University of Nevada, Reno

Aedre, an Automated Watering System

A thesis submitted in partial fulfillment of the requirements for the degree of
Bachelor of Science, Electrical Engineering

by

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Dr. Yantao Shen, Ph.D., Thesis Advisor

May, 2016
THE HONORS PROGRAM

We recommend that the thesis prepared under our supervision by

Duy-Tan Jonathan Pham

entitled

Aedre, An Automated Watering System

be accepted in partial fulfillment of the requirements for the degree of

Bachelor of Science, Electrical Engineering

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Dr. Yantao Shen, Thesis Advisor

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May, 2016
Final Report

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A. **Plan Summary/Overview**

**Background**
The rapid growth of home gardening, partly due to the organic food movement, has increased desire and demand for a smarter irrigation solution. In order to tap into this growing agricultural market, Clearwater Industries has created Aedre, an automated watering solution. Aedre is designed not only for the home gardener or food producing cooperatives, but rather anyone that enjoys vegetation for decoration, consumption, or any other use. The Aedre automated irrigation solution is designed in conjunction with a smartphone based application, or human machine interface (HMI), that allows users to optimize watering in such a way that plants are neither under watered nor over watered. The process used to create this system involves data processing through a microcontroller, saturation level detection through use of moisture sensors, and water distribution through solenoid valves connected to drip lines.

**Work Objective Statements**
With the increased demand of educational and professional needs of the average person, there is a need to save time and energy when it comes to the hard work of cultivating vegetation. The Aedre aims to accommodate these needs through the use of moisture sensors to determine water saturation levels of soil around a plant or a group of plants. The moisture thresholds of the Aedre are the key intellectual merit of this project as they determine the optimal water consumption. Secondly, the smartphone application created for the Aedre gives users an element of remote controllability that has not yet been utilized by the irrigation industry and will introduce convenience to the frequent traveller. The user-friendly interface allows users to water their plants based on moisture thresholds which are either determined by the user (manual mode) or predefined by the application (automatic mode). These predefined thresholds are designed to optimize water usage while maximizing plant growth.

**Methods**
The Aedre system will consist of two different parts: a sensor and watering system controlled by a microcontroller and the phone application for user interaction. The sensor system consists of moisture sensors that send moisture readings in the soil to an Arduino Mega microcontroller. The Arduino interprets these measurements and decides whether or not to send an open signal to the solenoid valves based on the thresholds the user set in the phone application. If the soil is too dry, the valve is opened and the moisture sensors update the new moisture levels in the soil. Once these measurements are above the threshold, the Arduino sends a signal back to the solenoid valves, shutting off water flow to the plants. All of the moisture thresholds for every plant are either set by the user through the phone application in manual mode or is predefined in automatic mode. The user can also choose to water a plant immediately, regardless of the threshold settings, with the push of a button.
Conclusions and Significance
Aedre’s main purpose is to make plant care as easy as possible while optimizing water usage and plant health. Watering a plant based on how much moisture is in the surrounding soil eliminates a lot of “guesswork”. This ensures that water is not underused or overused. Water optimization is especially important in desert climates and drought-stricken environments. Adding a phone application for control makes learning the graphical user interface (GUI) very straightforward as most people are already familiar with using smartphone applications. Users will feel more comfortable with a phone application and will not have to think twice when it comes to watering their plant.

B. Project Description
i. Introduction/Background

Today, most irrigation systems are based on either manual control or scheduled timers. Most of these systems do not measure soil saturation levels to determine whether or not a plant, or area of plants, have received an optimal amount of water for efficient growth. Virtually no irrigation systems currently use smartphone applications for control. Clearwater Industries is looking to address and solve these issues with the Aedre.

The Aedre automated irrigation solution is a smartphone based human machine interface (HMI) that allows customers to optimize watering in such a way that plants are neither under watered or over watered. The process used to create this system consists of a microcontroller for processing data, moisture sensors to detect saturation levels, and solenoids connected to drip lines for water distribution.

