the existing practices in lawn care. This came from our research in various lawn care practices and consulting with experts in lawn maintenance. The three main concepts that we generated were to provide complete lawn care and landscaping services, providing smart controls installation for existing sprinkler systems and to adopt the usage of grey water and rainwater storage systems for lawn maintenance.

From our concepts, we chose our alpha design to include three options for customers: complete lawn care, smart controller installation, and native plant landscaping. A customer could choose to hire us to do any or all of our lawn services. The complete lawn care consists of watering, mowing, and/or fertilizing customers' lawns; we would perform these tasks at the rate a healthy lawn needs, which is less than what most companies do, saving resources. Smart controllers regulate sprinkler systems; they only water lawns when necessary by taking soil moisture and weather forecast into account. The third option would replace some grass with native plants, which require no additional watering than rain because they have adapted to their native region; the customer would have less lawn to water after installing native plants. All three of these services would reduce water usage compared to current practices, resulting in a more sustainable design.

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<sup>1</sup> "EPA WaterSense." 2013. Web. EPA. <<http://www.epa.gov/watersense/>>.

<sup>2</sup> "The Intelligent Use of Water™ Infographic." 2011. Web. Rain Bird Corporation. <<http://www.rainbird.com/corporate/IUOW/infographic.htm>>.

<sup>3</sup> Mayer, Peter W., et al. Residential End Uses of Water. 99-41861 Vol. AWWA Research Foundation, 1999. Print.

## **1. Introduction**

The EPA estimates that 50% of water used outdoors for residential lawn irrigation is wasted due to inefficient irrigation practices.<sup>1</sup> Suburban residents place a high priority on a lush green yard, without understanding the complexity of the system and simply overwater in order to solve any issues with dry spots or sparse coverage. Overwatering can cause runoff that not only then has to be treated by the town facilities, but can also end up in surrounding lakes and rivers with harmful toxins from fertilizer applied to these same lawns. These toxins have a large effect on the eco-system of the water. At the same time, it is estimated that 5.3 billion people will suffer from water shortages by 2025.<sup>2</sup>

## **2. Product Functional Status**

### **2.1 Current State**

The current residential irrigation industry earns \$2.5 billion annually<sup>3</sup> and consumes three times more water for irrigation in the United States than corn<sup>4</sup>. The EPA estimates that residential outdoor water use consumes nearly 9 billion gallons of water per day<sup>1</sup>, mainly for landscape irrigation and eighty percent of the water consumed by an average home during the summer is for outdoor use<sup>5</sup>. Homes with automatically timed irrigation systems use about 50 percent more water outdoors than those without. A system can waste even more if it's programmed incorrectly, a sprinkler head is pointed in the wrong direction, or there is a leak.

### **2.2 Gold Standard for Lawn Care**

There are three lawn maintenance tasks needed to maintain a healthy lawn: watering, mowing, and fertilizing. Pest control is another, but it is less important to lawn health than the others. The EPA recommends watering deeply but not often. This equates to about one inch of water per watering, and you should only water when the grass begins to wilt from dryness, which is usually only once a week.<sup>6</sup> Turf grass is healthiest when kept around 2.5-3.5" tall, and only 1/3 of the height should be cut when mowed.<sup>6</sup> Most lawnmowers are set at a height that is too low for healthy grass, and it's best to leave the grass clippings to deliver nutrients back to the soil, instead of sending them to the landfill. Fertilizer should only be applied once per year to develop a healthy soil, which need nitrogen, phosphorus, and potassium<sup>6</sup>. Many people water more frequently, mow shorter, and fertilize more often than what a healthy lawn requires, so we believe there is a need here that we could fill, while reducing environmental impacts.

### **2.3 Behavior of Homeowners**

In American culture, the appearance of your lawn can be considered to be indicative of the personal values of a household<sup>7</sup>. This attitude is a social motivator and can influence people's preferences when it comes to a lawn. Traditional idealized lawns are a blanket of soft, green turf grass, and this belief is reflected in the 40 million acres, about 2%, of American land covered in turf lawns<sup>8</sup>. These homes can be divided into two categories with regards to watering habits, homeowners with an in-ground irrigation system (IGS) and those without (NIGS). According to a study done in three cities in Kansas, IGS homeowners water three times more frequently than NIGS homeowners.<sup>9</sup> Independently, the American Water Works Association estimates that IGS homeowners use 35% more water than those without.<sup>10</sup> The study done in Kansas also noted that IGS homeowners were more likely to water their lawns on a schedule, while NIGS homeowners were more likely to adjust the amount of water and the schedule of the watering based on how dry it looks. IGS homeowners were less likely to adjust the amount or schedule of the watering, which is attributed to the "set-it and forget it"

mentality that having an automatic system can encourage.<sup>9</sup> This mentality may contribute to the fact that households using automatic timers for sprinkler systems use 47% more water than in-ground systems that are controlled manually.<sup>10</sup>

Another interesting fact that studies have brought to light is that attitude towards water usage tend to be a poor indicator of water consumption behavior.<sup>11</sup> There is a large disconnect between what people perceive their water efficiency to be and the amount of water they waste. In a study done in 2010, almost every participant found conservation to be important even though many of the homes fell into the “wasteful” category of water usage.<sup>12</sup> The same effect was found for perceptions of knowledge such that majority of the homes in the “wasteful” category considered themselves to be knowledgeable about effective irrigation.<sup>12</sup> In 2007, BBC Research & Consulting of Denver Colorado conducted 36 in-home visits in order to understand how customers perceive and use water, to test the acceptance of personalized water conservation tips and to gather evidence on what effect this visit has. 89% of the participants reduced their water usage one year after the in-home visit.<sup>13</sup> Part of this in-home visit was the offering of a “smart” sprinkler system controller. At the time of the follow-up, four homes had installed the controller and they reduced water usage by an average of 29% compared to the average 18% reduction by the other houses that received an in-home visit.<sup>13</sup>

## **2.4 Technical Benchmarks**

There has been considerable research and development over the last 25 years to improve the quality of lawn irrigation as well as reduce water waste. These innovations have included numerous patents including: interactive irrigation control systems<sup>14</sup> (1979), sprinkler controllers which compute sprinkler cycles based on inputted data<sup>15</sup> (1987), advanced irrigation control and flow management systems<sup>16</sup> (1991), evapotranspiration forecasting irrigation control systems<sup>17</sup> (1997), irrigation accumulation controllers<sup>18</sup> (2001), and smart water timers<sup>19</sup> (2010). All of these innovations have been developed in industry and are available as current products<sup>20</sup>. Many irrigation installation companies already offer these product options to consumers<sup>21</sup> as installation options.

Advanced or “smart” irrigation systems allow users to reduce their water demand as compared to traditional timer and manual systems by utilizing weather, soil, and water penetration data to optimize the location and volume of water this is applied to the roots of the turf grass. These controllers use the principles of evapotranspiration weather forecasting as well as soil sensors to determine when lawns most need extra water and when they water can be withheld due to forecasted weather changes. A study by the Public Policy Institute of California found that when a sample group of 62 users installed these systems they were able to reduce their overall water consumption by 26%.<sup>22</sup>

## **3. Design Ethnography**

### **3.1 Data Collection Strategy**

Initially our team did not fully understand outdoor water usage, but we knew that we wanted to build a project around saving water used outside (not including agriculture). Some important questions for us were: How can we reduce outdoor water usage, while maintaining the same quality of grass and/or other plants? How can we make our product/service more appealing to customers than existing offerings? Where would we have the most impact on society by saving water?

We first needed to understand how to properly and efficiently manage having a thick green lawn and then understand the habits of people who take care of their lawn. We did this through research and interviews. Information through observation is limited because we did not have the opportunity to watch the daily practices of the user and no one on the team owns a lawn. Performing an organized observation in relation to lawn care would be a timely process that would not yield as much value as interviewing. From previous experience, our team members have observed water waste first hand when sidewalks are watered by automatic sprinkler systems. Our research was targeted at understanding the gold standard of eco-efficient lawn care. We took into consideration the entire system from underlying soil, to the type of turf grass to mowing practices and determined their relationship to water efficiency. To perform interviews we first had to figure out the potential users and stakeholders.

The users included homeowners, groundskeepers at golf courses, universities with turf, and any corporation that has a well-maintained lawn. The stakeholders are people who enjoy the lawn either aesthetically or through use and people who stand to make a profit on the lawn such as real estate agents or neighbors (if your neighborhood looks nice, the value of your property will go up). Also increasing water efficiency decreases runoff, reducing the amount of water needed to be treated and reducing toxins entering the nearby bodies of water. This makes the town responsible for water treatment a stakeholder and also the aquatic life in the surrounding rivers and lakes would be affected and those who fish or study the ecosystem are also stakeholders. Depending on the level of knowledge of the groundskeepers they could also be considered experts as their job is to maintain the lawn and with a lot of lawn, water is a large cost consideration incentivizing water efficiency. Another expert in the field would be sprinkler installation companies, botanists, nurseries, fertilizer/pesticide companies and landscapers. Because we were not sure what exactly our product or service was going to be at this point we did not identify any clients directly.

Through interviews we captured attitudes towards lawn care and the habits of those who actively took care of their turf. The interview with groundskeepers was intended to see what measures they took to optimize their efficiency if any and what their priorities are in order to determine if there was an opportunity to capture that market. With so many golf courses and universities nationwide with acres of turf grass, we thought that we might be able to have the largest impact improving their efficiency. With nature as their priority we assumed the caretakers of the Ann Arbor Arboretum would have efficient practices and would serve as a good source of information. From sprinkler companies we wanted to determine when and why people usually install systems, how many customers were concerned with water efficiency, whether the company zones the lawn for the customer or whether the customer is responsible for zoning, how much maintenance is involved, the average cost, and how many smart controllers are currently installed. Unfortunately we were not able to get in touch with any sprinkler companies, but developing an ongoing relationship with a sprinkler system installation company is a high priority. From homeowners we wanted to know why they chose to care for their turf and what their habits and beliefs were in regards to maintaining a healthy lawn. How many people were concerned with water efficiency, how much water do they use, how close is their lawn care practices to what the EPA recommends and how attached they were to their habits were targets of our interviews.

The strategy for interviewing homeowners varied based on the relationship between the interviewer and interviewee. Several team members interviewed family members and thus a

structured formal interview was not appropriate. The key information that we were looking to get from each interview was how they cared for their lawn.

### **3.2 Summary of Observations**

One of our first observations was that penetrating the market of golf courses and playing fields was not feasible. The largest priority is the playing field and that takes precedence over environmental concerns and water usage (see interview 2). We also concluded that penetrating the market for large-scale grounds keeping is not feasible. Groundskeepers of universities already use efficient practices with factors such as evapotranspiration rate to determine how much to water their lawn (see interview 1). Based off of interviews 3 and 4, we found that real estate agents do not play an active role in maintaining lawn care unless there is something quick and easy to change, such as removing shrubs (see interview 3).

One of our main conclusions for homeowners was that if someone has already spent the time and effort into creating a beautiful looking yard, they will be hesitant to change practices unless they can ensure that their lawn will stay beautiful (see interview 3, 7, and 10). Many people have their lawn zoned out and have already taken the time to determine how much water each zone needs (Interview 3, 7, and 8). There also seemed to be varying levels of priorities in lawn care. Some people wanted it green and perfect (see interviews 10 and 7). Some just wanted it functional, so their kids can play on it (see interview 11). Others had different priorities in terms of their yard such as gardens (see interview 12). One homeowner we interviewed who doesn't currently water their lawn would be willing to start if the product was efficient enough. However, most of those who do not currently water their lawn deemed outdoor water use as unnecessary and found other ways of maintaining a healthy lawn such as leaving the blades long or leaving the cut grass on the lawn to deliver nutrients (see interviews 11, 12 and 13). By using natural native species, leaving the blades long and leaving the cut grass on the lawn a homeowner can still have a nice looking lawn (see interview 12). In interview 13 the homeowner mentioned that she leaves her grass long because the grass roots are proportional to blades thus you had to leave the roots long in order to get deep nutrients to the grass. Although the correlation between the grass roots and the length of blades isn't true, it is true that longer grass leads to healthier grass.

For homeowners, their location had a large effect on their beliefs, priorities and habits regarding lawn care. For example, one homeowner we interviewed lives in a low-lying area where runoff ends up in a river just down the street and his concern far more than overwatering was the amount of harmful fertilizer his neighbors use (see interview 7). Others had neighborhood restrictions on when they could water their lawn or how nice their lawn had to look (see interview 8 and 10 respectively). Also some locations may meter outdoor water separately from indoor water that needs to be treated (see interview 9).

Many people already use control systems and employ an outside company come to turn on and off the system, which is called winterizing (see interviews 7 and 3). Often times the homeowner was responsible for adjusting the controls themselves (see interviews 10, 3, and 7), but one interviewee had an outside company control everything about her system and she had to mention which areas were being overwatered to have the company adjust the settings (see interview 8). Others managed to do everything by themselves including control, maintenance and winterizing (see interview 9).



## 4. Description of Design Personas

Mayor Hawthorne of Lincoln Park a small democratic suburb outside of Detroit is an environmental enthusiast, aged 55 years old. Many of the neighborhoods in his district have standards for how nice a yard looks. Every morning on his 5 o'clock run he sees the sprinkler system of almost every house in the neighborhood shoot water onto the grass, "gosh what a waste" he thinks to himself. But beauty is a priority around Lincoln Park, people take the appearance of their lawn very seriously and who is he to interfere? Impose a district wide ban on sprinkler systems! There would go his re-election. When Mayor Hawthorne saw the website for Lawn Wizards, he thought it would be a great way to ensure that his residents were at least using the water as efficiently as possible. He gets excited about encouraging district residents to give it a try, thinking wouldn't it be nice if I didn't have to dodge that puddle that builds up when 535 Abbey Road decides to water the sidewalk!

Andrew and Karen have been living in the same house in the historical area of Lexington Massachusetts for the past 30 years. Andrew is the Vice President of Prestige Worldwide, which is just one town over and makes \$250,000 annually. His neighborhood has standards on how his half acre of land must look, but Andrew holds himself to an even higher standard because there is not much greater in life than stepping off his back porch onto his beautiful soft green lawn. He has had the same irrigation system since he can remember and he hasn't changed the settings in at least 10 years because he hasn't had to, the lawn always looks flawless. The control system is from the early nineties and doesn't take into account any weather patterns, but Andrew doesn't think about that because he's making money and his lawn looks just perfect. Andrew hires workers to take care of his lawn as he prefers to spend his Sunday's doing something with his family as opposed to doing house chores. The sprinkler company winterizes the irrigation system and takes care of maintenance, an independent lawn company takes care of fertilizing and pesticides, and then Timmy, his neighbor, mows the lawn about once a week. 'I wish the water bill didn't jump \$200 dollars a month' he thinks to himself, especially since his wife, coupon-cutting Karen, has always thought that's just a ridiculous price to pay. As Karen has become increasingly environmentally conscious after watching *FLOW: For the Love of Water* on Netflix, the bickering over the water bill has gotten more frequent. Stop fighting about the water bill you two, Lawn Wizards is here to help you both get what you want!

Susan is a single homeowner from Ann Arbor, who has her own small business making jewelry from recycled material. Though she doesn't make much money, she does take great pride in the appearance of her lawn and puts in the time and money to fertilize, mow and water her lawn. Plus she often finds her three cats, Larry, Curley and Moe, sunbathing in the front yard on a nice summer day. The sprinkler system in the yard was there when she moved in five years ago. The system is on a time, but it doesn't have any "smart" capabilities or a rain sensor, so she has to control the system manually when she knows it is going to rain. Susan doesn't need to have turf grass, she just needs her lawn to look nice, and thus she is open to the idea of changing the landscape of her lawn by adding flowers and/or bushes.

## 5. Project Requirements and Specifications

### 5.1 Stakeholder Requirements

One of the things Andrew and Susan have in common is a need to have their yards looking beautiful. Whether the solution entails native plants, rainwater collection, or simply a smart controller, the appearance of their house is tied to a sense of pride and identity around the

neighborhood. That being said, any attractive solution cannot compromise the appearance or health of the lawn. Susan and Andrew understand that solutions may have a period of time for installation in which the lawn may be under construction, but they need this period to be minimized. The other thing they have in common is the desire to spend a little less time worrying about their lawn. While Susan doesn't mind fertilizing and mowing herself, she is not an avid gardener and doesn't derive much joy from the experience. Andrew already doesn't spend much time thinking about his lawn, but it does annoy him that he has to hire out three different companies to take care of his lawn.

In terms of cost, Andrew and Susan diverge a bit. While Andrew has some flexibility surrounding cost and payback period, Susan is a little more frugal in her spending, and may therefore be willing to invest in something with a one-time up-front cost, like a smart controller or rain garden. That said, she is far less likely to pay any monthly service fee. Andrew is open to service as he already pays for one, but the cost of the monthly fee is definitely a consideration for him. Andrew and Susan are both happy to save a couple bucks anytime on their water bill, and if that means a win for Earth, all the better.

Mayor Hawthorne is also a stakeholder as he will be a large supporter of our service. His primary concern was the amount of water that ended up hitting sidewalks and being run off. He not only wants to see a reduction in the amount of water that is being used for lawns, but he also wants to make sure as little of that water as possible ends up in the town treatment center.

With Mother Nature being a stakeholder, one of our primary considerations is the amount of chemicals in fertilizer and pesticides that are released via runoff. This can result from over-watering, misaligned sprinkler heads, and dramatic rainfall. To that end, the main goal of the project in terms of sustainability is reducing the amount of water used outdoors. Although we cannot change the average American's desire to keep an immaculate lawn, we can make sure this is attained using the least amount of water. According to a study done by National Geographic, 40% of renewable water basins are already depleted<sup>23</sup>. If this trend continues, the topic is likely to become one of great concern, but by implementing efficient watering practices, the amount of resources needed to preserve fresh water can be minimized.

The amount of chemicals that end up in surrounding bodies of water can also impact the biodiversity of the ecosystem. The nitrogen from the fertilizer is one of the primary issues. Greenhouse gas emissions from the gas engines of riding lawn mowers are also an environmental consideration. The only social concern we considered is the potentially adverse effects some fertilizer, pesticides and herbicides can have on not only human health, but also the wellbeing of birds, dogs, cats, squirrels and any other creatures that come in contact with the lawn.

## **5.2 Turning Requirements to Specifications**

In order to turn user requirements into engineering specifications, the team performed research, conducted interviews, and gathered information through a survey, which can be seen in Appendix 3. A priority across the board for our consumers is the appearance of the lawn. The appearance is associated with both the health and quality of the lawn, which we broke into two pieces: the density of the blades of grass and the greenness. Through experimental measurements, we determined the expected density of blades of grass for a healthy lawn is about 30 blades per square inch or more. Normalized Difference Vegetation Index (NDVI) is a measure of how healthy vegetation is determined from the visible (Red) and near infrared (NIR) light reflected by the vegetation given by the equation,  $NDVI = (NIR - Red)/(NIR + Red)$ . A

healthy tree has an NDVI of about 0.72<sup>24</sup>. The range of 0.3-0.8 was chosen as the target because it is the range of healthy canopy.<sup>24</sup>

The amount of time the consumer spends on their lawn was targeted to be a 10% reduction. We decided to use percent so the measure could apply to those who don't mind spending time on their lawn, such as Susan, and those who don't, such as Andrew. 10% was chosen based off Interview 17 in the appendix. Also the allowable installation time was determined to be 5 days based off Interview 17.

Based off interviews the payback period of the investment was also an important factor. Using question number 8 in the survey, we quantified the desired payback period to be one year. The majority of the respondents (7 out of 19) said that a payback period of 1 year was desirable while the remaining respondents said that a payback period over one year was acceptable. It should however be noted that there was not an option for a payback period of less than one year for the respondents to choose. An operating cost of 500 dollars a year was chosen based off an interview in which the homeowner pays 25 dollars per service for mowing the lawn and \$400 dollars for 6 months of fertilizing services (Interview 16, Appendix 1). As customers always would like to see the biggest reduction in their water bill possible, a reasonable number was determined through research. According to a study done by the BBC, 4 houses that installed smart controllers had a 29% reduction in their water bill compared to the average reduction of 18% for 36 houses<sup>13</sup>. Thus a reduction in the water bill of 20% was determined to be reasonable.

### 5.3 Relative Weight Allocation

The customer importance ratings were obtained on a scale of 1-5 from the survey, which were then converted into percentages and that is how the relative allocation was generated. The following matrix shows the relative weights allocation for each of the requirements based on the customer survey results (Appendix 3: Survey Results).

Table 1: Functional Requirement → Critical to Satisfaction Metrics → Customer Ranking Averages

Customer Requirement	Metric	Ranking Avg.	Allocation
Reduction in water bill	≥ 20%	2.5	10
Reduction in time spent by customer for lawn care	≥ 10%	4.32	17
Minimizing operating cost	≤ \$500/year	4.17	16
Quality of grass: blade density		4.33	17
Quality of grass: greenness	NVDI value (0.3-0.8)	4.33	17
Start-up (installation) time	< 5 days	2	8
Payback period	< 1 year	4.17	16
	<b>TOTAL</b>	<b>25.82</b>	<b>100</b>

## 6. Sustainability Evaluation

Our goal is to reduce water usage for lawn maintenance by providing smart technology at reduced costs to home-owners. To consider the environmental improvement that can be attained out of this project, we followed the four steps described in the guide from the Technical University of Denmark.<sup>25</sup>

## 6.1 Use Context Description

Our service creates the nexus between manufacturers of devices used for monitoring water irrigation system for turf maintenance, experts from the subject and the end users. The primary group of customers of this service are home owners, living in the suburbs, who are the caretakers of their own lawns. This is a service that can have a one-time installation or that can be leased for a specific period of time. Considering the different requirements for lawns based on application or environment, suburban homes will be the main target environment in which this service can be installed.