Currently there are few watering systems that utilize smart technology, but they are costly and are still mainly analog systems. The problem with analog systems is that they are prone to noise, more expensive for a high quality product, and have non-linear active components. Since smart technology is rising, a question one would ask is if there is a future for smart technology in the irrigation market. According to Market and Market, the market for irrigation systems is projected to be worth $3.56 billion, while TechCrunch says smartphone users are projected to be $6.1 billion by 2020. With the introduction of the Aedre, consumers now have a smart yet affordable option when it comes to a plant watering system.
ii. Business Plan of Project

Business Focus
Clearwater Industries plans on targeting the residential market with the Aedre system. This market includes plant hobbyists, home growers, conservationists, and new plant growers. With the introduction of the Aedre, residents will have the option of having a smart watering system. Moreover, because of Aedre’s easy-to-use smartphone application, all smartphone users are potential customers. Depending on the success of Aedre, the market for the system can potentially expand to commercial markets such as agricultural cooperatives, corporate offices with plants as decor, research facilities, and even greenhouses. The commercial market has already established automated systems from companies such as Rain Bird. Aedre will have an advantage of being a new product that is cheaper than the Rain Bird system.

Market Analysis and Strategy
Clearwater Industries will endorse products through several outlets such as: kickstarters, advertisements, networking, social media, sponsorships, word of mouth, etc. Taking advantage of kickstarter avenues, Clearwater Industries will be able to be funded for production while also giving eager customers an opportunity to review our product early while at a discounted price. By initially marketing our product as a kickstarter, we will be able to obtain supplemental funding while also demonstrating to buyers that our product is well worth their money. We believe that the best marketing strategy is to create such quality products that they will sell themselves. Clearwater will also network by talking to local business and co-ops to test the Aedre to evaluate the product. Additionally, Clearwater will go to multiple Home and Garden shows to market to those looking to install a new system or add to their old one. Some Home and Garden shows that Clearwater Industries would attend would be ones near Reno such as: the Reno Home and Garden Show, the Auburn Home Show, the Sacramento Home and Garden show, and The Fresno Home and Garden show. A website promoting the Aedre will also be made once the final prototype is built and ready to ship out. In addition to the website, there will be promotions through social media, such as Facebook or YouTube, and press releases through online newspapers.
Financial Projections

As a start up company, we have devised a conservative financial model. Once expansion of the company is stable Clearwater Industries will then pursue a more aggressive business model. The financial model is a tentative one that is based on the success of Aedre, market acceptance, production costs, and growth of Clearwater Industries. For this financial model to hold, a few conditions must follow through for the first few months of production. The primary assumption that must hold true is the lack of personnel cost for the first few of months to raise the revenue price for Clearwater Industries. Since Clearwater Industries is a small start up company, personnel costs will be negligible to non-existent for the startup portion of the company. The following assumptions will be made in order for financial stability:

- The acceptance of our primary prototype Aedre in the irrigation industry.
- Proper management of Clearwater Industries in the event of growth and expansion.
- Keeping competitive pricing against similar technologies that may surface.
- Successful marketing strategies to properly provide value to prospective markets.
- Fortifying potential investors with minimal interest costs.
- Partnering with successful market shareholders to pinpoint distribution to the appropriate buyers.

Given the initial specifications for Clearwater Industries, the estimated start up cost is $3000. Figure 1 illustrates the cash flow for Clearwater Industries over the next five years from the initial $3000 dollar investment.
Figure 1: Cash Flow over 5 years

If predictions hold true and as long as Clearwater Industries can overcome the first year, the margin for profit is more than tripled. The five year estimates are based on predictions from the following yearly models shown in Table 1.

Table 1: Cash Flow Revenue for first year

<table>
<thead>
<tr>
<th>Cash Flow (12 months)</th>
<th>Clear Water Industries</th>
<th>Fiscal Year Begins: Feb-16</th>
<th>Total Item EST</th>
</tr>
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<td>Cash on hand (beginning of month)</td>
<td>Pre-Startup EST</td>
<td>Nov-09</td>
<td>Dec-09</td>
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<tr>
<td>Cash Sales</td>
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<td>13,200</td>
<td>25,400</td>
</tr>
<tr>
<td>Collections from CR accounts</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Loan or other cash in</td>
<td>3,000</td>
<td></td>
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<tr>
<td><strong>TOTAL CASH RECEIPTS</strong></td>
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<td>13,200</td>
<td>25,400</td>
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<tr>
<td>Total Cash Available (before cash out)</td>
<td>3,000</td>
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</table>
Table 1 illustrates the revenue section of the first year projected cash flow for Clearwater Industries. The revenue from the initial investment of $3000 will be just enough to propel Clearwater Industries successfully into the untapped irrigation markets based on our current product. Table 2 illustrates the predicted expenses for the first year of Clearwater industries.