## 6.2 Environmental Impact

Although our project is aimed at providing the service of connecting manufacturers to homeowners, in following the life cycle, we also took into consideration, the life cycle of the product itself. This is just to give a complete picture of the system. The product lifecycle can be seen in Figure 1.

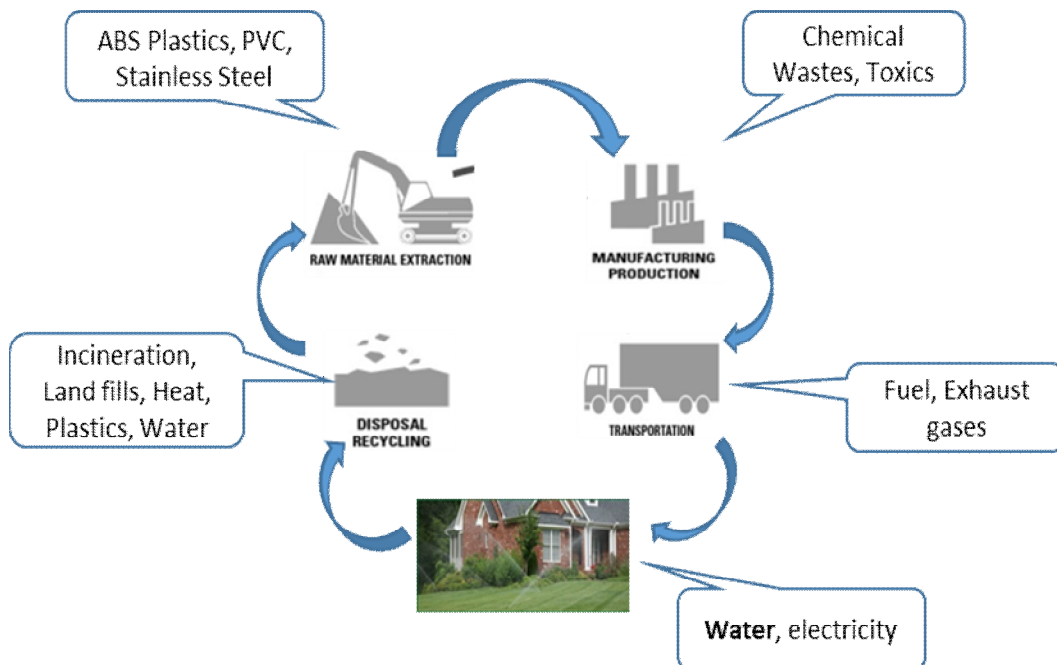






Figure 1: Life cycle of Smart Water system for Lawns

This figure shows the life cycle of the product, starting from raw material acquisition until the end-of-life. Among the impacts shown above at various stages of the product life, the scope of this project will be focused on reducing water consumption during the use-phase.

## 6.3 Environmental Profile/Root Causes

To understand the environmental profile of this product, we constructed the MECO matrix based on our observations and research. The various factors through the stages of the lifecycle that impact the environment are listed. Here again, the product itself has been included in the analysis.

Table 2: MECO Matrix for the Smart Water system

MECO	Raw Material	Manufacture	Transport/Packaging	Use	Disposal/Recycle
<b>Materials</b>	Plastics, Stainless Steel, PVC		Paper, Cardboard, Tape 	<b>Water **</b>	
<b>Energy</b>	Heat,	Heat, Electricity, Gas	Fuel, Electricity	Electricity	Heat, Compressed Air, Electricity
<b>Chemicals</b>	Natural Gas, Crude Oil	Toxins, Oil, Paint (Lead), Other Fluids	Paint (Lead)		
<b>Other</b>	 	Air emissions			Electronic Waste, Landfill, Incineration

The above MECO matrix shows the different root causes of the environmental impacts during the product life-cycle. This is constructed taking into consideration all the resources that contribute to the production, supply, use and disposal of the product.

As a company that serves as a consultant for lawn maintenance, we would not have much control over raw materials, manufacturing, or transportation, unless we selectively chose eco-friendly suppliers. The focus of our project is to reduce the water in the use-phase of the product life cycle, since that is where we would have the biggest influence. We would hire specialists to evaluate the land and help setup the system in the most efficient way. We would use smart technology (controllers and sensors) to eliminate wasteful lawn watering, so the lawn would only be watered when it really needs it.

### 6.4 Stakeholder network

In our system, the important stakeholders and the information flow can be summarized in Figure 2, below:

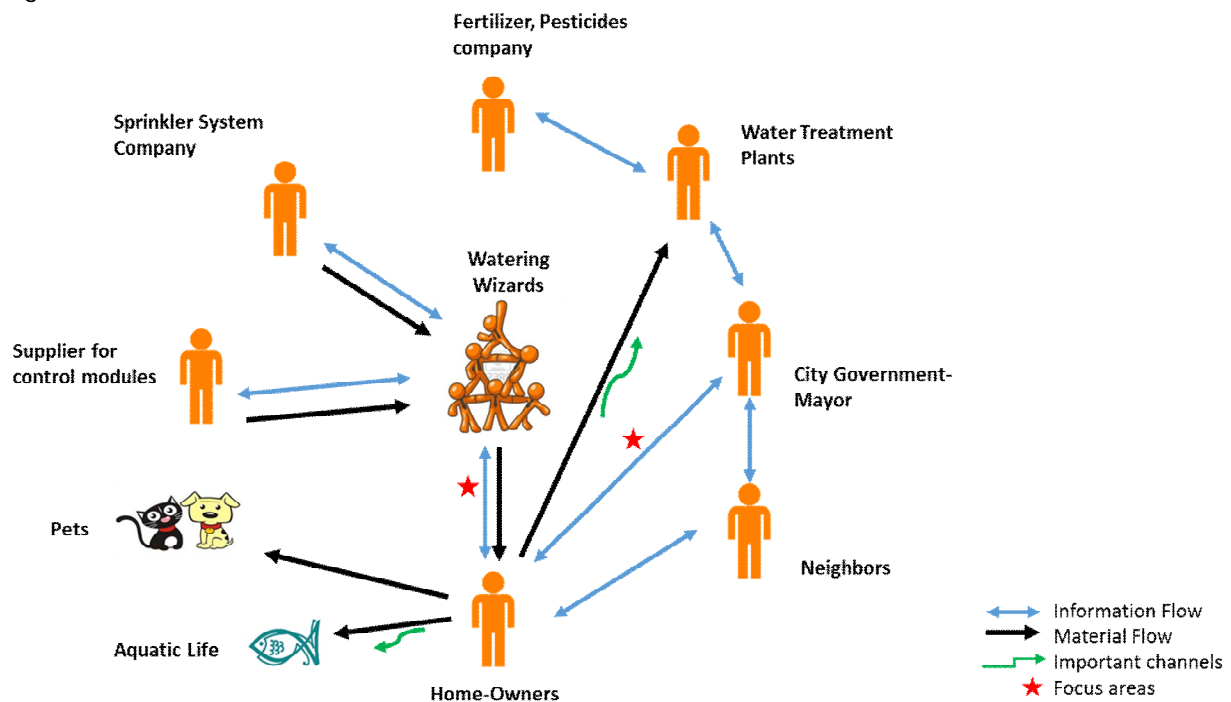


Figure 2: Stakeholder Network

This picture represents the Stakeholder network of this system of offering smart water technology for lawn maintenance. The home-owners are the end-users of this service and have to be willing to adopt this new system. To aid this process, the mayor of the area can play a major role. Since the water run-off caused due to over-watering the lawn contains the fertilizers/pesticides, this affects the waste water treatment plants followed by the aquatic life in rivers that the storm drains flow to. This could affect the overall investment that goes into treating the run-off water. Aquatic life also gets affected, as in the event of heavy storms, this excess water may reach the water bodies surrounding the area. Thus, involving city municipality stresses on the apparent need and thereby will lead to the successful implementation of this proposed system. Other stakeholders include the neighbors, who play a role in the overall evaluation of property. Over-fertilizing the soil leads to over-watering, thus fertilizer and pesticide companies are also important as the level of water in the soil determines the quantity of fertilizers it can hold. Upon communication with Watering Wizards, home owners will have access to expert assessment with support from the Sprinkler System companies, and will then be supplied with the required controller modules to implement this smart system.

### 7. Baseline Sustainability Assessment

Depending on the region of country, homeowners use 30-60% of their household consumption of water outdoors<sup>1</sup>. In particular, there are large peaks in consumption during summer months when the irrigation needs of a lawn outpace the typical rainfall received as shown below in Figure 3. While the seasonal effects are most vivid in northern states where the seasons are most extreme, these patterns can be observed across the United States.

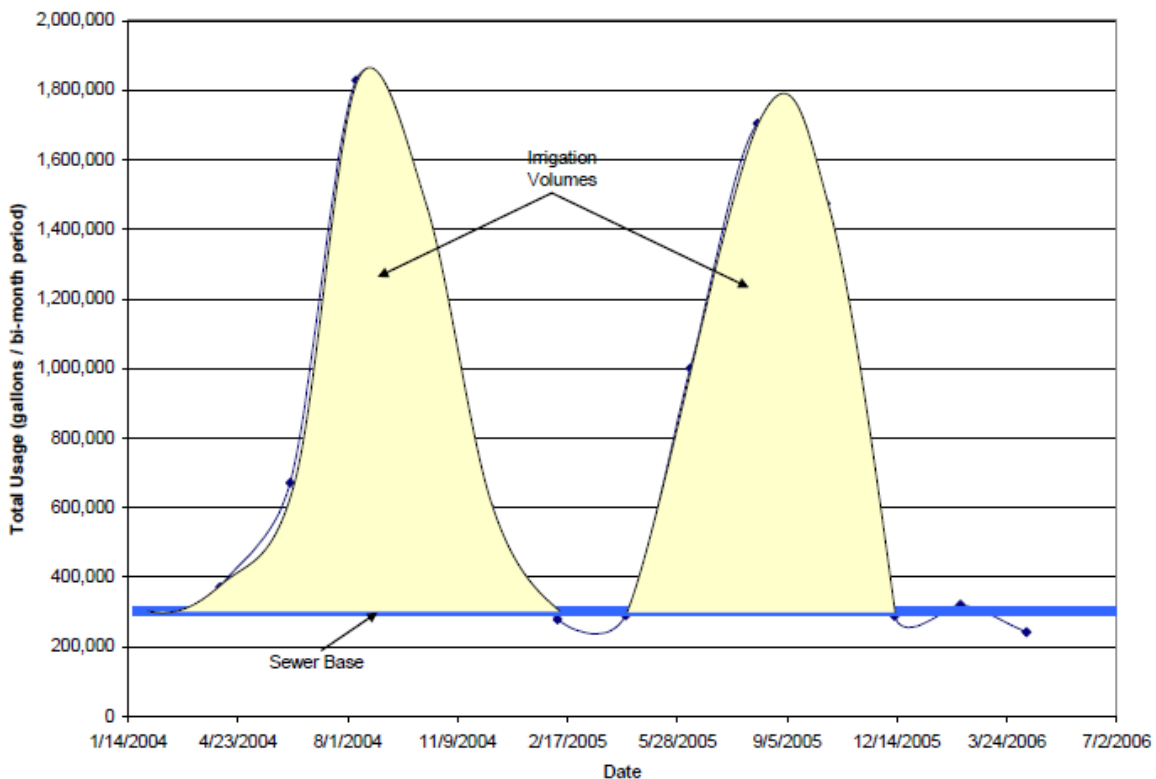


Figure 3: Typical residential water consumption pattern for a household in Lincoln, NE<sup>26</sup>

## 7.1 Irrigation requirements of a lawn (Net ET)

The amount of water irrigation required by a lawn (net ET) is expressed as the difference between the evapotranspiration (ET) rate of the lawn and the amount of rainfall during the same time period<sup>26</sup>. The ET rate of a given lawn is the amount of water that is lost by the lawn and is a function of the weather, maintenance practices, and the type of turf grass planted for the lawn. The excess volume of water applied to the lawn is the difference between the actual height of water irrigated and the net ET multiplied by the area of the lawn. Typical values for the actual height of water applied and the calculated height of water required for Central Florida are shown in Figure 4. Note that calculated values are not available for September 2004 due to hurricanes in the area.

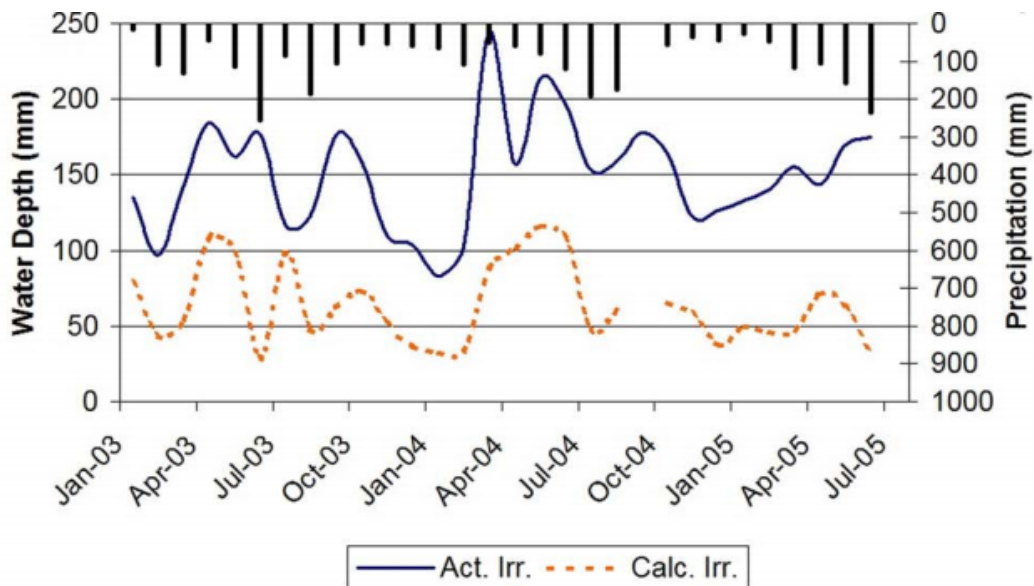


Figure 4: Actual irrigation compared to calculated irrigation in Central Florida with typical patterns where calculated irrigation is based on ET balance equations<sup>27</sup>

## 7.2 Residential outdoor water consumption

A study was performed by the American Water Resources Association (AWRA) in 1999 to determine the residential end uses of water<sup>28</sup>. This study involved surveying 14 diverse locations across the United States to determine the exact consumption of water by residential buildings. Table 3, found on the following page, shows a comparison of the average annual outdoor and indoor use of water for these locations.

Table 3: Annual indoor, outdoor, and total use for a variety of US locations<sup>28</sup>

Study site	Sample size	Outdoor Annual Use (kgal/home)	Indoor Annual Use (kgal/home)	Total Annual use (kgal/home)
Waterloo	37	7.8	67.7	75.5
Cambridge	58	7.8	71.2	79.0
Tampa	99	30.5	56.1	86.6
Lompoc	100	43.5	62.1	105.6
Seattle	99	21.7	54.1	75.8
Eugene	98	48.8	65.1	113.9
Denver	99	104.7	61.9	166.6
Walnut Valley WD	99	114.8	76.3	191.1
Boulder	100	73.6	54.4	128.0
Tempe	40	100.3	65.2	165.5
Las Virgenes MWD	100	213.2	70.9	284.1
Scottsdale	59	156.5	60.1	216.6
Phoenix	100	161.9	70.8	232.7
San Diego	100	99.3	55.3	154.6

For these 14 locations, the net ET was compared to the average irrigation application rate. From Figure 5, it is shown that the average residential household will irrigate their lawn at 55% of its net ET with a correlation of  $R^2 = 0.7624$ .

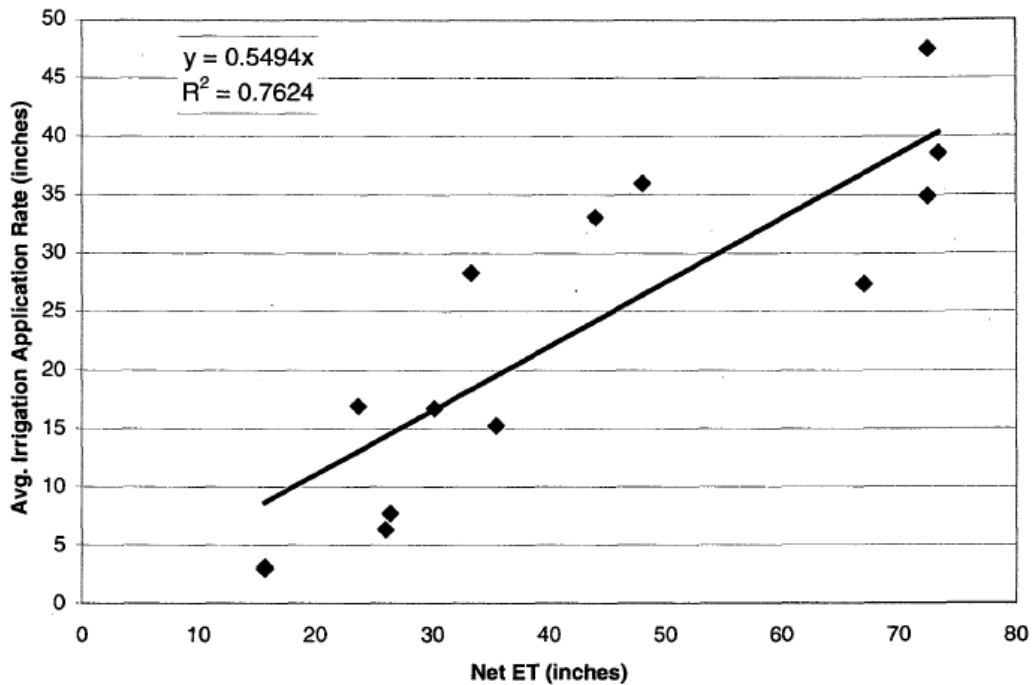


Figure 5: Irrigation application rate compared to net ET<sup>28</sup>



From Figure 6 below, it can be seen that 80% of households water their lawns at or below the net ET of that given lawn.

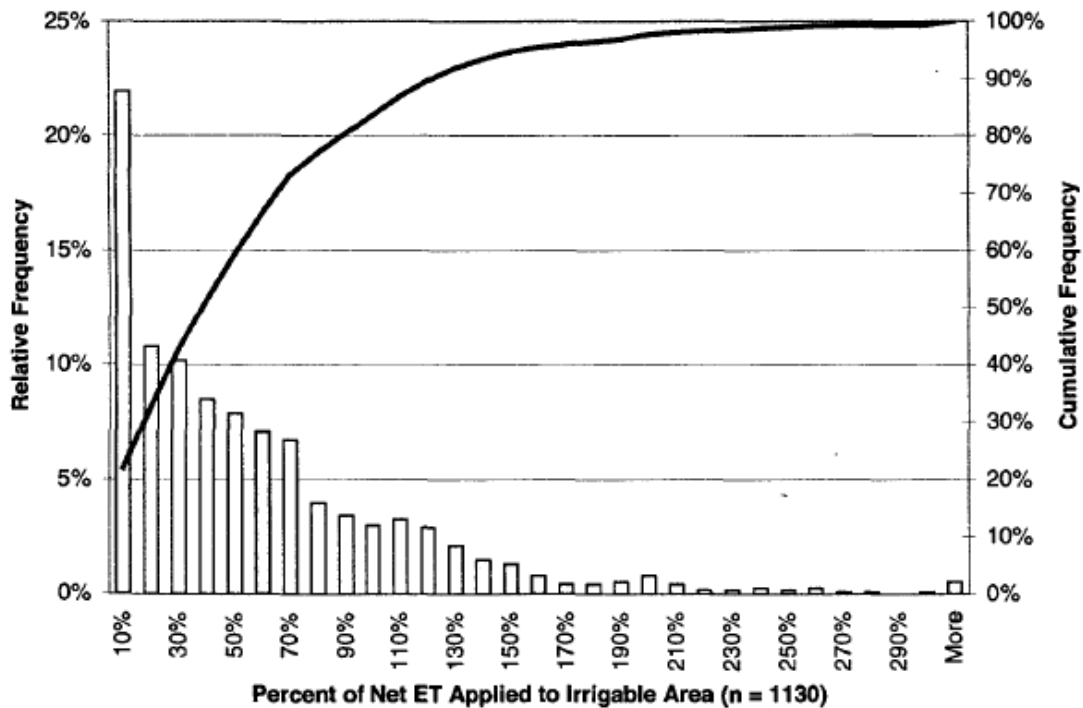


Figure 6: Histogram of percent of net ET applied to irrigable area<sup>28</sup>

While Figure 6 shows that only 20% of total households irrigate their lawns excessively, our other ethnographic research shows that the majority of these over consuming households use automatic sprinkler systems<sup>1</sup>. Though this study was not done in Ann Arbor, the diversity of the cities the study encompassed is wide enough to assume that Ann Arbor will have similar statistics. These users take great care of their lawns and are willing to incur extra cost on their monthly water bills in order to maintain a high quality lawn. Typically, irrigation above net ET is result of automatic sprinkler systems that are programmed to irrigate more frequently and longer than is necessary for a lawn.

### 7.3 Energy and air emission effects of water supply

Jennifer R. Stokes and Arpad Horvath of the University of California Berkley performed a hybrid life cycle assessment of the *Energy and Air Emission Effects of Water Supply*<sup>29</sup> in California in order to evaluate different methods for creating potable water for the California population. This assessment yields data for a number of different water purification methods and allows for evaluation of the environmental impact of residential irrigation. Usually, outdoor water is from the same source as inside water and is purified to high standards. Tables 4-6 on the following page contain the life cycle inventory of environmental effects from the purification and distribution of clean water.

Table 4: Total environmental life cycle effects of water purification and distribution for California case study<sup>37</sup>

	imported water (IMP, current source)	desalinated seawater, conventional pretreatment (DC)	desalinated seawater, membrane pretreatment (DM)	desalinated brackish groundwater (DBG)	recycled water (REC)
supply					
piping/aqueduct length	CRA, 400 km SWP, 1100 km Other, 125 km	3.2 km	3.2 km	4.8 km	1 km
electricity use (kWh/y/m <sup>3</sup> )	1.7	0.38	0.38	0.26	0.45
treatment					
description	flocculation (floc), filtration (filt), disinfection (disinf)	floc, filt, reverse osmosis (RO), disinf	membrane filtration, RO, disinf	filt, RO, disinf	filt, disinf
chemical use (g/y/m <sup>3</sup> )					
acid (hydrochloric or sulfuric)		81	81	65	
alum	0.35				53
aqueous ammonia	0.84	8	8.4	13	
calcium carbonate		26	26		
caustic soda	3.3			17	
chlorine	5.3				19
CO <sub>2</sub>		26	26		
ferric chloride	4.0	18	0.40		
sodium hypochlorite	1.9	6.0	6.5	11	
other <sup>b</sup>	2.8	8.2	7.5	3.0	4
electricity use (kWh/y/m <sup>3</sup> )	0.17	4.1	4.0	2.4	0.19
distribution					
description and pipe length	potable system (1000 km)	IMP + 3 km connection to plant	same as DC	same as IMP	nonpotable (35 km)
electricity use (kWh/y/m <sup>3</sup> )	0.22	0.72	0.72	0.22	1.5

<sup>a</sup> Case study data are per cubic meter of water. <sup>b</sup> Other uses include chemicals with an annual consumption of <5 g/y/m<sup>3</sup> for all sources, which include polymers, polyelectrolytes, scale inhibitors, zinc orthophosphate, sodium hydroxide, and fluoridation and membrane cleaning chemicals.

Table 5: Life-cycle assessment results of California case study<sup>37</sup>

water source	energy (MJ/m <sup>3</sup> )	GHG (g CO <sub>2</sub> equiv/m <sup>3</sup> )	NO <sub>x</sub> (g/m <sup>3</sup> )	PM (g/m <sup>3</sup> )	SO <sub>x</sub> (g/m <sup>3</sup> )
imported water (IMP)	18	1093	1.9	0.40	2.9
desalinated ocean water, conventional pretreatment (DC)	42	2465	3.4	0.77	6.9
desalinated ocean water, membrane pretreatment (DM)	41	2395	2.9	0.71	9.4
desalinated brackish groundwater (DBG)	27	1628	2.0	0.41	4.2
recycled water (REC)	17	1023	1.0	0.48	2.9

Table 6: Water supply life-cycle emission factors<sup>37</sup>

water source	annual per capita consumption <sup>a</sup>		California's statewide supply <sup>b</sup>	
	energy (GJ)	GHG (kg CO <sub>2</sub> equiv)	energy (TJ, % of California's electricity)	GHG (Tg CO <sub>2</sub> equiv, % of California emissions)
IMP	5.8	360	210000, 22	13, 2.6
DC	14	800	500000, 52	29, 6.0
DM	13	780	490000, 51	29, 5.8
DBG	8.9	530	320000, 34	19, 3.9
REC	5.5	330	200000, 21	12, 2.5

<sup>a</sup> Annual per capita water consumption is 326 m<sup>3</sup> (35). <sup>b</sup> Assumes California's population is 36.5 million. California electricity consumption estimates are from ref 36, and GHG emissions are from ref 37.

In Figure 7, below, the relative environmental weights of different water purification techniques are compared for every life-cycle phase of the water distribution system.

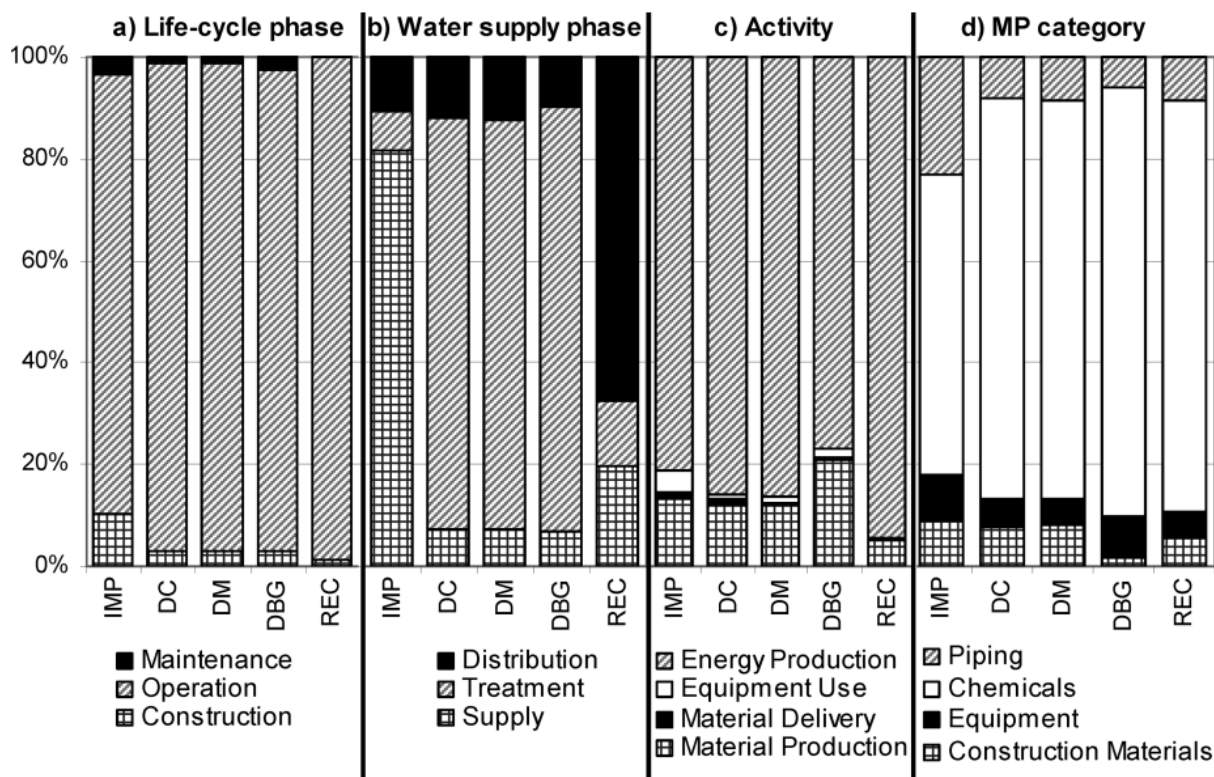


Figure 7: Relative carbon emissions resulting from different water treatment techniques<sup>29</sup>

#### 7.4 Effect of fertilizer and pesticides on the environment

With over-watering being common, the amount of pesticides and fertilizer in the run-off is a large environmental concern. The EPA has done a significant amount of research on the environmental effects of fertilizers and pesticides.<sup>30</sup> Lawns produce significant amounts of nutrient-rich storm water runoff, and research shows that such runoff can potentially cause eutrophication in streams, lakes, and estuaries.<sup>31,32</sup> Research also suggests that suburban lawns and municipal properties produce more surface runoff than previously thought.<sup>33</sup> Pesticide runoff can contaminate drinking water supplies with chemicals toxic to both humans and aquatic organisms.<sup>34</sup>

Homeowners tend to an estimated 40 million acres of turf<sup>35</sup>. If classified as a crop, lawns would rank as the fifth largest in the country on the basis of area after corn, soybeans, wheat, and hay. Fertilizers applied to lawns are roughly equivalent to the application rates for row crops<sup>36</sup>. Urban lawns receive an estimated five to seven pounds of pesticides per acre annually<sup>37</sup>.

78 million households in the U.S. use home and garden pesticides. Suburban lawns and gardens receive more pesticide applications per acre (3.2-9.8 lbs) than agriculture (2.7 lbs per acre on average). Of 30 commonly used lawn pesticides 19 have studies pointing toward carcinogens, 13 are linked with birth defects, 21 with reproductive effects, 15 with neurotoxicity, 26 with liver or kidney damage, 27 are sensitizers and/or irritants, and 11 have the potential to disrupt the endocrine (hormonal) system.<sup>34</sup>

## **7.5 Air emission effects from lawn mowing**

Each weekend, about 54 million Americans mow their lawns, using 800 million gallons of gas per year and producing tons of air pollutants.<sup>38</sup> Garden equipment engines, which have had unregulated emissions until the late 1990's, emit high levels of carbon monoxide, volatile organic compounds and nitrogen oxides, producing up to 5% of the nation's air pollution and a good deal more in metropolitan areas.<sup>38</sup>

## **8. Concept Generation**

To generate our concepts, we utilized a number of methods: research, interviews, and brainstorming sessions. First, we researched as much as we could about outdoor water usage. From our research we developed a base knowledge of what products and practices already exist. We also learned about several problems regarding lawn care, such as over watering, over fertilizing, and mowing too short. We then interviewed many people to learn about their habits and their needs when it comes to outdoor water usage and lawn care. Once we had our research and ethnographic data, we brainstormed to come up with ideas that would satisfy customer needs, while reducing environmental impact at the same time.

From our research and interviews, we know that lawn quality, greenness and grass blade density, and minimizing time spent on lawn maintenance are some of the most important things to the customer. We came up with ideas in the following four categories: smart controllers, landscaping, rainwater/grey water use, and lawn consulting. We discuss some of our top ideas below from those categories. A complete list of our generated concepts can be seen in Appendix 2.

An idea for smart controllers involves selling or leasing smart controllers to people with existing sprinkler systems. A smart controller is a device that takes the soil moisture and weather forecast into account in order to only water lawns when necessary. These smart controllers would greatly reduce wasted water due to overwatering, saving the customers money on their water bills. This would be aimed at customers who are interested in saving money on their water bill.

One idea for landscaping involves taking care of all aspects of residential lawns. This includes the three most important aspects of lawn maintenance: mowing, watering, and fertilizing. They are all related to each other. For example, if you fertilize or water too much, you end up having to mow more. From our research, many people tend to over water who have sprinkler systems. Many people also over fertilize. By offering all 3 services to people, we would mow, water, and fertilize the right amount to maintain a healthy lawn, which is less than what many people do now. This would significantly reduce the amount of water and fertilizer used, saving the customer money.

Another landscaping idea involves offering landscaping using native plants. We would offer things like rain gardens, which customers like for their appearance, and they significantly reduce runoff during storms. Native plants typically do not need any additional watering other than naturally occurring rain, because they have adapted to the amount of rain their environment receives. We would offer to replace as much turf grass with native plants as customers want. By having some native plants (and less grass) customers' lawns would require less water, saving them money and enhancing the beauty of their lawn.

A consulting idea involves giving lawn care advice to customers. They would come to us if they wanted to optimize their sprinkler system and/or lawn care. We would visit their lawn to assess it. We would then give them advice that is specific to their region and lawn. Clients could be homeowners or even customers who own larger portions of land, like apartment complexes or company buildings. This would be aimed at more do-it-yourself kind of people, who just need some instruction before they can make it work.

One idea involves saving the customer money by collecting rain water in cisterns for lawn irrigation. Because there is a large spike in water usage during the summer, we believe that this could potentially save customers a lot of money who water their lawns, while reducing water demand to the city. We would set up rain water collection that would feed to water tanks, which would be hooked up to the customer's sprinkler system.

## 9. Concept Selection

### 9.1 Conception Selection process

Based on our research and ethnography studies, we came up with several ideas to execute our project. For evaluating the merits and demerits of each, we decided to use a Pugh Matrix for concept selection. For doing the same, it was important to generate the Functional Specifications and Customer Importance Ratings of these specifications. To obtain the values for Customer Importance Ratings, we conducted a survey (Refer to Section 5.3: Relative Weight Allocation) and sent it out to our personas and collected their inputs on the same.

After obtaining these rating averages, they were converted to a 1-3-9 scale for the Pugh Matrix to understand the magnified differences in each specifications' importance. The Pugh Matrix was constructed to evaluate the 11 different concepts that we shortlisted. The -2, -1, 0, +1, +2 scale (High *negative* impact → High *positive* impact) was used to rate the performance of each concept against each of the specifications. The concept with an overall higher positive rating would be the winner. The Datum for this analysis was selected to be the sprinkler systems without smart controls that is most commonly used currently. (Refer to Appendix 3: Pugh Chart, for the complete Pugh Analysis.) Figure 8 shows the top 5 concepts from our selection process.

Item	Requirement	Overall Importance	1	2	3	4	5	6
			Complete Lawn Care Service	Native Plants Landscaping	Turf Edging Service	Smart Controls Installation	Sprinkler System Maintenance	Neighborhood Wide Control System
1	Reduction of water bill	3	+1	+2	0	+1	+1	+1
2	Reduction in time spent by customer on lawn care	9	+2	+2	0	0	0	0
3	Minimizing Operating Cost	3	-2	+2	0	+2	+1	0
4	Quality of grass-Blade Density	9	+2	0	0	+1	+1	+1
5	Quality of grass-Greenness	9	+2	0	+1	+1	+1	+1
6	Start-up (Installation) time	1	+2	-2	0	+1	0	-1
7	Pay back period	3	-2	-1	0	-1	0	+1
Add Row		37						
<b>Counts</b>								
	Count of Pluses		5	3	1	5	4	4
	Count of Minuses		2	2	0	1	0	1
	Count of Same (0)		0	2	6	1	3	2
	Pluses - Minuses		3	1	1	4	4	3
<b>Sums</b>								
	Sum of Pluses		9	6	1	6	4	4
	Sum of Minuses		-4	-3	0	-1	0	-1
	Total		5	3	1	5	4	3
<b>Weighted Sums</b>								
	Weighted Sum of Pluses		59	30	9	28	24	24
	Weighted Sum of Minuses		-12	-5	0	-3	0	-1
	<b>Total</b>		<b>47</b>	<b>25</b>	<b>9</b>	<b>25</b>	<b>24</b>	<b>23</b>

Figure 8: Pugh chart with Top 5 Concepts shown

Based on the Pugh matrix scores, the top five concepts are the following:

*Concept 1) **Complete Lawn Care Service***

*Concept 2) **Native Plants Landscaping***

*Concept 4) **Smart Controls Installation***

*Concept 5) **Sprinkler System Maintenance***

*Concept 6) **Neighborhood Wide Control System***

Complete Lawn Care Service is the concept that received the highest score on the Pugh Chart. This justifies the results from our ethnographic research, that is, customer value for this idea was the highest from the perspective of the persona. The only negative impacts of this concept are that, the customer is required to invest in the service, and the type of service they choose will impact their savings in terms of water use, hence the payback period may not be less than 1 year. Also, the operating cost may be high as they will be paying the service representatives to perform the lawn care activities. But it greatly benefits them in the aspect of reducing the time they spend on lawn care and it will result in improved quality of their lawn, which was of the highest importance to the persona based on our research and will prove to be the motivator for the customers to adopt this system.

Native Plants Landscaping received the second highest score in tie with Smart Controls Installation System. Native Plants Landscaping, from the survey results and customer interviews, seemed to be one that customers are willing to try out. The extent to which they adopt this (percent of their lawn that they are willing to replace with native plants) will be based on their preference and we were willing to offer that option to the persona. Although this concept ensures the reduction in the water bills since they do not need to be watered, and also benefit in terms of reducing time the customer spends on lawn care and with minimized operating costs, there is upfront cost and time associated with the installation of this system and it does not improve the quality of the lawn.

The smart controls installation system only applies to those customers that currently own a sprinkler system (for those who do not, it will be too high an investment cost to fully install the smart sprinkler system). This concept too will reduce the water bill in terms of saving water based on weather prediction, soil sensors and other such smart control systems. The operating costs would be minimum since, after the upfront installation cost (which based on our study was about \$150 on avg.). It will also improve the quality of the grass by utilizing and providing the optimum amount of water, which will ensure that the fertilizers, pesticides, etc., do not get washed away with the run-off water as is the case with excess watering practices.

Although the concepts 5 (Sprinkler System Maintenance) and 6 (Neighborhood Wide Control System) both received scores really close to that of Concept 4, based on our ethnography and customer surveys, it was found that these two ideas did not attain significant acceptance or willingness to be adopted (Refer to Appendix 3: Survey Results). This can be attributed to the fact that the personas preferred to have self-control over the system as opposed to having a neighborhood based automatic control system. Also, the maintenance requirements for a sprinkler system may not be high enough to run a business on it, hence that could be a reason for the customers to not appreciate the idea as much as we thought it would. Hence these two ideas, although rated at a decent score on the Pugh chart, were eliminated from our analysis.

Hence, we decided to combine the top three concepts to generate a hybrid concept, to ensure maximum profitability for the customer. Following Pugh Chart shows the score of the new concept when compared to the others.

Item	Requirement	Overall Importance	Sprinkler System with no smart controls	Concepts			Hybrid
				1	2	4	
				Complete Lawn Care Service	Native Plants Landscaping	Smart Controls Installation	Complete Lawn Care service with smart controls installation and Native Landscaping
1	Reduction of water bill	3	D a t a u m	+1	+2	+1	+1
2	Reduction in time spent by customer on lawn care	9		+2	+2	0	+2
3	Minimizing Operating Cost	3		-2	+2	+2	+1
4	Quality of grass-Blade Density	9		+2	0	+1	+1
5	Quality of grass-Greenness	9		+2	0	+1	+2
6	Start-up (Installation) time	1		+2	-2	+1	-1
7	Pay back period	3		-2	-1	-1	0
Add Row		37					
<b>Counts</b>							
Count of Pluses				5	3	5	5
Count of Minuses				2	2	1	1
Count of Same (0)				0	2	1	1
Pluses - Minuses				3	1	4	4
<b>Sums</b>							
Sum of Pluses				9	6	6	7
Sum of Minuses				-4	-3	-1	-1
Total				5	3	5	6
<b>Weighted Sums</b>							
Weighted Sum of Pluses				59	30	28	51
Weighted Sum of Minuses				-12	-5	-3	-1
Total				47	25	25	50

Figure 9: Pugh chart with Hybrid concept included in analysis.

The Hybrid concept of providing a Complete Lawn Care Service that includes Sprinkler System Installation and Native Landscaping, has a higher positive impact on the functional requirements for customer satisfaction. That is, this concept fell within the critical to satisfaction metrics described in section 5.3.

## 9.2 The Alpha Design - Description

Based on our analysis from the ethnography studies, customer surveys and Pugh Chart for concept selection, we generated our alpha design. This includes three options for customers: complete lawn care, smart controller installation, and native landscaping services. To make this service available to the customer we plan on building a Business Website that showcases the different kinds of services we offer that the customer can choose from and contact us for the same. This list of services will also include explicit details of each, also information on what benefits can be acquired out of the service the customers choose to pick. These benefits include the percent savings in terms of water usage, the detailed description about the contract chosen, that is, the lawn maintenance cycles per year that is offered, etc. For customers that are not aware of the relative benefits of each service, this catalog of detailed descriptions will be beneficial.

Once the customer decides to sign a contract with us, our team of experts will visit the location and analyze the prospects in terms of the service offerings and finally, the required setup will be installed or the required service will be provided. The following flowchart describes the concept from the customer's perspective.