**Table 2: Cash Flow expenses for the first year**

<table>
<thead>
<tr>
<th>CASH PAID OUT</th>
<th>300</th>
<th>300</th>
<th>300</th>
<th>0</th>
<th>400</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>500</th>
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<tbody>
<tr>
<td>Cost of services; includes shop supplies</td>
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<td>100</td>
<td>100</td>
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<td>Insurance</td>
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<td>6</td>
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<td>12</td>
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<td>27</td>
<td>30</td>
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<td>36</td>
<td>270</td>
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<tr>
<td>Electrical Components</td>
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<td>130</td>
<td>140</td>
<td>150</td>
<td>160</td>
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<td>180</td>
<td>190</td>
<td>200</td>
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<td>220</td>
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<tr>
<td>Miscellaneous</td>
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<td>1,000</td>
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<td>1,000</td>
<td>1,000</td>
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<tr>
<td><strong>SUBTOTAL</strong></td>
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<td>9,746</td>
<td>9,559</td>
<td>9,272</td>
<td>9,666</td>
<td>12,298</td>
<td>12,311</td>
<td>12,324</td>
<td>12,837</td>
<td>12,350</td>
<td>12,363</td>
<td>12,370</td>
<td>137,510</td>
</tr>
<tr>
<td><strong>TOTAL CASH PAID OUT</strong></td>
<td>3,653</td>
<td>9,746</td>
<td>9,559</td>
<td>9,272</td>
<td>9,666</td>
<td>12,298</td>
<td>12,311</td>
<td>12,324</td>
<td>12,837</td>
<td>12,350</td>
<td>12,363</td>
<td>12,370</td>
<td>137,510</td>
</tr>
<tr>
<td><strong>Cash Position (end of month)</strong></td>
<td>-563</td>
<td>-9,496</td>
<td>-5,858</td>
<td>-11,270</td>
<td>27,985</td>
<td>46,487</td>
<td>37,476</td>
<td>91,152</td>
<td>143,765</td>
<td>156,815</td>
<td>210,452</td>
<td>250,876</td>
<td>282,487</td>
</tr>
</tbody>
</table>

Table 2 illustrates the predicted expenses for the first year of Clearwater industries. Evident in Figure 1, the revenue for the company is predicted to be negative but then jump once our product is fully emerged into the irrigation industry. The cash flow revenue is illustrated in Figure 2.
Figure 2: Projected Revenue for Clearwater Industries

The projected profit from revenue is estimated to exceed $2,400,000 by the year 2020. This price includes expansion costs, employee compensation and room for error for any unforeseen problems.

To expand the revenue potential of Clearwater Industries we will expand the target audience by expanding our product range. Below are the expected revenues for the expansion procedures that Clearwater Industries plan to implement.
iii. Technical Focus

Technical Methods
Aedre aims to maximize plant health and life while optimizing water usage. The system will consist of a microprocessor unit with Wi-Fi connectivity that is connected to moisture sensors for detecting the moisture levels in the plant soil and solenoid valves to control the flow of water to the plant. Everything in the system is configured and controlled using a phone application. The following is a detailed description of how the Aedre system works to help conserve water while optimizing the health of plants.

Water detection and delivery system
Only one parameter will be monitored by the Aedre system: soil moisture. Moisture sensors will be used to measure the amount of water present in the surrounding plant’s soil. Wet soil is a better conductor than dry soil, so the output voltage of the moisture sensor will be higher as moisture in the soil increases. These sensors will be placed a predefined distance away from the plant to optimize the values of the measured moisture levels. If the sensors are placed too close to the water outlet, they might read a higher value of the soil moisture content than is actually present, causing the plant to receive insufficient amounts of water. The opposite could be said if the sensors are too far from the water outlets. Moisture readings could be measured lower than they actually are and the plant could be overwatered. The theoretical and technical preparation of the Aedre included experimentally finding the predefined threshold values. Clearwater found the appropriate threshold value that approximately waters a moderately sized plant once every twelve hours.

Once the Arduino Mega gets a moisture reading, it compares it against the moisture thresholds, set by user if in manual. If the reading is higher than the threshold, the Arduino waits until the next moisture sample. If the reading is lower, a signal is sent to the 12-volt solenoid valve to open and distribute water to the plant. MOSFETs will act as switches between the Arduino and the solenoids to provide enough voltage and current to activate the valves. The moisture sensor will continue providing measurements to the Arduino. Once the Arduino reads a measurement above the threshold, it will send a signal back to the solenoid to shut off the water flow. The circuit diagram for the prototype of the Aedre is shown below in Fig. 3.
Prototypes and System Configuration

As shown in Figure 3, three moisture sensors are connected to the digital I/O pins on the Arduino Mega. The three solenoid valves are hooked up to a different set of digital I/O pins in order to receive a signal telling them to open when moisture levels are too low. The moisture sensors are powered using two 9 Volt batteries in series. When the Arduino activates the valves, it must turn on the corresponding MOSFET switch to complete the circuit, allowing the current from the batteries to reach the solenoid valve. Although it is hard to see, Fig. 3 shows the Arduino Wifi shield stacked on top of the Arduino Mega which gives Aedre Wi-Fi capabilities and gives access to the Aedre phone application.