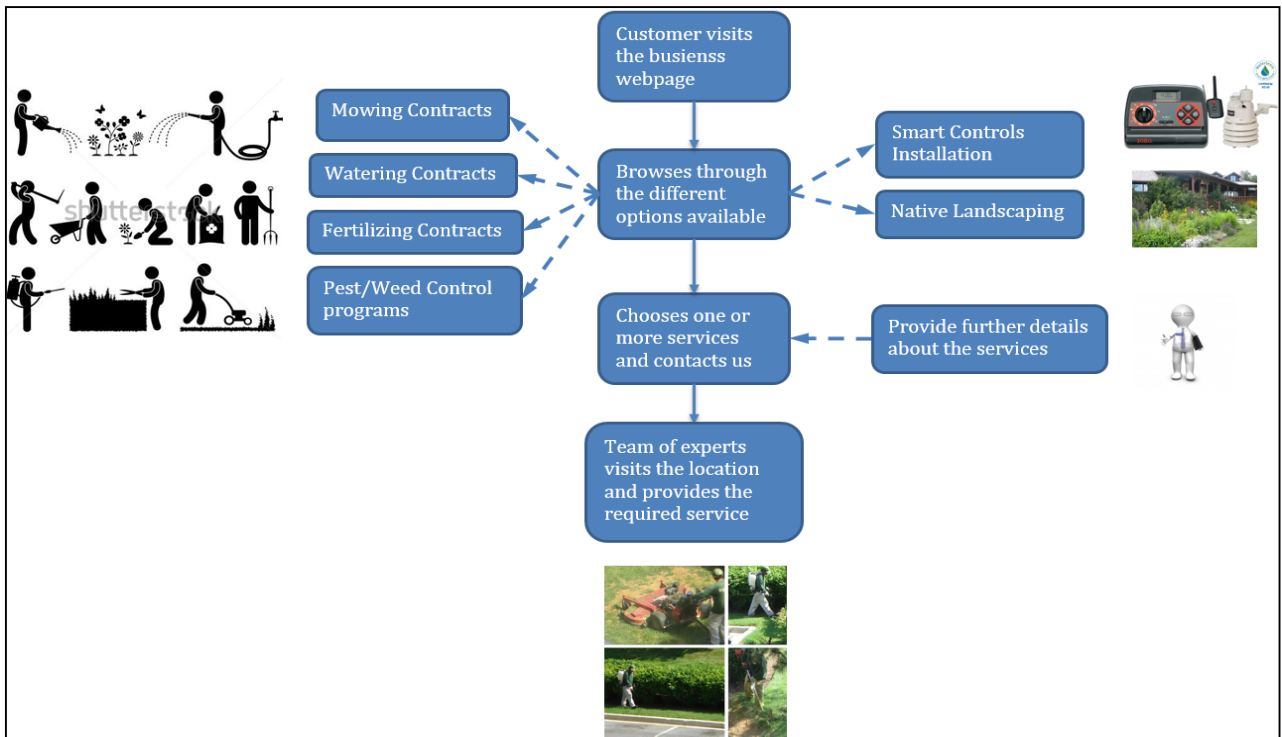


Figure 10: Flow chart describing the First Concept Selected-Alpha Design

## 10. Alpha Design

Our alpha design will provide a complete lawn care service for customers that will reduce the amount of water, pesticides, and fertilizer consumed while maintaining similar or better customer satisfaction with the quality of their lawn. The reduction in water consumption will be accomplished by the installation of native plants that do not require irrigation where they are desired by the customer, installing smart irrigation controllers to optimize the irrigation schedule to match the evapotranspiration needs of the lawn, and maintaining the irrigation system and lawn to minimize wasted water. Pesticide and fertilizer use will be reduced by installing native plants, following best practices in the application of chemicals on lawns, and maintenance of the lawn and the irrigation system to minimize runoff of chemicals from the lawn. We assume in this evaluation that the air emissions from lawn mowing will not be significantly improved by our lawn care service.

### 10.1 Water consumption reduction from alpha design

Our complete lawn care service will reduce water consumption in three ways:

1. Installation of native plants to do not require irrigation
2. Smart irrigation controllers that optimize irrigation schedules to match the evapotranspiration needs of a lawn
3. Maintenance of the irrigation system and lawn to minimize wasted water



Native plants are plants that are naturally adapted to the climate in which they are planted and do not require irrigation, pesticides, or fertilizer.<sup>39</sup> From our survey of potential customers we observed that there was significant interest in this option, however, from interviews of potential customers we also observed that most customers would only be interested in a limited installation of native plants. As a result, the improvement in consumption would be limited to the customer willingness to install native plants on the majority of their yard. From interviews and our survey, we believe that it would be reasonable to assume that our persona would be interested in 20% of their lawn being converted to native plants, on average. In particular, customers are interested in converting the bed areas of their yards into native plants. Therefore, our service would result in 20% less water consumed by the lawns that our service covers due to native plant installation.

Smart irrigation controllers use soil sensors, rain measurement, and weather prediction in order to best match the net evapotranspiration of lawns. These controllers attempt to optimize irrigation matching of the difference between lawn evapotranspiration and rainfall referred to as net ET. Excessive irrigation is measured as the amount of irrigation above net ET (demonstrated in Figure 2). In a study by the Public Policy Institute of California<sup>22</sup>, it was found that 33 homes using automatic sprinkler systems were able to reduce their water consumption by 18% on average by switching to smart controllers. An additional 62 customers were targeted for smart controller retrofits, resulting in an average reduction of 26%. In general, we would assume that an automatic irrigation system (similar to what our persona would utilize) would see water savings of 20% from the installation of a smart controller.

In addition to better matching the ET rate of a lawn through better irrigation control, water consumption can be reduced by reducing the ET rate of a lawn through best lawn maintenance practices<sup>6</sup>. These include mowing a lawn less frequently and to a higher height, reducing the frequency of watering in order to force the lawn to conserve more water, and reducing water runoff.

## **10.2 Pesticide and fertilizer consumption reduction from alpha design**

Our complete lawn care service will reduce pesticide and fertilizer consumption in two ways:

1. Installation of native plants to do not require pesticides or fertilizer
2. Follow best practices in the application of chemicals on lawns
3. Maintenance of the irrigation system and lawn to minimize chemical runoff

The installation of native plants is discussed above in the water consumption section. In addition to the reduction in irrigation, native plants do not require fertilizer or pesticides and will also result in a 20% chemical reduction.

Best practice for applying chemicals to lawns is to fertilize only once a year and to use a minimal amount of approved pesticides.<sup>39</sup> Currently, large lawn service companies apply fertilizer multiple times per year and use pesticides liberally. Our service would guarantee equal lawn quality with less chemicals and, as a result, improved human health.

In addition to reducing the amount of chemicals applied to lawns, our service would reduce the amount of chemicals expelled to rivers, lakes, and municipal water systems through reduction of water runoff from lawns. The reduction of runoff was discussed previously as a technique to reduce water consumption but will result in less chemical runoff as well.

## **11. Alpha Design Feedback**

### **11.1 Strategies and methods**

In order to obtain a good sustainable design, one important problem is to ensure the design not only green but also appealing to customers. Therefore, validating our Alpha design through feedback needs to be done carefully. The strategies we used were mostly interviews and feedback from Design Expo.

In interviews, we asked a number of potential customers or people sharing similar interests with our personas. They were home owners with beautiful lawns living in Ann Arbor and suburban areas. Most of our interviewees have already used sprinkler system for watering their lawn. These people are more interested in irrigation technology (smart controllers and sensors) than those using hoses to manually water their lawn only when the soil looks dry or it does not rain for a long time (observation from our previous interviews – Appendix 1). Also, most sprinkler users have simple timing controllers which are highly likely to water excessively, so we thought our product (smart controller option) would be more attractive, and we would get more feedback from them. Another focus group included people who currently hire professionals (companies or experts) to mow, fertilize, and weed their lawn. This group helped us to gather more accurate data in terms of service price since research and contacting competitors did not provide us enough information. For all potential customers, besides asking about lawn condition (size, grass) and current lawn service, we told them our product description with cost, options, payback time, and service quality details. The purpose is to evaluate how customers think about our product, especially in terms of cost, and how willing they are to use our product.

To get feedback in Design Expo, we tried to talk to people about our design concept as much as possible. The poster, where there were pictures of beautiful green lawn and native plant landscape, helped to attract people passing by to stop and give comments and feedback. With this method, we receive opinions from a wide range of people, including environmental experts, nature lovers, home owners, students, etc., which actually surprised us and led to a change in our Alpha Design.

### **11.2 Feedback results**

From our interviews, the feedback we got for our prices is relatively positive since our price is lower than our customers' current service. The rate we charge for one time service is actually comparable to our competitor but we save them money from using less resources (less water, less fertilizers, etc.) and less frequent service (fewer numbers of mowing and fertilizing, etc.). For example, most our customers pay \$20-25 for one time mowing their lawn, 4 times per month while we offer mowing option with \$60 a month (we only mow 2-3 times a month). Also, a majority of our customers prefer monthly payment to one-time-service payment (they need to repeat paying every week for mowing). Additionally, one home owner living in an upscale neighborhood, has recently re-sodded her lawn; thus she is not interested in our landscaping option. However, it also means that native plant can have a potential with people who are looking for a new lawn replacement. One customer uses rain sensor for their controller but the sensor does not work properly, which may lead to their doubt in the effectiveness of smart controller. Many customers are willing to switch to our service if we ensure to use bio-friendly and less harmful to health resources while charging the same rate.

There was also some feedback from the Design Expo. Toby, a home owner living in rural area with a big land area, was very interested in our product, especially the native plant landscaping. He told us his interesting story of replacing the majority of his lawn by native plants by himself, which he wished to have some guide or help from an expert to alleviate hardship and loss (a majority of his plants died in the first year due to the lack of knowledge in choosing types and planting method). And now, when his house is surrounded by beautiful and natural plants, he can see many wild animals in his garden, and even have wild turkey for dinner. His story and experience again verified the potential for developing landscaping option in rural areas.

### **11.3 Influences on subsequent design changes**

Feedback on our Alpha design validated the price we came up with our service is reasonable and competitive. Also, the monthly payment method for our lawn care service (mowing, fertilizing, and weed and pest control) is preferable since it is easier for customers to see their savings than one-time-service payment where they pay the same for each time and we do less frequently.

The most significant change in our Alpha design is an addition to our personas or our focus customers. Our Alpha design only focused on home owners living in suburban areas since they are more willing to invest money in improving their lawn maintenance and they set a relatively high standard for lawn. The feedback from Toby at the Design Expo led us to target to home owners in rural areas as well. Before Design Expo, based on our interviews, people living in rural areas with large area of lawn do not water their lawn, they do not need their lawn look green either since a low water bill is more important. They also let their lawn grow naturally and mostly do the maintenance by themselves. Thus, we thought there would be a very few chance to attract these people to use our service. Native plants usually do not require additional water and care, but they require proper growing methods. Therefore, our landscaping option can be very attractive to customers in rural areas, where we provide appropriate native plants and growing methods.

Another observation from our interviews is that people tend to cling to their current lawn service since they usually doubt the quality of a new service. The effectiveness of smart controllers is also questionable for some customers. Therefore, in order to succeed in the competitive market, our design need to target more in marketing or how to really persuade customers to switch to our service. For example, we can offer one month free trial or more (mowing or smart controller leasing for example) to increase chances of getting their trust. We can also highlight the green and eco-friendly feature of our product (environmental sustainability) to customers living in nice neighborhood, who have a good awareness of their health and environment.

## **12. Final Concept Description**

Our final design is a complete lawn care package, including:

(1) Smart control installation: integrating the smart controller and sensors into the current sprinkler system of the customers. We have 2 payment options: one-time payment and monthly lease. In order to attract customers, we also offer free month trial for customers who are using sprinkler system with timing controller. The purpose is to show them how smart controller really work and save their water bill; and once they know, they will highly likely use our product.

(2) Total lawn care service: taking care of mowing, fertilizing, edging, pest control (if needed), and weed control (if needed). For mowing, we offer monthly payment where customers pay us once a month instead of each time we do the service. It is lower than other lawn service price in the market since we only mow 2 or 3 times a month instead of every week, and customers do not need to take care of when we come to do the service. Though doing less frequently, we still assure to maintain a healthy level of lawn as they require. In terms of fertilizing, we use bio-friendly fertilizers, weed and pest control, which are not only harmless to human health and environment but also more attractive to a large number of customers. The frequency is also fewer: we fertilize only twice a year instead of 4-6 times as many other competitors.

(3) Native plants landscaping: replacing a part or entire turf grass by native plants, saving considerable resources (water, fuel for mower, fertilizer, etc.) and satisfying the aesthetic requirements of customers for their lawns. We not only provide an appropriate selection of native plants (depending on the region, soil type) but also the method of growing and taking care at the early phase to ensure the high percentage of survival.

Our focus customers include homeowners living in suburban and rural areas. For suburban home owners, the highlight will be on smart controller and lawn care service option; native plants landscaping can be added later on when customers feel pleased with our service and look for a more environmentally sustainable solution (we gradually build up trust and raise their awareness of environment as well as benefits of native plants). For rural homeowners, the highlight will be on native plant landscaping. We need to emphasize on its economic benefits (no water, less care) as well as natural beauty for the living area.

## **13. Business Plan**

### **13.1 Company Description**

Complete Sustainable Lawn Care Services provides clients with the expertise and means to reduce their outdoor water consumption while maintaining a healthy green lawn. The company provides four main services: mowing and trimming, fertilizing and pest control, native plants landscaping and smart controller installation.

*13.1.1 Meeting Market Need:* The market need we are addressing is the need to take care of a lawn as efficiently as possible in terms of cost, maintenance required, and environmental impacts. We will be providing a service similar to others, but at a lower cost and with an emphasis on preserving the environment and saving money on the water bill. Not only do we provide the services necessary to maintain the traditional American turf lawn, but we also by educate consumers about lower maintenance/cost alternatives such as native plants.

*13.1.2 Potential Customers:* Our primary customers will be those that already spend significant time and/or resources to maintain a beautiful healthy looking lawn. Other customers we are trying to reach are those that are environmentally conscious, but still care about having a nice lawn. These consumers may be those who buy local produce, as they are likely to have a good appreciation for the advantages of native plants in the area. Also, as the depleting of fresh water becomes a concern, our customer base is likely to expand due to increased cost and concern. According to a study done by the American Water Works Association the cost of expanding and repairing the U.S. drinking water system between 2011 and 2035 will be at least \$1 trillion, which will be paid for primarily by raising household water bills.<sup>40</sup> Native landscaping will be able to capture this potential increase in our customer base.

### **13.2 Market Analysis**

*13.2.1 Target Market:* Our target market consists of middle to upper-income homeowners primarily those that hire lawn-care companies already and have a sprinkler system. Professional Landcare Network also estimates that the landscaping service sector alone generates an annual \$35.6 million dollars in value-added services.<sup>41</sup> Irrigation and Green Industry magazine stated that the U.S. green industry, including lawn and landscaping services, irrigation contractors and lawn and landscape product suppliers, generates \$67 to \$69 billion annually.<sup>41</sup> Furthermore, according to an IBIS World report, the market for landscaping companies is expected to grow by 5.9% annually from 2013 to 2018.<sup>42</sup> This is a large projection compared to the 1.3% annual growth from 2008 to 2013.<sup>42</sup> Though data for the sales of smart controllers was not found, sales of evapotranspiration controllers and moisture-sensing devices are increasing and these products are likely to take the lead in the future.<sup>43</sup>

*13.2.2 Competition:* The status quo now is having sprinkler companies deal solely with irrigation, landscaping companies, some who primarily mow lawns and some who specialize in the design and planting of gardens, and lawn care companies to fertilize, perform weed control and seed the turf. Because we are encouraging homes that already have a sprinkler system to adopt a smart controller and disregarding maintenance of existing lines, we will not interfere with much of sprinkler companies' business. Native plants landscaping companies (none advertised in Michigan) and lawn care service providers (such as TruGreen) are more direct competitors to our service.

The main advantage that we have over other companies is that we can save money via the reduction in not only the water bill, but also the frequency with which lawn is mowed and fertilized. Also for those homeowners that still desire turf lawn, we can provide them with the satisfaction of knowing they are maintaining their lawn as eco-friendly as possible. Though landscaping companies have the ability to use native, low maintenance plants, we will market ourselves as the go-to company for that specific need. The disadvantage of our service to many competitors is that a lot of people already use services and may not be willing to give us a try. People tend to be laissez-faire when considering their lawn care practices with the “why fix what’s not broken” mentality.

*13.2.3 Pricing:* The average cost to mow a 200 sq. ft. yard is \$15-\$60 in Ann Arbor.<sup>44</sup> “Straightline Lawn Care” a company based out of Ann Arbor was advertising a special of \$30 per mow.<sup>45</sup> Assuming we visit a house at least twice a month, the monthly cost of \$60 is validated. The cost of the fertilizing and pesticide treatment is \$200 a year. We expect this to be a marketable price as Tru Green has a variety of services ranging from \$225.00 - \$362.30 for lawn care bundles that include a fertilizer/ pest control plan tailored to your lawn.<sup>46</sup> Native Landscaping is estimated to be \$4,800 per acre for the seed in Washtenaw County.<sup>47</sup> The cost per hour for a landscaping professional can range anywhere from \$40-\$120.<sup>48</sup> Because the cost of the plants will be so low, the hourly rate will be \$80. The cost of purchasing and installing a smart irrigation product will be 10% above the retail value of the desired controller. A table of our prices can be found in Appendix 5.

*13.2.4 Barriers to Entry:* Barriers to entry into the market for landscaping companies are low and steady according to IBIS.<sup>42</sup> There is no formal training or certification that is required to enter the market though one can attain certifications to emphasize good quality through organizations such as PLANET: Professional Landcare Network.<sup>49</sup> Also there is not much upfront investment for equipment, with the largest cost being the truck and the mowers. All other costs such as labor, fertilizer/pesticides and smart controllers are scalable with growth. Until we gain enough clients to support growth, there shouldn’t be a need for any office space. Furthermore, there is space for smaller firms to enter the market as the larger firms account for only 4.5% of the available market for 2013 for landscaping companies.<sup>42</sup>

### **13.3 Product Description**

*13.3.1 Service Description:* Currently our service has not been developed to a prototype yet. Our service will be tailored to the needs of each customer and the main benefit is the satisfaction of knowing they are saving time, money and the environment while still maintaining a beautiful lawn. A customer can opt to redesign their lawn with native plants, knowing they no longer have to water their lawn and can spend 50% less resources maintaining it.<sup>47</sup> A customer can also hire us in order to achieve the lowest cost turf maintenance. We will guarantee satisfaction on the appearance of their lawn and at least 10% reduction in their water bill.

*13.3.2 Feedback and Validation:* During and after the Design Expo, we received constructive comments from people who were interested in the service we are offering. The most important observation was that potential customers did not have any concerns with our price points for the service modules given the water bill reduction that comes along with it, but they needed to see proven results of our methods for reduction in water usage (section 13.4.1 fully describes how we plan on addressing these concerns). Also, since native landscaping is an entirely different module, it seemed to attract customers into trying it on a part of their lawn but not wholly, because it changes the perceived lawn quality. On the long run, we plan on advertising

native landscaping as our major business, since the benefits from water savings are highest from this practice.

### **13.4 Marketing and Sales Strategy**

The most important success factor of our business is to market our service in a way that will convince customers to adopt this system by expressing the sustainability improvements in terms of monetary savings for the customer.

*13.4.1 Market Penetration:* The differentiator in our model is the savings in lawn care expense that we market. To convince customers into buying our concept, we plan on providing free trials for the first month, where we will install the smart controllers and practice optimized mowing, fertilizing, etc., and prove that the results are positive. The customer can then be given the option to sign a contract for a certain period of time for any particular service that they choose. Our basic service plan would be for mowing/trimming and fertilizing, and the price would then increase based on any additional modules the customers choose, such as, native landscaping or smart controls installation. In order to promote native landscaping, it is important to build a trust relation with the customers. We plan on doing so by convincing them first with the use of smart controls and optimized mowing/fertilizing practices, and then promoting the native landscaping for added benefits. Also by promoting native landscaping over the long run, given the rising concern with available water resources, we believe that our service would stand out in the competition.

*13.4.2 Communication:* The most beneficial communication strategy would be to aim at word-of-mouth expansion of our business. That is, using one or two housing units that are most centrally located and noticeable for its lawn quality in an area for pilot runs and advertising the success on that unit among the neighboring households would be most beneficial. This house would then be tagged as a success story, which would attract other houses nearby to try our service. Incentives and discounts would be provided for customers that refer our service packages to other households. Another idea we have is to contact the neighborhood community heads to promote our service to incoming homeowners, which will act as a contingency for their lawn care. Also important would be to advertise in gardening stores for promotional events and use them as suppliers. All these ideas need to be tested fully before launching the service.

*13.4.3 Channels of Distribution:* For the distribution strategy, it is our aim to choose suppliers that use more sustainable products in the lawn care business. We will setup a team of experts that would serve as consultants directly to the customers, and also hire an expert to train the staff every year on the optimized lawn care routines. It would also be beneficial to hire a department for R&D to update our service standards with time and to keep track of new technologies in the market.

*13.4.4 Growth Strategy:* In the future, we plan on expanding our business by buying out small lawn care companies to adopt our sustainable practices or to franchise the service modules/packages to other small companies. This would be a horizontal expansion strategy, thereby expanding the customer base while providing the same service standards. Also, for more of a vertical expansion, we plan on considering the design of mowers or other smart controllers that would be more sustainable over the life of the product than the current products, and to market the products along with sustainable lawn care practices.

### 13.5 Basic Financial Analysis

As our business revolves around providing a service as opposed to a product, the investment costs are not too high as there is no need to own a huge work space or a high level of equipment for us to be fully operational. Hence all our calculations are based on owning an office space of 1000 sq.ft. (which is equivalent to a 2-Bedroom apartment space in Ann Arbor), and with most of our costs coming from labor. The assumptions (see Appendix 5) we made in the construction of our Business Model are as follows:

- We used TruGreen<sup>45</sup> as our benchmark for generating pricing and market share estimates. This company currently owns a third of the market share<sup>50</sup> and it is our target to reach its value (approximately 30%) in the best case scenario, and 50% of that (15% of total) in the worst case. All predictions are considered for first 5 years of operation.
- Our metric for measuring demand is the number of owner occupied households<sup>51</sup> (family, married couples, individuals above 65 yrs of age, etc.) in Ann Arbor, and we assume that 70% of these households would want to hire a service for lawn maintenance (the rest probably prefer outdoor activities and would not be willing to allow an outsider maintain their lawn). Also, we assumed that the marketing cost to be 2.5% of the net profit after paying off the operational costs and in investment.
- The major investment is incurred from setting up an office space, acquiring a team of experts to serve as consultants and to purchase initial equipment for the first year. This came up to be about \$27,000 for the first year, which is reasonable as we plan on starting with a small team of 5 skilled and 5 unskilled workers, and to purchase 1 lawn mower. The market demand was thus estimated using an S-curve adoption (see Appendix 6). The profitability charts for the best and worst case scenarios from year 1 through 5 are shown below. As seen, the Break Even is attained a little after 2 years of being operational which is a good start considering we will be a new company in a highly competitive space. But our idea is to promote and expand the business for native landscaping, which we believe will greatly improve our sales. Also included in the analysis are costs for marketing. This will include the promotional strategies that we plan on following (see Appendix 7).

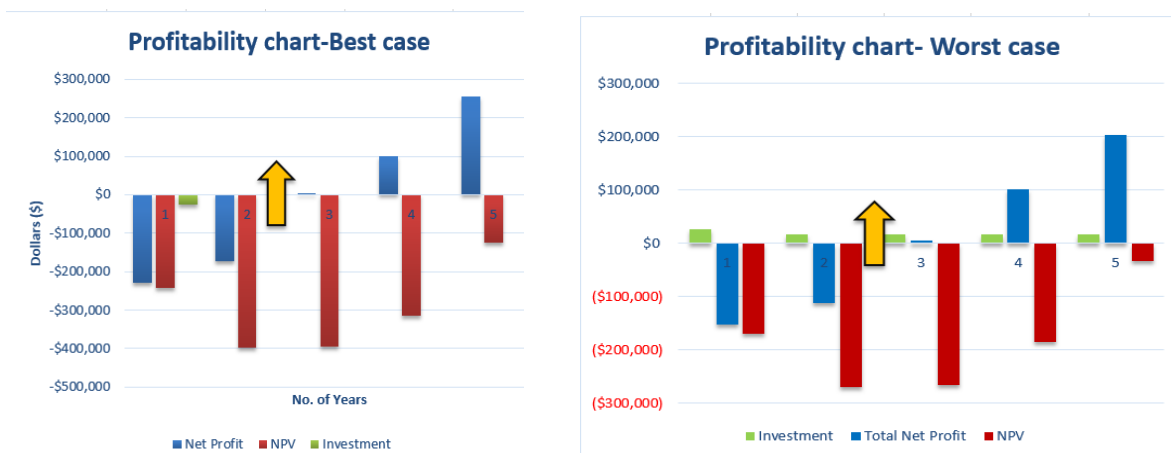


Fig 10. Profitability chart: Best and Worst case scenarios



## 14. Additional Reflections on Project Outcome

### 14.1 Design Sustainability

In order to evaluate the sustainability of our product, we considered the triple bottom line, the full life cycle of our product, and the possibility of a rebound effect.

**Triple Bottom Line:** This approach considers three important factors in the success of any product: economic, social, and environmental. These factors encompass the total cost of a product to the world by considering all of the direct and indirect costs.

*Economic:* The economic benefit of our service for the customer would be the reduction in cost for the consumer to care for their lawn. Our service would reduce their water bill through water saving strategies and reduce the number of lawn care cycles required to maintain the quality of their lawn. In addition, the cost of our service providing lawn care would be reduced by reducing the amount of fertilizer and pesticides. Additional revenue streams would include the sale or lease of smart controllers and the installation of native plants.

*Social:* Our service would have small effects on societal concerns. By providing this service we are enabling our customers to fulfill the societal expectation that they maintain beautiful lawns while allowing for a more environmentally sound option. Our service will largely start as a service to provide installation of smart controllers and lawn maintenance. However, as time goes on, the trust that we build with our customers will allow us to build acceptance for native plant installations in society.

*Environmental:* This service would work to reduce the consumption of water, pesticides, and fertilizer. Not only would less pesticides and fertilizer be applied but there would also be less chemical runoff into public water systems due to the reduction of total chemicals and improvement of water runoff. The main focus of our service will be the reduction of water consumption for lawn irrigation that will be achieved through the proper maintenance of lawn, installation of smart controllers, and the installation of native plants.

**Life Cycle Considerations:** This approach considers all of the stages of a product life from cradle to grave. Important considerations for an entire life cycle are raw material extraction, material processing, manufacturing, distribution, use, repair, maintenance, disposal, and recycling. These considerations can be grouped into four main categories: material extraction, manufacturing and distribution, usage, and end-of-life. The extent of changes for our new service would include a change in how lawn care is performed, replacing traditional irrigation controllers with smart controllers, and installing native plants to replace turf grass in select locations. All of the changes that our service would provide would not significantly improve the material extraction or manufacturing from the current state. All of our significant changes would come from the usage stage where we will reduce the consumption of water, pesticides, and fertilizer and the end of life phase where we will reduce chemical runoff from lawns. In addition, our reduction in the number of required lawn care cycles would also reduce the emissions from mowing lawns and transportation to customer locations.

**Rebound Effect:** This effect explains lost benefits from the theoretical environmental gains from a product. It can be seen as increased consumption of a good because it becomes less expensive to use for the customer. The rebound effect will affect our product because, if we can successfully offer our service for a lower price because of our improved consumption of water, pesticides, and fertilizer, there will be increased demand for lawn care from customers that would not have used lawn care before we offered our service. For example, if our service were

to succeed in reducing consumption by 30% for lawns that we serviced but at the same time demand increases by 10% from customers that would not have performed these operations on their lawns otherwise then we would reduce the impact of lawn care by 23%. The lost 7% is a result of the rebound effect. It is important to consider that, for our service, the rebound effect will only be observed for customers that did less lawn care than before our service became available. Our design persona is a customer that currently performs an excessive amount of lawn care that we are trying to save money by offering our service, therefore, by targeting our marketing at this persona, we intend to minimize the rebound effect of increasing the amount of customers interested in lawn care. Additionally, our service will not offer the installation of new lawn irrigation systems but rather will just offer the service of taking care of the current lawn more efficiently.

**Conclusion:** This service provides a sustainable alternative to current lawn care services by reducing the cost to the customer and improving the environmental impact of lawn care. This is accomplished with minimal affects to the current life cycle outside of improvements to the usage and end of life phases and will be marketed to heavy consumers in order to reduce the rebound effect of the service becoming available to new customers. There will be minimal improvement in the material extraction and manufacturing of our products as well as any social concerns created by the current lawn care culture.

## 14.2 Design Critique and Recommendations

After reflecting on our project there were several strengths. We did a lot of research about existing products for smart lawn care and we found that every product we could think of already exists. Therefore, it was a good decision for us to focus on a service. During the design expo, some people expressed a lot of interest in our native plant option, which provided us with positive feedback about our project. By having native plants as an option, we can also make people aware of installing native plants in places where water scarcity is an issue. Smart controllers would also help to make people aware of how much water and money they are wasting with simple timers for sprinkler systems.

While our project had many strengths, there were also some weaknesses. We don't have enough data to be able to tell if saving money on water bills is something that's actually important to people or not. Our project depends on people being interested in lowering their water bills. If people have been overwatering their lawns and use our service to start watering less, one concern is that the grass will be used to overwatering and will not look as good during a transitional period to a healthier watering cycle. If this happens, customers would not like our service because of the possibility of their grass looking worse, even if it's only for a short time. The specifications for our project involved a lot of estimation; it was hard to get set numbers for them in just one semester. We were never able to physically test our service on an actual lawn, to see if our lawn care approach would keep the lawn just as healthy as other lawn care companies.

Taking all these weaknesses into account, we have many recommendations for future work on this project. We would to make sure our project addresses a real need people have. We recommend conducting focus groups and many more interviews to see how important reducing water usage is to people. We originally suggested starting this business somewhere in Michigan, but water is abundant here, so that is not a good idea. We suggest starting this business somewhere where water scarcity is an issue that people are more concerned about: Arizona, California, or other desert areas. After doing these things, we suggest making the

specifications much more data driven, based on what people want. We recommend testing out all of our services on test lawns to see if our lawn care strategies maintain the desired lawn quality, and making sure people are happy with the results. We suggest doing a lot more research into our prices, costs, and funding requirements. We would need to work with someone who knows a lot more about business to help make sure our business would be profitable. We received some good feedback at the design expo; Toby lives in a rural area, owns acres of property, and recently installed native plants on his entire property. He was very interested in our native plants service, so we suggest looking a lot more into installing native plants in rural areas, where people own a lot of land. Doing more research and interviews with personas like that would be very helpful. We also suggest contacting suppliers to establish what products and equipment we would use.

### **14.3 Project Reflection and Future Class Recommendations**

We really learned a lot from this class, and have a much better understanding of sustainable design. We understand what the challenges are with it, and why it is so hard to do. One thing we still don't really understand is how do we take the environmental specifications into account when making a product? If you focus on those, you could end up with a product that customers don't really want, and if you just make a something just for a customer, it probably won't be any more sustainable than alternatives.

Of the topics covered in class, we're glad you spent so much time on needs finding. It was extremely helpful to learn about, because some of us had never learned about it before, and it's truly vital for engineers to learn! Also, the guest speaker who spoke on stakeholders and needs finding was awesome! We think you should have spent less time on LCA and much more time on business topics, specifically all the basics that a startup business would need to know, especially for the people who would be interested in continuing the project after the semester, but don't have a good enough business background to be able to do that. We don't feel prepared to actually implement our project in the real world if we were going to.

As for the rest of the class, we have a few major suggestions. The videos you had us watch at the beginning of the semester were very interesting, and we learned a lot from them, specifically the TED talks, Millennium goals, and Autodesk videos. That being said, don't have us watch videos of lectures beforehand and then discuss them in class; it is a huge waste of time, and this was one of our least favorite aspects of the class. Just lecture in class instead. A video is not interactive, so we can't ask questions in the middle of it if we have any. It would be much better use of time to simply have an interactive lecture in class and no pre-class video.

Another big area that could be improved is class participation. After watching/reading the pre-class assignment, you have us discuss it as an entire class. This usually results in the same people talking every class. This may work well for extraverts, but it does not work well for introverts or people who don't like talking in front of the class. A much better way to get everyone involved would be to ask us questions, and have us split up into small groups and discuss them for a few minutes. Then have a few groups tell the class what they talked about. We have seen this work much better for getting people engaged in something.

We have a few other general suggestions for making the class better too (not as important as the suggestions above). The questions for the pre-class assignments should be optional. You should ask a question if you truly have a one, but not if you don't. Many people just make up a random question because they have to. You would probably get better questions if only people who really had questions asked them.

Most of us felt that assignments 2 and 3 (the reflection assignments on the design reviews) were a waste of time. We did not get anything out of it. Many people we talked to just BSed something to be done with it. We suggest getting rid of those assignments and just asking more free response questions in the peer evaluation on CATME. You could ask things like, "how did you contribute to the DR, list at least # things." The way students see these assignments is: they write a paper (DR) and turn it in, and then they have to write a paper about that paper. It just doesn't make sense, and most people we talked to don't put much thought into them. Instead of reflections on the DR, you could have completely different assignments that would help students understand other aspects of the class more, such as business concepts, needs-finding, or LCA.

#### **14.4 Acknowledgements**

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## Appendix 1: Complete Observations

### Observations with Professionals

**Interview 1:** Questionnaire distributed to Robert Doletzky, Grounds Senior Supervisor at the University of Michigan, by Archana Sridhar regarding turf maintenance at the school.

1. The total span, in Sq. ft. of turf land that is covered by the Ground Services (North Campus):  
For North Campus (Zones 5 through 8, Refer Appendix):  
Turf Square Footage= 9269494 SF  
Irrigation Square Footage=1546578 SF
2. The frequency at which it is watered, mowed, treated (pesticides if any), 7. Costs associated with each practice, 5. The technologies and practices used: such as weather watch, etc.

This is done based on priority of the area. The following table provides a good summary of the observations:

(P.S. This is the summary I created based on Robert's data sheet. I hope it makes sense to you guys!)

#### 3. The type of water system used

We use a centrally controlled irrigation system called Maxicom, see attached article that hit the press a couple years ago.

#### 4. The time that each round of watering takes per span

The Evapotranspiration rate for the day determines the amount of time it takes to water.

#### 6. The time of the day on average at which the maintenance is done (watering, mowing, etc)

All watering takes place at night, usually between 2 am and 8am.

#### 8. Importance of mowing the grass regularly

For areas that have been designated as turf, it is important to mow regularly to reduce the competition of invasive plants like noxious weeds as well as keep the stand of grass as healthy as possible to reduce the need for pesticides. More Info - <http://www.turf.msu.edu/mowing-lawn-turf>

Turf Crew Work	Time to complete activity once (Hrs.)			Total	Frequency of activity in a year			Total	Total time taken per year			Total	Total Cost per year			Total
	1	2	3		1	2	3		1	2	3		1	2	3	
Activity by Zone Priority---->																
Lawns-Fertilizing	107.3826	670.6524	612.3891	1390.42	4	3	0	7	193.2	194.1	0	387.3	\$ 15,887	\$ 74,101	\$ -	\$ 89,988
Lawns-Weed Control	107.3826	670.6524	612.3891	1390.42	2	1	0	3	96.6	64.7	0	161.3	\$ 7,843	\$ 24,692	\$ -	\$ 32,534
Lawns-Aerating	178.971	1117.754	1020.649	2317.37	2	1	0	3	160.8	108	0	268.8	\$ 13,534	\$ 40,817	\$ -	\$ 54,351
Lawns-Renovations	35.7942	223.5508	204.1297	463.475	6	5	2	13	112.8	126	47.6	286.4	\$ 8,051	\$ 41,907	\$ 14,909	\$ 64,866
<b>Irrigation Crew Work</b>																
Activity by Zone Priority---->																
Irrigation-Start up/Blow out	33	70.1	0	103.1	2	6.5	9	17.5	40.2	39.8	0	80	\$ 2,601	\$ 5,528	\$ -	\$ 8,129
Irrigation-Inspection/Repair	57.7	122.7	0	180.4	2	6.5	9	17.5	228	226.2	0	454.4	\$ 13,794	\$ 29,314	\$ -	\$ 43,108
Irrigation-Miss Dig Locations	8.2	17.5	0	25.7	2	6.5	9	17.5	45.2	45.2	0	90.4	\$ 2,870	\$ 6,098	\$ -	\$ 8,968
				0												
<b>Mowing and Hardscape Crew Work</b>																
Activity by Zone Priority---->																
Lawns-Mow w/ 72" rider	23.9	149.0	136.1	308.983	46	29	16	91	437	377	216	1030	\$ 40,831	\$ 160,343	\$ 80,559	\$281,733
Lawns-Edging	6.0	37.3	34.0	77.2458	14	6	0	20	145.6	69	0	214.6	\$ 3,099	\$ 8,380	\$ -	\$ 11,479
Lawns-String Trimming	11.9	74.5	68.0	154.492	46	29	16	91	257.6	179.8	62.4	499.8	\$ 20,416	\$ 80,172	\$ 40,279	\$140,867

**Interview 2:** Jordan Hemingway by Karl N: Jordan worked as a groundskeeper at a golf course for a few summers during high school and college.

Grass quality and health = priority one. Everything is secondary, your playing surface is key.

Greens even more so, they get additional watering and flushing to take care of hot spots (dry areas). The greens are designed to have a lot of drainage, I spent a lot of time spraying down greens with a large hose.

Granted, they keep track of usage, and adjust flow rates and times for weather patterns.

**Interview 3:** Cissy Westerkamp by Jenna Boeing. Cissy has been a real estate agent for 15 years in the Boston area. She is a very close family friend so this was more a conversation than an interview. The goal was to figure out what role real estate agents have as stakeholders if any.

*I asked how much the lawn plays a role in making a sale and if she ever gets involved in fixing up the lawn in order to raise the selling price*

-Never know what people are looking at/for and it depends a lot.

-She went to a listing today that was a 5 million dollar listing that she wouldn't pay 1 for. They had lots of land that they didn't take any care of it. They boast gardens, but didn't deliver so it depends on how you market it. A lot of people don't understand the value of a good lawn

-Another factor with lawns is that when there's a lot of property, a lot of people don't want to take up the responsibility of taking care (think oh we will have way too much to do) but what they don't realize that the new clean smaller properties they are buying are depreciating in value as they are living in it. All about the re-sale value that she doesn't think people are really understanding right now because most people want something new with a big house and a reasonable yard size. Having a nice size lawn or unique landscape that is maintained adds value to the property that people don't seem to be wrapping their heads around (having a pool is the same effect)

*I asked if she gets involved in fixing up the lawn of properties she is selling*

-It is against the law for her recommend a specific company that she hasn't tried. Can never steer somebody in a direction where they look like they are supporting other company's. She can tell people what she knows, give names if they ask, but can never send them directly to a company, so she doesn't get involved in that manner

-Whether she recommends that someone fix up their yard is very situational; if they want to bring in people who care about gardening she will encourage people to fix up the land, depends on the marketing angle you're coming from and also depends on how much work it would take to make the yard look better. If you have a really beautiful yard that just needs to be treated for grubs she will recommend it because it is an easy fix that delivers a lot of value, but if it isn't very obvious or the lawn isn't terrible, she doesn't get involved. Never recommends in ground irrigation systems though she does think they are effective, it is just too much for her to get involved in (a lot of up front investment and not a clear payoff in the market)

-When she was talking about her experience with a in-ground system she installed on her last home, she said it took a little bit to determine the proper schedule. You had to pay attention to the different zones and adjust it accordingly. There is a timer on her system and she has someone come in the spring and fall to turn off/on her system. She thought if we had a system to make sure it looked good it would work, but for the people that really care about the appearance of their lawn they have already found a system



(efficient or not) to achieve that and will be hesitant to change.

**Interview 4:** Chris Duprey by Jenna Boeing. Chris has been a real estate agent in the Boston area for past 6 years. We had a very brief phone conversation because he was on the run.

Chris said that he doesn't get involved in lawns. He will not recommend lawn services to people because he can't guarantee a higher market value for those services. It really depends on the buyer and the seller. If the lawn is really, really bad he may suggest to the owner that it might help sell if they fixed it up a bit depending on the house that is attached, but wouldn't put a number on how much they should spend or how much they will get in return. The lawn has to be big and bad for it to really make a difference.

**Interview 5:** Kevin at the arb by Ethan Wampler.

Ethan: Hi Kevin, I was curious about how much outdoor water the arb uses. Do you know if they water plants, or do they just let plants get watered naturally from the rain? If you have time, could you tell me about what it takes to maintain the arb?

Kevin: We do water new plantings using a water cart. I think it has a 200 gallon capacity. Other than that, we don't use water to maintain the plants. Other water usages might be for the bathrooms of the field offices and caretaker residences. The caretaker residences do have washer units (2). As far as I know, that is the extent of water usage in the arb.

Ethan: Does the arb use any fertilizers or pesticides? If so, how much and on what plants?

Kevin: We use herbicide (glyphosate) on invasive plants. This includes honeysuckle (*Lonicera tatarica*, *Lonicera mackii*, *Lonicera japonica*), buckthorn (*Rhamnus cathartica*, *Rhamnus frangula*), lesser celandine (*Ranunculus ficaria*), and possibly some others that I am not aware of. During our main invasive removal time (the winter) we probably use about 10 oz of mixed herbicide a week on average. I am forwarding your email to some people more knowledgeable than me about fertilizer and pesticide use. Tom is in charge of natural areas and Adrienne is in charge of some of the collections in the arboretum.

**Interview 6:** Tom and Adrienne from the arb by Ethan Wampler.

Could you help Ethan? He has questions about the Arb's fertilizer and pesticide use. I know we use herbicide on invasives, but I don't know if we use chemicals on anything else.

Adrienne: I do not use any fertilizer in the Peony Garden or the garden at the reader center. I am reluctant to use herbicides for any herbaceous weeds because of my concern about the the "good guys" that are surrounded by the weeds. My team hand-weeds all the herbaceous or digs any woody invasive a that have gotten too big to pull.

Tom: My name is Tom O'Dell and I am the Woody Plants and Trails Manager for the Botanical Gardens and Arboretum. Kevin is correct, our primary use of water outdoors at

the Arb is for watering new plantings. That includes watering at the time of planting and then watering the plants as needed thru the growing season. The amount of water needed varies year to year and depends on the number of plantings and seasonal rainfall. We do fertilize our newly planted trees and shrubs at planting time with an organic fertilizer and do some supplemental feeding with a liquid organic fertilizer thru the first growing season. I do spray a small amount of insecticide in the Spring to control leaf eating insects on our Rhododendrons.

### **Observations with Homeowners**

**Interview 7:** Eric Shealy performed by Jenna Boeing: Homeowner of a house in Wellesley Massachusetts with a very nice yard. Lives in a low lying area near a pond and often there is flooding around his house.