Figure 4, shown below, illustrates the logic diagram that the Arduino program will follow.
First, the system checks if it is in automatic mode. If it is not in automatic mode, it receives the user-defined moisture threshold through the phone application to set the corresponding plant’s threshold level. If in automatic mode, the Arduino will use predefined threshold values. Then the system will take moisture samples from the moisture sensors. If the soil is too dry, it sends a signal to the solenoid valves to open. From there, it continues to monitor the moisture sensors more frequently while the valves are open. Once the moisture measurements are back above the threshold level, the Arduino sends a voltage signal to close the solenoid valve and will continue to monitor moisture levels.

Power Source and Wi-Fi Communication
A 9-volt 1000mA DC power adapter will be used to power the system. This adapter was chosen due to the amount of voltage and current it can provide. It will be able to provide enough power to allow the Arduino to send strong signals to the solenoid valves. For communication with the phone application, the Arduino Wi-Fi shield 101 was chosen. This particular shield allows the unit to plug directly into the Arduino board by mounting it. Since the shield is only about half the size of the Arduino Mega, plenty of pins are left over to connect all the components. Schematics for the Arduino Mega and the Wi-Fi shield are provided in Appendix B and C, respectively.
Phone Application Capabilities
The phone application will be built so that the user may use the Aedre system manually, if so desired. The user will have the ability to control three main items: setting the system to Automatic, changing the thresholds of each moisture sensor, and watering a plant in real time. The application will be displayed so that the user can control any of the capabilities at the same time. The only way to use the Aedre in manual is through the phone but can be switched to Automatic with a hit of a button. When the user turns the system to Automatic, the phone will send a signal to the Arduino Mega, allowing the microcontroller to function entirely off the moisture sensors. Another decision the user can make is to water the plant or stop watering the plant. There will be a light on the application to signify to the user which solenoid valve is open or closed. When the user wants to water the plant, they will press the corresponding icon in the application and the phone will signal the Arduino Mega to toggle the solenoid valve open. The light will change on the screen telling the user the solenoid valve is open. If the user wants to shut off the solenoid valve, they would press the icon again. The phone will then signal the Arduino to toggle the solenoid valve off and the light will update again, telling the user that the solenoid valve is closed. Lastly, the user is able to change the thresholds (0 to 100) on their own using manual mode. When the user wants to change the threshold, the user will move a slider to the desired threshold value which corresponds to the percentage of saturation that will trigger the system to start watering. The phone will then take the information from the user and set the Arduino Mega to be sensitive to the desired threshold. The logic of the phone is shown below in Figure 5 to further illustrate what the user can do on the application.

Figure 5: The logic diagram of phone application
The application itself will be constructed using another application called Blynk. Blynk is a platform for both Apple and Android applications to control “Internet of Things” (IoT). With Blynk, one is able to build a graphic user interface (GUI) on their smartphone and control the microcontroller with various widgets. One will be able to construct and modify the widgets to their liking, whether it be placement or type of icon used. Moreover, the user will be able to control the microcontroller anywhere in the world via the Blynk server, as long as the microcontroller is connected to the internet. The Blynk server and libraries are open sourced so using Blynk for a prototype is a great resource and free to use. A preliminary design on what the interface will look like for the Aedre is shown below in Fig. 6.

Figure 6: Prototype GUI of Aedre phone application
As shown in Figure 6, the Aedre application features controls and information regarding each plant (of three). The top button allows the user to toggle between manual and automatic mode. The “WIFI” light signifies whether or not the Arduino is successfully connected to Wi-Fi. The “M SENSOR” modules allow the user to read the moisture levels of each plant’s soil in real time. The three LEDs to the right signify which solenoid valves are open. The “TOGGLE SOL” buttons allow the user to force the corresponding solenoid valve to open and supply water to the plant, regardless of which mode is on. Finally, the three sliders at the bottom allow the user to adjust the moisture thresholds at which each plant will get watered at. These sliders only have effect when the system is in manual mode.