*When I told him I was calling to talk to him about his lawn because I love his beautiful yard the first response was:*

-Well first Jen you have to understand the deep male need for a nice lawn, its a definition of success to come home to a luscious green yard (he was being a bit emphatic)

*I asked how he managed the upkeep.*

-He needs sprinkler system to keep it so green, flooding of groundwater only happens in certain areas of the neighborhood and the heat will burn the grass and it will go dormant without water, keeps it thick to keep the crabgrass out

*I asked the controller to his sprinkler system:*

-His is on a timer. He messes around with it sometimes to make areas that look parched liven up, but it's pretty much auto-pilot; come once a year to blow out the pipes, sometimes will notice a head will be missing but not maintenance otherwise, automatic off when it rains

-Not hooked into the weather grid it's pretty much a cup with water and when the water dries up it will start going again

*I told him that we were thinking about designing a smart controller and asked if he thinks that something he would be interested in*

-If it makes the lawn that much better, people would pay for it, wireless probes that could give feedback for the soil would be the most useful he thinks. Soil is very specific, amount of water that a lawn needs is more related to the underlying soil and how the lawn is exposed to the direct sunlight so a control system would be unique for each lawn to be most effective. He thinks the bigger concern than water is the concentration of fertilizer because most people completely over fertilize and thats whats really bad for the environment with run off. If a soil monitor could electronically tell you moisture content and fertilizer it would help people realize they don't have to fertilize as much which would cut down on cost and environment run off

-Run off and contaminates going to the nearby river is a really bad in the area and people over fertilize with harmful products and then the rain drags it to the river.

-He's careful about not over fertilizing and gave the impression the people in his neighborhood were not, but didn't seem to be worried about over watering by himself or his neighbors

**Interview 8:** Sue Ullrich: single, early 70's homeowner with about a quarter acre of yard and an automatic sprinkler system

-Has an automatic sprinkler system that is turned on in the spring and winterized in the Fall by an outside company.

-They set her four lawn zones when they turn on the system in the spring. She has her lawn timer set to water on even days because she has an even number house and the neighborhood is trying to reduce peak water usage by staggering watering to every other day.

-The timer is set to water around 4am because this is the most efficient time to water her lawn. The company typically comes in the spring with an idea of how her system should be configured. Usually, 10 min of watering every other morning. She has to tell them to only do 3 min on the zones between houses because there is significant overlap between her system and her neighbor's such that they would excessively water if they didn't turn down the system.

**Interview 9:** Don and Kristi Nagengast performed by Karl Nagengast: married, mid 50's couple that only water their front lawn with an automatic sprinkler system

-They have a separate meter for lawn water, which is pumped directly from nearby Lake Michigan and is not potable. As a result, they do not have to pay a sewer fee for watering their lawn; significantly reducing the cost. Despite this, they still pay ~\$50/month for irrigation and ~\$15/month for indoor water usage during the summer.

-They water their lawn on a timer every morning at 4am for 20 min. This time is partially decided by when they start their day in order to avoid reducing water pressure for showers. Don does all of the work on the system himself including starting the system in the Spring and winterizing. He said that the hardest part of setting up the system is achieving uniform water penetration.

-Typically, turning down the volume of water results in dry spots springing up where sprinkler coverage is lower

**Interview 10:** Lan Nguyen performed by Ha Nguyen. Lan is 30-40 years old, housewife, married, 2 adults & 3 kids in a house in the suburban area of Ann Arbor.

*1. Hi Lan, it's so nice to meet you again. I see you have a very beautiful lawn in front of your house. Do you mind if I ask what do you keep your lawn for?*

Oh, simply to make my house beautiful; it's also for my neighborhood. We have an agreement between residents: every house owner needs to keep their yard clean and beautiful, if I don't take care of my lawn, my neighbor will remind me. Another reason is to have a good place for my kids to play in.

*2. Wow, that's why all the houses in your area look so beautiful. So what are your requirements for a good lawn?*

The most important one is the greenness. Secondly, soft & smooth; the grasses shouldn't be too high – I mow them frequently, each time I can only cut about 1/3 of their height. Besides, there mustn't be weeds – it's very important because they make the lawn very ugly.

Oh, it's for summer. In winter, I don't need to care much because the grasses all die.

3. *You seem to set a high standard for your lawn. So is taking care of your lawn your hobby?*

No, it's rather a duty to keep your house beautiful. Also, mowing or weeding is a good exercise for my husband.

4. *Did you choose the type of grass for your lawn?*

No, it had been already grown before I bought this house; so I just kept maintaining it. If I had to start from beginning, I would definitely choose the suitable type.

5. *How often do you water your lawn?*

3 times a week, but it also depends on the weather. If it's sunny & hot, I'll water more; if it rain, I'll water less, even skip.

6. *So do you water all year around?*

No, I only water for about 5 months in summer. I don't water in winter.

7. *When do you water your lawn? In the morning, during the day, or evening? And for how long?*

In the morning, 3 times a week, and for 20 mins each time

8. *Do you care about the amount of water used for maintaining your lawn?*

Of course, because watering the lawn requires a lot of water, especially when I want to keep my lawn green in the summer.

9. *Do you think your current irrigation system is wasting some water?*

I don't think so. I use the sprinkler system and it only focuses on the grass, so I think my system is quite efficient.

10. *You said you adjust the amount of water depending on the weather. So does your system automatically take account of the weather forecast?*

Oh, no. I only have a time setting when it starts and for how long. In terms of weather, I have to control manually: if I see it rains, then I will turn off the sprinkler sooner. Sometimes, right after I finish watering, it rains.

11. *Do you consider changing your irrigation system to a more efficient one?*

No, the irrigation system is pretty expensive and mine is efficient enough. Also, changing is not simple. In fact, I only need to water for 5 months a year, and I can still afford the water bill.

12. *If there is a product or service claiming to save lots of water for maintaining your lawn, do you considering buying or using it?*

As I said, if I need to buy a new whole system then No. However, if it can ensure to save tons of water and using it is not complicated, I will consider.

13. *Thank you Lan.*

**Interview 11:** Interview with Lien Dang performed by Ha Nguyen. Lien is 30-40 years old, housewife and half-time student, married, 2 adults & 2 kids in a small house in the suburban area of Ann Arbor.

1. *Hi Lien, it's so nice to meet you again. I see you have a small lawn in front of your house. Do you mind if I ask what do you keep your lawn for?*

For the cleanliness, beauty and a playground for my kids

2. *So what are your requirements for a good lawn?*

I don't have a high requirement for my lawn. Just be clean and neat, that's enough.

3. *Do you like taking care of your lawn? I mean is it one of your hobbies?*

- No. I'm too busy with studying and taking care of my family.
4. *Do you care about the type of grass for your lawn?*  
Not much. I just use the popular type as other.
  5. *How often do you water your lawn?*  
Haha, I don't water my lawn at all. I let the grass grow naturally from the rain water, and it's enough.
  6. *Do you think irrigation for lawn wastes water?*  
Of course, that's why I don't water. And my lawn is still relatively good though it's not very green, but I don't set a high standard for it, so it's ok.
  7. *If there is a product or service claiming to save lots of water for maintaining your lawn, do you considering buying or using it?*  
Probably yes.
  8. *Thank you Lien.*

**Interview 12:** Roger Johnson by Ha Nguyen. Roger is 40-50 years old, employee, married – husband, 2 adults & 3 kids in a house in the countryside outside Detroit, gardening enthusiast.

1. *Hi Rogers, I see your hobby is gardening. Do you mind if I ask how big is your yard?*  
It's relatively big, about 9-10 acres. The rear yard is bigger than the front. I even need to use a riding mower for my lawn.
2. *Wow, I'm very impressed. Why do you keep your lawn?*  
Just for some beauty and a place to play in. Actually, I like my garden much more than the lawn. I have 2 oak trees, a maple tree and tons of flowers.
3. *So what are your requirements for a good lawn?*  
Very simple, I only need it clean and tidy. I let all native plants growing in my lawn, so I have a mix of many different grasses, whatever can grow and survive. Some people like their lawn to be really soft and smooth but I like it as natural. However, I have to cut so that they're not too high. My lawn is about 4-5 inches high.
4. *So is taking care of your lawn your hobby?*  
Probably though I don't spend much time for it. I love gardening much better, I like growing flowers and green trees.
5. *Did you choose the type of grass for your lawn?*  
As I said, I let them grow naturally. Whatever grass can grow and survive. I have clovers, plantains, dandelions, and many types of grasses.
6. *How often do you water your lawn?*  
I don't water at all. It will be a huge amount of water if I water them since I have quite a big yard. Even the garden, I only water when it's too dry.
7. *But is your lawn green?*  
It's not super green like some people require, but green enough for me. Naturally, you know. Oh, I can show you some photos of my garden. (it look very green) Fortunately, we live in Michigan so the rain helps a lot.
8. *How can you keep your lawn green without watering?*  
Actually, many people like their lawn very green and soft, so they cut the grass very low. This requires much more water than a high lawn. Since I keep my lawn tall, about 5

inches, I only need to mow once a week and I don't need to water. My lawn naturally grows, all of the plants are native so they are stronger, and their roots are deeper to be able to get the water and nutrition inherent in the soil. When I mow, I also leave the clippings on the lawn to help keeping the lawn moist; they also provide nutrition for the lawn. Thus, I don't need to use fertilizer either. Basically, whatever can grow and survive, let it grow. Just follow the nature.

*9. Do you think the lawn irrigation system is wasting water?*

Definitely, and I think watering lawn is not necessary provided that you know some tips to keep it grow naturally and beautifully.

*1. If there is a product or service claiming to save lots of water for maintaining your lawn, do you considering buying or using it?*

Probably not, since watering lawn is not necessary. Though it can save water, the water bill for will still be very high if I water my lawn.

*11. Thank you so much Roger.*

**Interview 13:** Sharon Ongaro by Ha Nguyen. Sharon is 60-70 years old, retired, married – wife, 2 adults in a house in suburban area of Ann Arbor, sustainability enthusiast.

*1. Hi Sharon, I see you are very interested in sustainability. Do you have a lawn in your house?*

Yes, the front yard. It's not big though.

*2. So why do you keep your lawn?*

My house looks more beautiful with a lawn. Also it's a place to sit and play, especially when my grandchildren visit me.

*3. So what are your requirements for your lawn?*

I only need it clean and tidy. I don't need it very green like others.

*4. So is taking care of your lawn your hobby?*

No, I just let it grow naturally. I only mow once a week and actually the grass is higher in my lawn than in others.

*5. How often do you water your lawn?*

I don't water at all. The rain is enough for my lawn, and in winter all the lawn is frozen so no need to water either.

*6. But is your lawn green?*

It's relatively green, probably brownish green for some people. Actually, you can tell which houses water the lawn, which don't from seeing the color of their lawns.

*7. How can you keep your lawn green without watering?*

The most important thing is to mow your lawn high. I keep my lawn as highest as possible (in the setting of my mower), about 3-3.5 inches. In fact, the root of the grass is as long as the height above the ground; thus the higher you let your grass grow, the longer the roots are. The longer roots help the grass get sufficient water and nutrition from deeper soil. So they can survive even if you don't water. Of course, they don't look as beautiful as those watered frequently.

There are some residential areas where you are required to keep your lawn green and beautiful but fortunately I don't live there. I like to save as much resources as possible, it's better for the environment. Even I prefer hanging clothes outside my house to let them

dry under the sunlight and wind; it's very popular in many European countries where people are more aware of sustainability.

8. *Do you think the lawn irrigation system is wasting water?*

Of course, and I think watering lawn is not necessary.

9. *If there is a product or service claiming to save lots of water for maintaining your lawn, do you considering buying or using it?*

Probably not, since watering lawn is not necessary.

2. *Thank you so much Sharon.*

**Interview 14:** Lan Nguyen performed by Ha Nguyen. Lan is 30-40 years old, housewife, married, 2 adults & 3 kids in a house in the suburban area of Ann Arbor. She has already used sprinkler system.

1. *Hi Lan, I see you have a very beautiful lawn in front of your house. Do you mind if I ask what do you keep your lawn for?*

Oh, simply to make my house beautiful; it's also for my neighborhood. We have an agreement between residents: every house owner needs to keep their yard clean and beautiful, if I don't take care of my lawn, my neighbor will remind me. Another reason is to have a good place for my kids to play in.

2. *So what are your requirements for a good lawn?*

The most important one is the greenness. Secondly, soft & smooth; the grasses shouldn't be too high – I mow them frequently, each time I can only cut about 1/3 of their height. Besides, there mustn't be weeds – it's very important because they make the lawn very ugly.

Oh, it's for summer. In winter, I don't need to care much because the grasses all die.

3. *Do you use any fertilizer for your lawn?*

Yes, 4 times a year. We do it by ourselves.

4. *So do you care about how much fertilizer is enough?*

Yes, we follow the manufacturers' instructions.

5. *Do you care about the type of fertilizer to use? For example, do you use bio-friendly or organic grade?*

No, I just use the regular type.

6. *When do you often use fertilizer?*

From spring to late fall marked by the us public holidays: mother day, memorial day, labor day and veteran day. Grass hibernates during winter time so we do not do anything.

7. *How frequently do you mow your lawn?*

Once a week during spring, about every other week during summer. And we do it by ourselves; it's a good exercise for my husband.

8. *How high do you mow? And when do you usually do it?*

We just cut off about 1/3 the length of grass, so about 2-3 inches. We mow in late afternoon, before watering.

9. *What do you do with the grass clippings?*

We put them in the trash bag.

10. *In term of watering for your lawn, do you know roughly how much you pay?*

About 30% of the total water bill.

11. *Do you water your lawn? And how frequently?*

Yes, of course. 3 times a week, but it also depends on the weather. If it's sunny & hot, I'll water more; if it rain, I'll water less, even skip.

12. *For how long? And when?*

About 20 minutes each time; in the morning.

13. *Do you water your lawn all year?*

No, I only water in the summer, so about 5 months.

14. *Do you use the sprinkler system?*

Yes

14. *Why do you use it? Do you think it saves more water than using hose?*

Yes, I do. Save our time and energy for sure

16. *What kind of the controller do you use? Does it take account of the weather forecast or the soil moisture?*

No, we just use the one with timer setting. So I have to turn it off when it rains. Sometimes, right after I finish watering, it rains.

17. *Do you think it works efficiently? Have you seen any runoff problem in your lawn?*

Yes, I think my system is pretty good. I see runoff sometimes but not much.

18. *Are you interested in implementing your irrigation system so that it can save more water?*

Of course, because watering the lawn requires a lot of water, especially when I want to keep my lawn green in the summer. I want to reduce water bill as much as possible.

19. *So how much do you want to see the water saving from the new system?*

20% at least.

20. *If there is a lawn care service, what extent do you want it to take care?*

Oh, everything related to lawn maintenance: mowing, fertilizing, and watering. I want to save our time.

21. *Are you willing to replace your current type of grass by the native plants, which require less water & care?*

No. We are happy with our current grass and lawn.

21. *If considering using lawn care service, what do your concern? For example, the cost, payback time, etc.*

Yes, payback time is important for me. 2 years I guess.

23. *Which one do you prefer, paying off all the cost or paying monthly rate with a contract?*

I have to see how much I have to pay totally, then I can compare and decide.

24. *If there's a warranty that you see the water bill saving (as soon as using the service) is greater than the monthly rate you pay, are you more willing to use the service?*

Yes

25. *Do you still want to use the service if it requires you to change your habit of taking care your lawn (e.g reduce the fertilizer, let the grass grow higher)?*

Yes

26. *What do you often rely on when selecting company of similar lawn care service?*

Their experience and the cost of the service; I also have a priority for local companies.

27. *Do you like to see your neighborhood use the same lawn care service like your house?*

Yes, if it bring benefits to the community.

28. *Do you have any other concerns related to lawn maintenance?*

Yes, weed control is also a problem in my lawn.



**Interview 15:** Bill Connett performed by Ha Nguyen. He is 60-70 years old, Professor at UofM, married, 2 adults in a house in the suburban area of Ann Arbor. He is also highly aware of environmental problem.

*1. Hi Bill, I see you have a very beautiful lawn in front of your house. Do you mind if I ask what do you keep your lawn for?*

I think just for the beauty and also for keeping things cooler and cleaner.

*2. Is it required to have a lawn in your neighborhood?*

I'm not sure it is required to have a lawn but I do know that Ann Arbor has some laws about lawns. Something to the effect that they can't be allowed to grow wild I think. However, it is something that is sort an unwritten expectation in my neighborhood.

*3. So what are your requirements for a good lawn?*

Very green - so green it hurts your eyes. We lived in Montana for 12 years where everything turns brown in the summer. It's so great to have a beautiful green neighborhood.

Thick enough to not show the soil.

Clean, definitely.

Watered so it stays green in hot weather... up to a point. If we go without rain then the city restricts watering to every other day and we tend to let the grass turn brown rather than create a water problem for the city.

*4. Wow, sounds a lot. So what is the most important feature you require?*

I think neatness is an important feature sort of a combination of all of the other attributes.

*5. Do your neighbors care about your lawn?*

They do care. The quality of care definitely varies but there is a self-imposed concern about trying to keep the neighborhood nice. The neighbors probably would not say anything if my lawn was a mess but we don't want them to think badly about the condition of our property and it also might hurt the value of our house and our neighborhood.

*6. Do you use any fertilizer for your lawn?*

We have a lawn service that uses non-phosphate fertilizer about 3 to 4 times a year.

*7. So do you care about how much fertilizer is enough?*

They decide on the concentration but we have changed our lawn service because we felt they were trying to apply fertilizer too often. We hired a different one that seemed to care more about environmental issues.

*8. Do you care about the type of fertilizer to use? For example, do you use bio-friendly or organic grade?*

Yes, we do care and not only because in part it is the law. We prefer to not have runoff into the water drains and to not use any more than necessary to keep the grass healthy.

*9. When do you often use fertilizer?*

The service does spring, and I think early summer, late summer and fall. It is better to apply smaller amounts more frequently than large amounts fewer times.

*10. How frequently do you mow your lawn?*

The service mows our lawn and we instruct them to mow it weekly.

*11. How high do you mow? And when do you usually do it?*

3 inches. They usually come in the morning but can be most anytime.

12. *What do you do with the grass clippings?*

The mowers mulch them so they go back into the lawn.

13. *Do you water your lawn?*

We only water when it is necessary and usually in the early evening. Some summers we don't have to water at all. And we would prefer to mow before watering.

14. *What type do you use for watering your lawn? Hose or sprinkler system?*

We use hoses for watering but have a micro sprinkler system for flowers, garden, etc. I enjoy "engineering" and maintaining the little sprinkler system. It is very water efficient.

15. *Do you care about the amount of water used for your lawn?*

We do and try not to use more than necessary to keep it healthy.

16. *Do you know roughly how much you pay for watering your lawn?*

Oh, good question... we don't know. The city does some averaging with the water and also charges for different levels of use. We try to stay in the lower tiers but do move into the higher one sometimes during hot summers.

17. *How frequently do you water your lawn?*

Only as much as necessary... generally not more than three times a week

18. *For how long? And when?*

Maybe an hour... hard to say as we move the sprinklers around and some parts need more than others.

19. *Do you adjust the amount of water depending on the weather?*

Yes, we don't water if there is sufficient rain. But we often get rain in small amounts and the soil dries out fast. This is especially true if you have sandy soil or if there is a lot of clay so the water runs off.

20. *How many months of the year do you water your lawn?*

In a dry year maybe 4 - 5 months. In some years, not at all. We love it when there is enough rain that we don't need to water.

21. *Back to the irrigation system, do you think using sprinkler consume less water than using hose?*

I'm not sure there is too much difference between a full lawn sprinkling system and using hoses. My thought is that the underground sprinkling systems probably use more water but do a better job. And it is more likely they use more water due to the ease of using them, not so much the engineering.

22. *So you think your watering habit is efficient?*

Kind of. We water in the evening when evaporation is lower and also we use sprinklers on the hoses that don't spray up into the air so much.

23. *Do you care about the water runoff when watering your lawn? Have you seen this happen with your lawn?*

We do care because of the waste and also because we don't want fertilizer and chemicals to run into the drain water and creeks and rivers. We have seen it occasionally. Mostly when we didn't pay attention but not very often.

24. *Are you interested in implementing your irrigation system so that it can save more water?*

Of course, because of the loss of water and also the cost.

25. *Are you interested in buying a lawn care service that can reduce your water bill?*

Probably. We use some deliquescent balls in some of our flowerpots that store and release water but not sure of such things for lawns. We also have had the lawn service aerate our lawn but it hasn't seemed very effective.

26. *So how much do you want to see the water saving from the new system?*

As much as possible, but I'm somewhat skeptical that we could save very much.

27. *If there is a lawn care service, what extent do you want it to take care?*

Oh, I want mowing and fertilizing.

28. *So you don't want a service on irrigation, or consultation?*

No, it would be fun to do watering by ourselves. I don't trust the consultation. For example, for our mowing service, we generally have to insist on how they mow the lawn they always want to cut it too short.

29. *Are you willing to replace your current type of grass by the native plants, which require less water & care?*

Actually, I would be interested if we could get the neighborhood to do it and if it didn't destroy the ability to use the lawn for other things

30. *If considering using lawn care service, what do your concern? For example, the cost, payback time, etc.*

Cost and installation time is important. That type of lawn work is very expensive. We have had it done and it was Thousands of dollars. And we would probably do some of that work by ourselves.