**Physical Implementation**

Figure 7 shows a picture of what the Aedre prototype physically looks like.

![Figure 7: Photo of Aedre prototype](image)

From Figure 7, the electronics of the Aedre system are kept in a black box. The tubing and solenoid valves to the right are sourced from a water pump which supplies water to each individual plant depending on which valve is open. As seen in Figure 7, the wires of the system create a lot of entanglement. However, in future iterations, the wires will be cleaned up and bundled together.
Costs and Budget
Figure 8 summarizes the cost of creating the Aedre prototype.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>Arduino Wi-Fi Shield</td>
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<tr>
<td>Arduino Power Adapter</td>
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<td>Pump</td>
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</tr>
<tr>
<td>Solenoid Valve ¼&quot;</td>
<td>4</td>
<td>45.24</td>
</tr>
<tr>
<td>¼&quot; x 50 ft tubing</td>
<td>1</td>
<td>4.27</td>
</tr>
<tr>
<td>92 piece drip fitting kit ¼&quot;</td>
<td>1</td>
<td>10.67</td>
</tr>
</tbody>
</table>

**Total Price** 237.17

The budget for this project was initially $500 provided by the University of Nevada, Reno. However, only $237.17 was used for this project meaning another prototype could be purchased and the budget would still not be reached.

Results and Future Improvements
The design of the Aedre watering system resulted in a compact system that can successfully water plants autonomously, eliminating the maintenance of house plants. Additionally, the Aedre delivers optimal amounts of water to plants, promoting efficient plant growth. Finally, the system is built in conjunction with a user-friendly phone application that gives users feedback and controllability from anywhere that has internet. For a video demonstration of the Aedre system, please visit: [https://www.youtube.com/watch?v=wWnKrD1ieA9Q](https://www.youtube.com/watch?v=wWnKrD1ieA9Q). Possible future improvements to the prototype include: expanding the number of plants that the Aedre can handle, extending the physical range that the moisture sensors can travel, cleaning up the wiring by using a wireless approach (more expensive), and improving the battery life of the system.
iv. Management Plan

Key Responsibilities
The key individuals and their specific responsibilities of Clearwater Industries are as follows:

Chief Executive Officer (CEO) – As CEO of Clearwater Industries, Dakota Dreyer serves as the leader and main visionary of the company. Dakota’s vision of Clearwater Industries steers the company in the direction towards success through his executive orders that trickle down the hierarchy of command. Dakota manages his fellow officers to ensure that Clearwater Industries reaches its long term goals one step at a time. His key responsibility is to make managerial decisions and allot tasks to team members as he sees fit to secure the success of Clearwater Industries.

Chief Technical Officer (CTO) – Michael Evans is the CTO of Clearwater Industries as he contributes his engineering expertise to ensure that the company continues to produce quality solutions. Michael is in charge of overseeing design, testing, and production from start to finish. His top priority is to construct the Aedre system from its components and to have a working prototype by the deadline. Any issues or bugs with the product will be handled by Michael.

Chief Financial Officer (CFO) – Eugene Anukam, with years of experience in sales and accounting, is Clearwater Industries’ CFO. Eugene is in charge of analyzing current market statistics to ensure that all of Clearwater Industries’ products continue to be both fundable and profitable. He is responsible for securing funds for Clearwater Industries while also optimizing costs to the company by researching economical alternatives to needed components of the Aedre system.

Chief Marketing Officer (CMO) – Johnny Foley, Clearwater Industries’ CMO, is responsible for the endorsement of the company’s products and services. Johnny keeps Clearwater Industries’ products appealing and marketable while also establishing their overall quality to various demographics. His key responsibility is to access all avenues of marketing—including social media, advertisements, and sponsorships—and get our product publically recognized.

Vice President (VP) – As VP of Clearwater Industries, Jonathan Pham provides support to all aspects of the company. When a department is in need of assistance, Jonathan ensures that the appropriate resources and support are made readily available. He is also in charge of making sure that executive decisions and big picture goals are being met. Jonathan’s key responsibilities are the same as the company’s—any department that is facing issues will be met with the appropriate support from the VP.
v. Summary/Conclusions

The purpose of the Aedre automated irrigation system is to provide a convenient and reliable way for individuals to expand their ability to cultivate vegetation in an automated and efficient way. With the introduction of the Aedre system, plant growers now have the ability to enjoy their vegetation without thinking twice to water them. There are several irrigation solutions on the market today, however the Aedre system provides an incredible advantage to time saving and water conservation due to the use of moisture sensors and smartphone application for control.
C. References Cited