Payback time, I doubt if we could get any reasonable cost recovery from reduced water bills. I'd prefer to try rain water barrels, etc. if that was the purpose or perhaps a combination.

31. *Which one do you prefer, paying off all the cost or paying monthly rate with a contract?*

Probably a monthly rate if it was affordable.

32. *If there's a warranty that you see the water bill saving (as soon as using the service) is greater than the monthly rate you pay, are you more willing to use the service?*

I think so but it would be this complicated balance between savings, esthetics, eco benefits, etc.

33. *Do you still want to use the service if it requires you to change your habit of taking care your lawn (e.g reduce the fertilizer, let the grass grow higher)?*

Perhaps, though if we let our grass grow higher it would fall over and that would definitely change the appearance, the ability to mow it, etc so we would have to learn new things, etc... Small changes may create larger issues.

34. *What do you often rely on when selecting company of similar lawn care service?*

Their program, cost, care of work, and environmental care.

35. *Do you like to see your neighborhood use the same lawn care service like your house?*

I would be happy to have one service for the neighborhood but it seems a little unrealistic the way things work in a neighborhood. There is some of that now. It's pretty common to have one service taking care of three to five other houses, just due to word of mouth advertising.

36. *Do you have any other concerns related to lawn maintenance?*

Yes, weed control and insect control. Japanese beetle grubs are a major issue that destroy grass lawns, and other pests like moles. Also there are issues of bird feeders which bring many other little creatures that affect the lawn and create other problems.

**Interview 16:** Michiko Kurabayashi performed by Ha Nguyen. She is 50-60 years old, housewife, 2 adults in a house in the suburban area of Ann Arbor.

1. *Hi Michiko, I see you have a beautiful lawn in front of your house. Do you mind if I ask what do you keep your lawn for?*

We are the second home owner. We bought the property with the already existed lawn. We have maintained it because green lawn in general makes the property look better and more saleable.

2. *So what are your requirements for a good lawn?*

Just simple green. Thick enough, mine is about 2 inches. Relatively clean. Also, I guess we have moles under the ground; they make holes all over our yard; so I hope we get rid of them.

3. *Do your neighbors care about your lawn?*

I think so. Seeing well-maintained yard while they are walking with their pet(s) is such a pleasure.

4. *Do you use any fertilizer for your lawn?*

Yes. Our professional lawn care service starts in April and ends in October. They come here for 7 times within 6 months.

5. *So do you care about how much fertilizer is enough?*

I don't do anything by myself and have no idea of what to do.

6. *Do you care about the type of fertilizer to use? For example, do you use bio-friendly or organic grade?*

I don't know, they do it for me.

7. *How frequently do you mow your lawn?*

The professional we hire come here to mow the lawn once a week.

8. *How high do you mow? And when do they usually do it?*

About 2 inches high. Sometimes they come in the afternoon, other times they come in the morning. They usually come to do their job at the beginning of the week, either Monday or Tuesday.

9. *What do you do with the grass clippings?*

I don't know what they do but it seems to have nothing left after they finish the job.

10. *Do you water your lawn?*

We don't water the lawn. We have had enough rainfall in the last couple of years.

11. *But when you water your lawn, do you use hoses or sprinkler system?*

We use hoses. We never water the lawn unless a draught happens.

12. *Do you know roughly how much you pay for watering your lawn?*

As I said above, we haven't watered the lawn in the last few years. When the draught happened in the past, I believe our water bills went up \$30-\$40 a month.

13. *Do you think using sprinkler consume less water than using hose?*

It is better to have sprinkler systems but we have enough rainfall to water the lawn naturally. Also once we have sprinkler systems, we have to hire professionals to expel all the water from the irrigation systems before winter comes.

14. *Do you care about saving water for lawn care, and why?*

Of course, because the water bill goes up.

15. *Are you interested in buying a lawn care service that can reduce your water bill?*

If it's watering stuff, then no because as I said, I don't need to water my lawn.

16. *If there is a lawn care service, what extent do you want it to take care?*

I need mowing and fertilizing; and I'm hiring professionals to do it for me.

17. *Are you willing to replace your current type of grass by the native plants, which require less water & care?*

No, it is too much work to choose something else to replace.

18. *If considering using lawn care service, what do your concern? For example, the cost, payback time, etc.*

We have had this service already. No concern at all. But if I had to choose a new service, I'd consider about the price, and the quality of their work.

For mowing the grass, we pay \$25 per service. For fertilizing, we pay \$400 for 6 months service.

19. *Do you still want to use the service if it requires you to change your habit of taking care your lawn (e.g reduce the fertilizer, let the grass grow higher)?*

It's too much to think if I need to change. That's why I'm hiring professionals do those stuffs for me, I don't want to worry about mowing or fertilizer.

20. *Do you like to see your neighborhood use the same lawn care service like your house?*

If majority people like it, why don't I join them to enjoy it as well.

21. *Do you have any other concerns related to lawn maintenance?*

We have moles under the ground; they make holes all over our yard; I hope we get rid of them.

**Interview 17:** Lisa Boeing performed by Jenna Boeing. She is a 50 year old housewife with a home in Bedford Massachusetts.

*I outlined the concepts and asked for feedback.*

Individual ones is more reasonable, something that automatically turns on and turns off. Everyone can control their boxes but no one does. Thinks its better to have an individual controller (even in a town half the town could). Would want something tailored to her needs, not something. As a consumer the expense of water is the most important and it is going to be going up. Conserving water and bringing down the cost of the bills, many consumers know that water is scarce and "I hate seeing lawns being watered, it's a huge waste." Have a system at their house that deals with their individual needs, unless you could say this is much more efficient and cost effective and worry free. How trustworthy is it. One of the good things about having a grid type system is that you could update your algorithm based on new technology.

*I asked about financials and what incentives would be reasonable.*

I don't really trust a pay back period, the only thing you can trust is if your paying a lot less. Would rather see reduction in the long term and need to pay upfront. Not worth it to do a monthly trial based thing. Paying a monthly fee versus a yearly thing is very personal and depends very much on what you are offering. In terms of how much time reduction, she thinks that 10% sounds reasonable but somewhere between 10-25 would be ideal. Some people enjoy spending time on their line.

The neighbors have been repairing their sprinkler system for 3 weeks and it has taken way too long. With a good workforce it should have only taken one at most. 5 would be a reasonable target for the repair time.

If you can give me a green lawn and I am paying less, sign me up. It's the bottom line. And hassle free, don't even have to think about it.

## **Appendix 2: Concepts Generated**

In this appendix, we will discuss all of our concepts that we generated.

### **Sprinkler/Smart Controller Systems**

One idea involves selling or leasing smart controllers to people with existing sprinkler systems. A smart controller is a device that takes into account how much moisture is in the soil and predicts upcoming weather patterns in order to only water lawns when necessary. These smart controllers would greatly reduce wasted water due to overwatering, saving the customers money on their water bills.

Another idea involves using one smart controller or some sort of weather monitoring service for an entire community/neighborhood. We would monitor the weather of entire subdivisions and determine how much to water everyone's lawn based on things like upcoming weather, moisture levels, etc. We could monitor the subdivision with satellite images, flyovers, or some other means. We would monitor things like how green the grass is, and other traits people find important.

Another idea involves doing sprinkler system maintenance in residential areas. We would evaluate residential sprinkler systems and fix and/or optimize it for them. We would check for leaks to make sure no water is being wasted that way. We would also make sure all sprinkler heads are pointed in correct directions and that they have an appropriate nozzle for how much lawn area they need to water.

### **Landscaping**

One idea involves taking care of all aspects of residential lawns. This includes the three most important aspects of lawn maintenance: mowing, watering, and fertilizing. They are all related to each other. For example, if you fertilize or water too much, you end up having to mow more. From our research, many people tend to over water who have sprinkler systems. Many people also over fertilize. By offering all 3 services to people, we would mow, water, and fertilize the right amount to maintain a healthy lawn, which is less than what many people do now. This would significantly reduce the amount of water and fertilizer used, saving the customer money.

Another idea involves offering a landscaping company that uses native plants. We would offer rain gardens as well, which customers like for their appearance, and they significantly reduce runoff during storms. Native plants typically would not need any additional

watering other than rain, because they have adapted to the amount of rain their environment receives. We would offer to replace as much turf grass with native plants as customers want. By having some native plants (and less grass) customers' lawns would require less water, saving them money and enhancing the beauty of their lawn.

### **Rainwater/Greywater use**

One idea involves saving the customer money by collecting rain water in cisterns for lawn irrigation. Because there is a large spike in water usage during the summer, we believe that this could potentially save customers a lot of money who water their lawns, while reducing water demand to the city. We would set up rain water collection that would feed to water tanks, which would be hooked up to the customer's sprinkler system.

Another idea involves collecting greywater from the customer's house. This would save the customer a money by reusing water that is relatively clean for lawn irrigation, instead of simply sending it to the sewer. It would also reduce water demand. This would involve retrofitting the customer's house to collect used water from sinks, showers, washing machines, etc. We would then treat the water, so it could be used for lawn watering.

### **Lawn Consultants**

One idea involves an interactive website that people can use to get any information they need about what their lawn needs. We would also have options for how involved they want to be. For instance, for customers who like do-it-yourself projects, they could choose to water, mow, and fertilize their lawn themselves, and we would provide them unique information to their area and lawn to optimize everything. The user would then choose how much they want to do.

Another idea is that we would offer a consulting service to customers. They would come to us if they wanted to optimize their sprinkler system and/or lawn care. We would give them advice that is specific to their area and lawn. Clients could be homeowners or even customers who own larger portions of land, like apartment complexes or company buildings.

## **Appendix 3: Survey Results**

Survey Design:

We are a team of students at the University of Michigan, trying to develop a service that will make lawn care easy for homeowners and benefit them with reduced water bills. Please take about 5 mins to complete this survey.

**\*1. How important are the following lawn maintenance attributes to you?**

	Very Important	Somewhat Important	Neutral	Unimportant	Very Unimportant
Appearance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Minimizing Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Minimizing time spent on lawn maintenance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other (please specify)

**\*2. How often do you perform the following lawn maintenance tasks?**

	0	1	2	3	4	> 4
Watering (times per week)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mowing (times per month)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fertilizing (times per year)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weed & Pest Control (times per year)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**\*3. Do you currently have a sprinkler system installed for your lawn?**

- Yes
- No

Other (please specify)

**\*4. If yes, would you pay to improve watering efficiency (reduce water bill) of your sprinkler system by predicting weather patterns?**

- I would like it that way
- It must be that way
- Neutral
- I am OK if it is not that way
- I do not like it that way

**\*5. Would you like to hire an expert to take care of your Lawn for you?**

	I'd love that	I'd like that	Neutral	I don't like it	I really don't like it
Watering	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mowing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fertilizing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weed & Pest Control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Or if you would prefer a particular service (please specify)



**\*6. How would you like it if a central system for your neighborhood controlled your lawn watering cycles?**

- I would like it that way
- It must be that way
- Neutral
- I am OK if it is not that way
- I do not like it that way

**\*7. How much grass would you be willing to replace with native plants, which require less watering and maintenance?  
(see picture below)**

- All
- Some
- None

**Picture showing a lawn containing Native Plants**



**\*8. What would be a good payback period for an investment in your lawn (in terms of water savings)?**

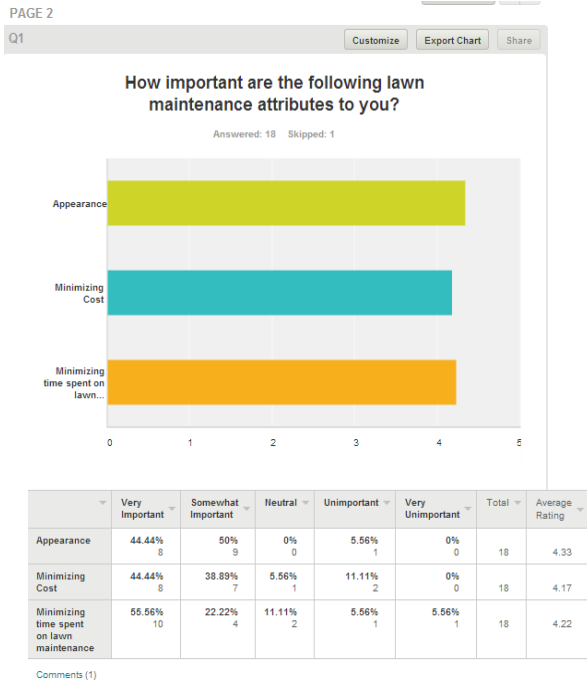
- 1 year
- 2 years
- 3 years
- >3 years

Other (please specify)

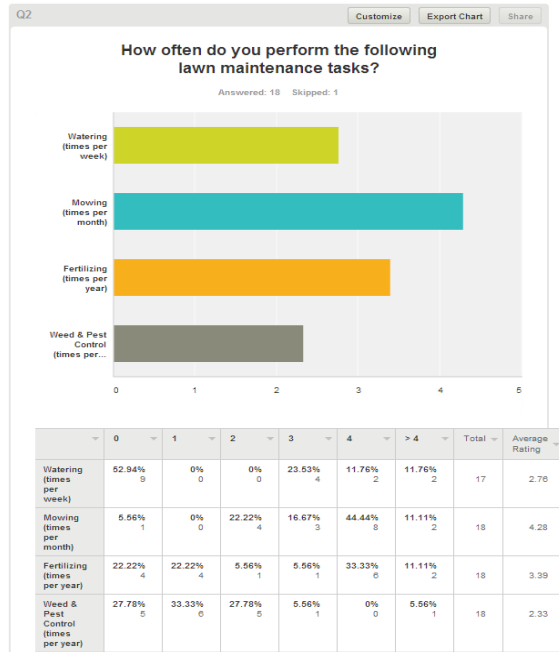
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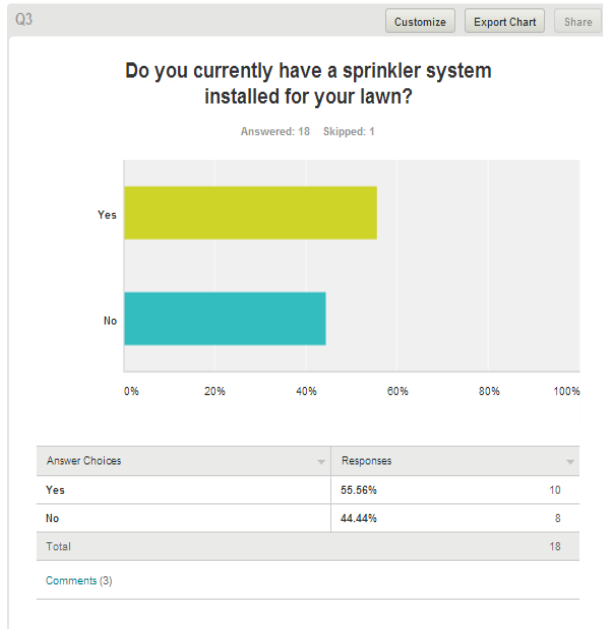
# Survey Results: Q1.



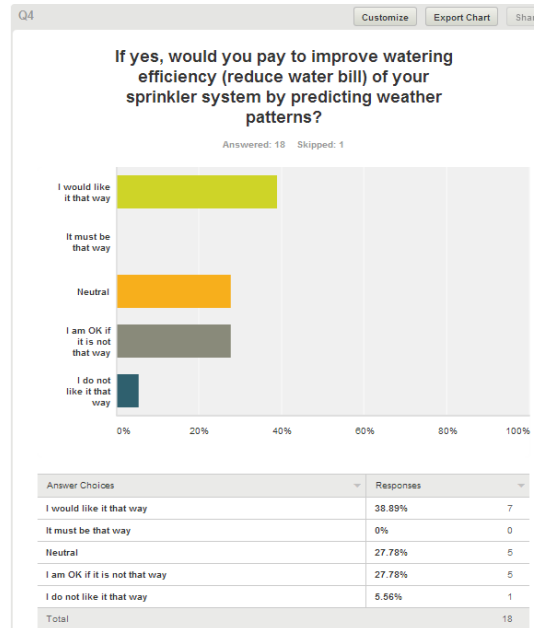
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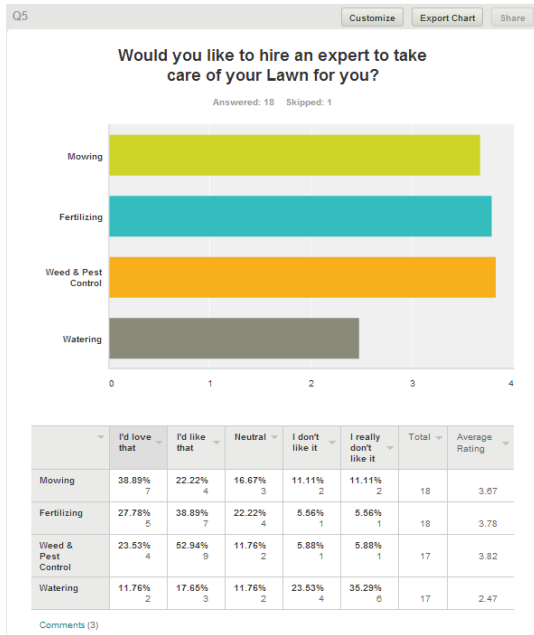
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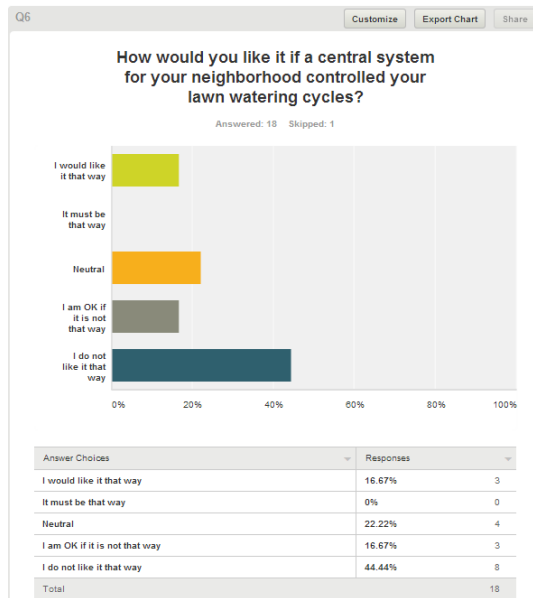
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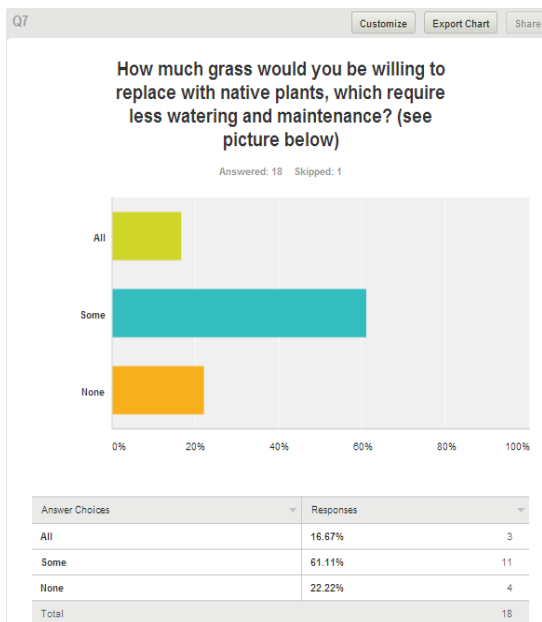
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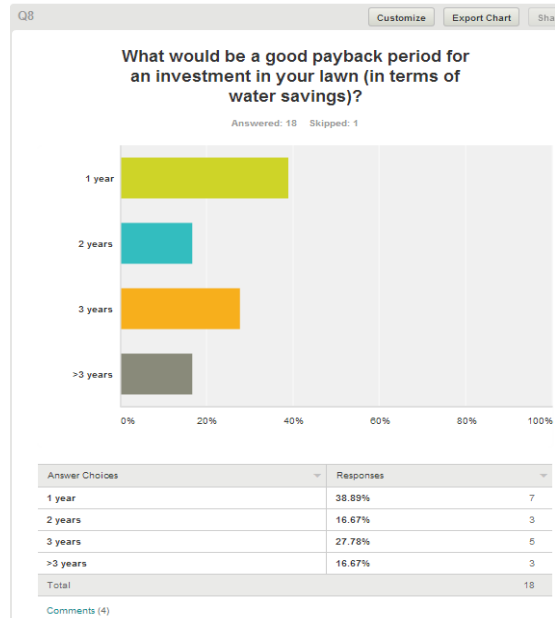
Q6.



Q7.



Q8.



Pugh

Matrix:

Evaluation

of

11

concepts:

**Pugh Selection Matrix**

Legend:

2	Highly Positive Impact
1	Positive Impact
0	No Effect
-1	Negative Impact
-2	Highly Negative Impact

Title

Project

Name

Date

Delete

Make Datum

Item	Requirement	Overall Importance	Sprinkler System with no smart controls	Concepts												
				1	2	3	4	5	6	7	8	9	10	11		
				Complete Lawn Care Service	Native Plants Landscaping	Turf Edging Service	Smart Controls Installation	Sprinkler System Maintenance	Neighborhood Wide Control System	Rain water collection	Grey Water Re-use	Consulting Service	Web-based Consultancy	Education Program for existing Lawn Companies		
1	Reduction of water bill	3	D a t u m	+1	+2	0	+1	+1	+1	+1	+1	+2	+1	+1	+1	
2	Reduction in time spent by customer on lawn care	9		+2	+2	0	0	0	0	0	0	0	-1	-1	-1	-1
3	Minimizing Operating Cost	3		-2	+2	0	+2	+1	+1	0	0	-1	0	0	0	0
4	Quality of grass-Blade Density	9		+2	0	0	+1	+1	+1	+1	0	0	+1	+1	+1	+1
5	Quality of grass-Greenness	9		+2	0	+1	+1	+1	+1	+1	0	0	+1	+1	+1	+1
6	Start-up (Installation) time	1		+2	-2	0	+1	0	0	-1	-1	-1	+1	0	0	0
7	Pay back period	3		-2	-1	0	-1	0	0	+1	+1	+1	0	+1	0	0
Add Row		37														
<b>Counts</b>																
Count of Pluses				5	3	1	5	4	4	4	2	2	4	4	3	
Count of Minuses				2	2	0	1	0	1	1	1	2	1	1	1	
Count of Same (0)				0	2	6	1	3	2	4	3	2	2	3		
Pluses - Minuses				3	1	1	4	4	3	3	1	0	3	3	2	
<b>Sums</b>																
Sum of Pluses				9	6	1	6	4	4	4	2	3	4	4	3	
Sum of Minuses				-4	-3	0	-1	0	-1	-1	-1	-2	-1	-1	-1	
Total				5	3	1	5	4	3	3	1	1	3	3	2	
<b>Weighted Sums</b>																
Weighted Sum of Pluses				59	30	9	28	24	24	24	6	9	22	24	21	
Weighted Sum of Minuses				-12	-5	0	-3	0	-1	-1	-1	-4	-9	-9	-9	
Total				47	25	9	25	24	23	5	5	13	15	12		

Pugh matrix: Evaluation of hybrid Concept along with the top 3 concepts:

Pugh Selection Matrix				Legend:	
Title				2	Highly Positive Impact
Project				1	Positive Impact
Name				0	No Effect
Date				-1	Negative Impact
				-2	Highly Negative Impact

Delete
Make Datum

Item	Requirement	Overall Importance	Sprinkler System with no smart controls	Concepts			Hybrid
				1	2	4	
				Complete Lawn Care Service	Native Plants Landscaping	Smart Controls Installation	Complete Lawn Care service with smart controls installation and Native Landscaping
1	Reduction of water bill	3	Datum	+1	+2	+1	+1
2	Reduction in time spent by customer on lawn care	9		+2	+2	0	+2
3	Minimizing Operating Cost	3		-2	+2	+2	+1
4	Quality of grass-Blade Density	9		+2	0	+1	+1
5	Quality of grass-Greenness	9		+2	0	+1	+2
6	Start-up (Installation) time	1		+2	-2	+1	-1
7	Pay back period	3		-2	-1	-1	0
Add Row		37					

Counts				
Count of Pluses	5	3	5	5
Count of Minuses	2	2	1	1
Count of Same (0)	0	2	1	1
Pluses - Minuses	3	1	4	4

Sums				
Sum of Pluses	9	6	6	7
Sum of Minuses	-4	-3	-1	-1
Total	5	3	5	6

Weighted Sums				
Weighted Sum of Pluses	59	30	28	51
Weighted Sum of Minuses	-12	-5	-3	-1
Total	47	25	25	50

## Appendix 4: Alpha Design feedback

**Interview 1:** Sharon Morganti performed by Ha Nguyen. Sharon is 50-60 years old, housewife, married, 2 adults in a house in an upscale neighbor, suburban area of Ann Arbor. She has already used sprinkler system and lawn service.

1. *Hi Sharon, can I ask you some questions about your lawn if you don't mind. How big is it approximately?*

My yard is about 120 front, 150 deep, 75 back

2. *How did you decide on your current lawn service? Or how did you hear about the business?*

Flyer in my mailbox, and the service sounds reasonable.

3. *How much do you currently pay for your lawn service?*

- Mowing: I use private service by a young company - "Mikes Lawn Service" \$20 per mowing, \$10 for edging

- Fertilizer, weed and pest control: I use "TruGreen Lawn Service" varying about \$60/\$70 per treatment; about 4 times a year

- For watering: we use sprinkler system. This year, since it rains quite a lot so we don't need to water much. But last year and the year before, the difference in water bill between summer and winter is \$60-75/month; so I guess it's about that sum for watering my lawn

4. *Would you be interested in a more efficient smart controller that would save you water during summer months? It cost \$150 but can save you about \$20/month or about 20-40% of water used for lawn.*

Oh, we have one rain sensor that isn't working but I will get it fixed next summer. But I'm interested in your smart controller; if it could take account of weather it would be very great.

5. *For smart controller we offer 2 options: you pay off one time (\$150) or you pay \$15/month for one-year contract (12 month). Which would you choose?*

One time payment. I don't want to pay for summer services in winter.

6. *For fertilizing, would you switch to our service if we charge you the same or a bit cheaper than your current service (about \$50-100 lower) but we use bio-friendly fertilizer, weed pest control, or similar type that is safer to environment & human health?*

Of course, yes.

7. *For lawn care service, our service offer mowing for \$60/month & we'll take care, ensuring your lawn look as nice as you require; you don't need to care about when & how often we mow your lawn. What do you think about this option?*

I like that option. Our service does every week, as they are paid for each time. Sometimes I have to stop them because it doesn't need it

*And fertilizing, we charge about \$200-300/year. What do you think about the price?*

It's reasonable price for fertilizing

8. *What do you think about native plant landscaping your lawn?*

*We will replace a part of your lawn with native plant so it looks beautiful while requiring much less water & fertilizer, no mowing...; and it's also good for environment.*

Sorry, I'm not interested. We've just re-sodded our lawn a couple of years ago and put in new landscaping.

**Interview 2:** Lan Nguyen performed by Ha Nguyen. Lan is 30-40 years old, housewife, married, 2 adults & 3 kids in a house in the suburban area of Ann Arbor. She has already used sprinkler system.

1. *Hi Lan. Sorry, I need to ask you some more questions about your lawn. Do you mind answering them? So how big is your lawn?*

Approximately 0.1 acre (~4000 ft<sup>2</sup>)

2. *Do you use any lawn care service?*

No, we do by ourselves. It's much cheaper than what they offer, and we quite enjoy doing it, a good exercise for my family

3. *So how much does it cost you for taking care of your lawn?*

For watering, I don't know exactly since it's not separate from my water bill. Probably it's about \$40 a month. For mowing & fertilizing, we do not budget it, roughly estimate ~ 100\$/ a season

4. *Would you be interested in a more efficient smart controller that would save you water during summer months? It cost \$150 but can save you about \$20/month or about 20-40% of water used for lawn.*

Oh, sounds good. I'd consider it.

5. *For smart controller we offer 2 options: you pay off one time (\$150) or you pay \$15/month for one-year contract (12 month). Which would you choose?*

Option 1 because I can afford it and avoid paying interest

6. *For fertilizing, would you switch to our service if we charge you the same or a bit cheaper than your current service (about \$50-100 lower) but we use bio-friendly fertilizer, weed pest control, or similar type that is safer to environment & human health?*

Yes, I would switch to your service if you offer me such a good deal. However, bio-friendly fertilizer and other types of environment- friendly chemicals are usually more expensive than regular ones.

7. *For lawn care service, our service offer mowing for \$60/month & we'll take care, ensuring your lawn look as nice as you require; you don't need to care about when & how often we mow your lawn. What do you think about this option?*

Unless we are so busy that we cannot find the time for mowing, we enjoy to do it by ourselves, looking the lawn became green and neat. By the way, a high-school boy across the street offers us \$10/one mowing (smiling)

*And fertilizing, we charge about \$200-300/year. What do you think about the price?*

I do not know exact amount of money we spent on fertilizers in a year. But \$200 - \$300/ year sounds too expensive to me.

8. *What do you think about native plant landscaping your lawn?*

We already have a garden with native plant so I do not think I need more plants. In fact, taking care of plant and a garden is equal to or even much more than taking care of a lawn. You have to pay attention to control weeds and water as well. Depending on the size of garden, you might want to spend a significant amount of time each day to keep the look nice. We are happy with our current landscaping so we do not plan on replacing or changing it, at least in next five years.

**Appendix 5: Pricing & assumptions in business model**

Service	Pricing
Mowing	\$60/month
Fertilizer/Pest Control	\$200/year
Native Landscaping	~\$90/hour*
Smart Controller	110% cost of desired controller (~\$150)

\*Note the cost of landscaping will vary based on the plant choice and the design of the yard. This is a rough estimate for simple native seeding.

- We used TruGreen (reference) as our benchmark for generating pricing and market share estimates. This company currently owns a third of the market share (reference) and it is our target to reach its value (approximately 30%) in the best case scenario, and 50% of that (15% of total) in the worst case. All predictions are considered for first 5 years of operation.
- Our metric for measuring demand is the number of owner occupied households (reference) (family, married couples, individuals above 65yrs of age,etc.) in Ann Arbor, and we assume that 70% of these households would want to hire a service for lawn maintenance (the rest probably prefer outdoor activities and would not be willing to allow an outsider maintain their lawn).
- In our first year as we start off, we assume that we can run the business with 1 lawn mower unit and a team of 5 skilled (management and team of experts) and 5 unskilled workers. As we grow, we plan on increasing unskilled workforce by an additional 3 workers by the third year and doubling our equipment at the start of third year.
- We also allocate some of our investment for website setup and an additional telephonic support system setup, along with a staff training module by team of experts on the optimized practices for lawn care.

Market demand estimation curve:



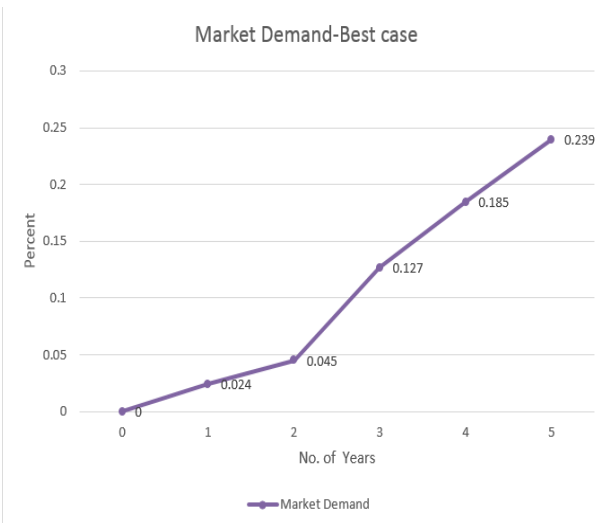
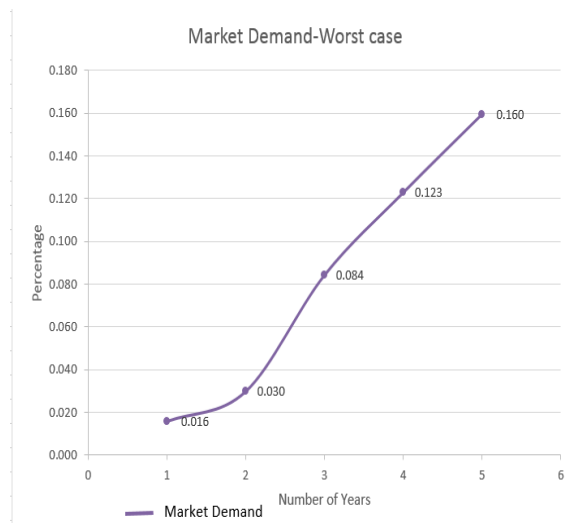


Fig. Market Demand: Best



and Worst case scenarios

## Appendix 6: S-Curve adoption

### Revenue Growth Estimator

using an S-Curve construction augmented with 2 of 4 adoption segments (early adopters, early majority, late majority, laggards)

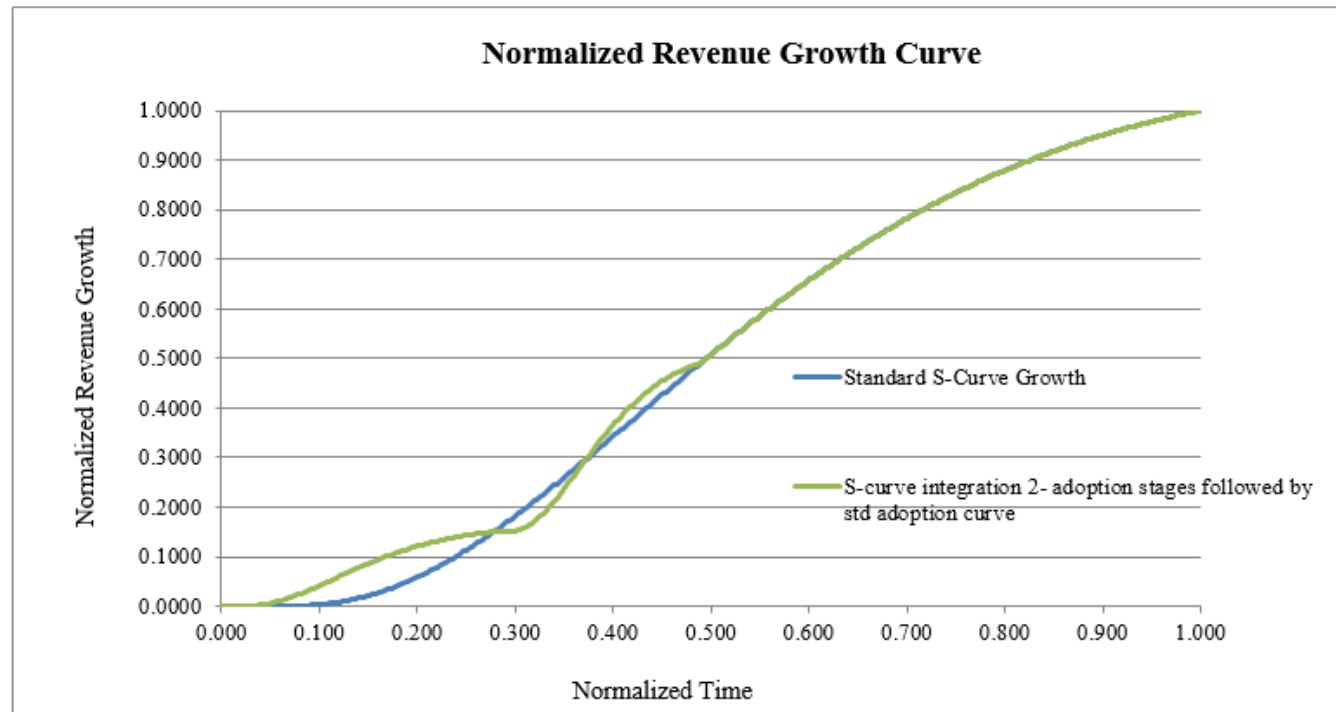
Years to Maximum Revenue: 7  
 Revenue at Year: 2  
 % of Max in year 2: 15.0%

#### References: Years to maximum sales:

Radio: 40  
 Microwave oven: 30  
 Personal Computer: 15  
 Cell Phone: 12  
 iPod: 7

#### S-Curve Construction

$$Y = [1 - (1 - \exp(-c/x))^x]^{(1-x)}$$



## Appendix 7: Pro-Forma Income Statement-Best case scenario

Pro-Forma Income Statement - Best Case Scenario							
		Year					
Revenues ('000)	0	1	2	3	4	5	
Market Demand	\$	767.64	\$ 1,524.25	\$ 4,541.23	\$ 7,008.61	\$ 9,630.65	
Market Share (%)	0	0.024	0.045	0.127	0.185	0.239	
Sales	\$	76,764	\$ 152,425	\$ 454,123	\$ 700,861	\$ 963,065	
Cost Price of Goods	\$	30,706	\$ 60,970	\$ 181,649	\$ 280,344	\$ 385,226	
<b>Net Profit</b>	<b>\$</b>	<b>46,059</b>	<b>\$ 91,455</b>	<b>\$ 272,474</b>	<b>\$ 420,517</b>	<b>\$ 577,839</b>	
		Year					
Fixed Expenses		1	2	3	4	5	
Lawn Mower Equipment	\$ 400	\$ -	\$ -	\$ -	\$ 400	\$ -	
Website and Phone service Setup	\$ 10,000	\$ 10,000	\$ -	\$ -	\$ -	\$ -	
Staff Training Courses	\$ 5,000	\$ 5,000	\$ 5,000	\$ 5,000	\$ 5,000	\$ 5,000	
Plant Layout	\$ 12,000	\$ 12,000	\$ 12,000	\$ 12,000	\$ 12,000	\$ 12,000	
<b>Net Investment</b>	<b>\$27,000</b>	<b>\$27,000</b>	<b>\$17,000</b>	<b>\$17,000</b>	<b>\$17,000</b>	<b>\$17,000</b>	
	<b>(\$27,000)</b>						
		Year					
Operating Costs		1	2	3	4		
Labor	\$ -	\$ 234,000	\$ 234,000	\$ 234,000	\$ 280,800	\$ 280,800	
Equipment Maintenance Costs	\$	100	\$ 100	\$ 100	\$ 200	\$ 200	
Utilities	\$ -	\$ 2,400	\$ 2,400	\$ 2,400	\$ 2,400	\$ 2,400	
Conveyance Costs	\$	16,640	\$ 16,640	\$ 16,640	\$ 16,640	\$ 16,640	
Marketing Costs	\$ -	0	0	58	2,587	6,520	
<b>Net Operating Cost</b>	<b>\$ -</b>	<b>\$ 247,288</b>	<b>\$ 248,673</b>	<b>\$ 253,198</b>	<b>\$ 302,627</b>	<b>\$ 306,560</b>	
<b>Total Net Profit</b>		<b>-27,000</b>	<b>-228,229</b>	<b>\$ (174,218)</b>	<b>\$ 2,275</b>	<b>\$ 100,890</b>	<b>\$ 254,279</b>
<b>NPV of Each Sum</b>			<b>-242,310.77</b>	<b>-397,364.06</b>	<b>-395,453.63</b>	<b>-315,539.50</b>	<b>-125,527.32</b>
<b>PV of each year's profit</b>			<b>(\$215,310.77)</b>	<b>(\$155,053.29)</b>	<b>\$1,910.43</b>	<b>\$79,914.13</b>	<b>\$190,012.18</b>

Calculations

## Pro-Forma Income Statement-Worst case scenario

Pro-Forma Income Statement - Worst Case Scenario									
		Year							
Revenues ('000)	0	1	2	3	4	5			
Market Demand	\$	511.76	\$ 1,016.17	\$	3,027.49	\$	4,672.41	\$	6,420.43
Market Share (%)	0	0.016	0.030	0.084	0.123	0.160			
Sales	\$	51,176	\$ 101,617	\$	302,749	\$	467,241	\$	642,043
Cost Price of Goods	\$	20,470	\$ 40,647	\$	121,099	\$	186,896	\$	256,817
<b>Net Profit</b>	<b>\$</b>	<b>30,706</b>	<b>\$ 60,970</b>	<b>\$</b>	<b>181,649</b>	<b>\$</b>	<b>280,344</b>	<b>\$</b>	<b>385,226</b>
		Year							
<b>Fixed Expenses</b>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>			
Website and Phone service Setup	\$ 10,000	\$ 10,000	\$ -	\$ -	\$ -	\$ -			
Staff Training Courses	\$ 5,000	\$ 5,000	\$ 5,000	\$ 5,000	\$ 5,000	\$ 5,000			
Plant Layout	\$ 12,000	\$ 12,000	\$ 12,000	\$ 12,000	\$ 12,000	\$ 12,000			
<b>Net Investment</b>	<b>\$27,000</b>	<b>\$27,000</b>	<b>\$17,000</b>	<b>\$17,000</b>	<b>\$17,000</b>	<b>\$17,000</b>			
	<b>(\$27,000)</b>								
		Year							
<b>Operating Costs</b>		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>				
Labor	\$ -	\$ 140,400	\$ 140,400	\$ 140,400	\$ 140,400	\$ 140,400			
Utilities	\$ -	\$ 2,400	\$ 2,400	\$ 2,400	\$ 2,400	\$ 2,400			
Conveyance Costs	\$	16,640	\$ 16,640	\$ 16,640	\$ 16,640	\$ 16,640			
Marketing Costs	\$ -	0	0	130	2,598	5,220			
<b>Net Operating Cost</b>	<b>\$ -</b>	<b>\$ 155,547</b>	<b>\$ 156,553</b>	<b>\$ 159,570</b>	<b>\$ 162,038</b>	<b>\$ 164,660</b>			
<b>Total Net Profit</b>		<b>-27,000</b>	<b>-151,841</b>	<b>\$ (112,583)</b>	<b>\$ 5,079</b>	<b>\$ 101,307</b>	<b>\$ 203,566</b>		
NPV of Each Sum			-170,246.18	-270,444.87	-266,180.52	-185,936.02	-33,819.34		
PV of each year's profit			(\$143,246.18)	(\$100,198.69)	\$4,264.35	\$80,244.50	\$152,116.68		

Calculations