Arduino Info (website). Retrieved from

Arduino Schematic. Retrieved from
http://pub.designspark.info/img/227108ab2e8d41001d7ced2186b6e702.jpeg

Arduino Wifi shield Schematic. Retrieved from

Moisture Sensor schematic. Retrieved from

D. Facilities, Equipment, & Other Resources

Clearwater Industries will utilize the access of the EE 491 lab at the University of Nevada, Reno to complete the project. This will be the primary location for designing, building, and troubleshooting the Aedre module. The EE 491 lab includes a plethora of supplies such as multimeters, oscilloscopes, and power supplies needed to assure the success of our prototype. The power supplied in lab can be tuned to the proper voltage and current ratings until the appropriate ordered power sources arrive. The Arduino Mega will be sending and receiving signals from the water pump, the moisture sensors and the solenoid valves. The oscilloscopes and multimeters will be used to test that the proper signal and voltages are being generated from the Arduino Mega. In addition to the EE 491 lab, Clearwater Industries will also utilize the numerous computers available in the ECC (Engineering Computer Lab) for any coding needed for the Arduino Mega. For further accessibility each member of Clearwater Industries will carry a laptop if additional coding is needed if the ECC is unusable.

For the design of the Aedre, Clearwater Industries will turn to the several UNR EBME faculty members for their expertise in such areas as analog to digital sampling, PCB design, and circuit design. For obtaining the prototype parts, Clearwater Industries will order the components through Tony Piazza by providing the parts list, which includes the URL’s to purchase each component. The primary distributors for our required products are Adafruit, Sparkfun, and Home Depot. All of these distributors are accredited manufactures, so Clearwater Industries is looking
to further do business with each distributor if the prototype works successfully. Tony is being of further use when he informed Clearwater Industries that many of the components needed for Aedre are available in his lab, thus reducing the prototype cost stated above.

Furthermore, the fabrication of the printed enclosure will done at the Delamare Library on the University of Nevada campus. As well as utilizing the 3D printer, Clearwater Industries will be utilizing the PCB fabrication machine when building the finished product of the Aedre.
E. Special Info & Supplementary Documentation

APPENDIX A – ARDUINO PINOUT DIAGRAM

![Figure 6: Arduino Mega Pin layout](https://arduino-info.wikispaces.com/file/view/Mega2-900.jpg/421499040/Mega2-900.jpg)

Figures taken from
Table 2: Arduino Mega Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions:</td>
<td></td>
</tr>
<tr>
<td>• Length</td>
<td>101.98mm/4.01in</td>
</tr>
<tr>
<td>• Width</td>
<td>53.63mm/2.11in</td>
</tr>
<tr>
<td>• Height</td>
<td>15.29mm/0.60in</td>
</tr>
<tr>
<td>• Weight</td>
<td>34.9g/1.23oz</td>
</tr>
<tr>
<td>Microcontroller</td>
<td>ATmega2560</td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>5V</td>
</tr>
<tr>
<td>Input Voltage (recommended)</td>
<td>7-12V</td>
</tr>
<tr>
<td>Input Voltage (limits)</td>
<td>6-20V</td>
</tr>
<tr>
<td>Digital I/O Pins</td>
<td>54 (of which 14 provide PWM output)</td>
</tr>
<tr>
<td>Analog Input Pins</td>
<td>16</td>
</tr>
<tr>
<td>DC Current per I/O Pin</td>
<td>40 mA</td>
</tr>
<tr>
<td>DC Current for 3.3V Pin</td>
<td>50 mA</td>
</tr>
<tr>
<td>Flash Memory</td>
<td>256 KB of which 8 KB used by bootloader</td>
</tr>
<tr>
<td>SRAM</td>
<td>8 KB</td>
</tr>
<tr>
<td>EEPROM</td>
<td>4 KB</td>
</tr>
<tr>
<td>Clock Speed</td>
<td>16 MHz</td>
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APPENDIX B– ARDUINO SCHEMATIC

Figure 7: Arduino Mega Schematic

Figures taken from
http://pub.designspark.info/img/227108ab2e8d41001d7ced2186b6e702.jpeg
APPENDIX C– ARDUINO WIFI SHIELD SCHEMATIC

Figure 8: Arduino Wifi Shield Schematic

Figures taken from
Table 3: Arduino Wifi shield Specifications

- Schematic
- Operating voltage both 3.3V and 5V (supplied from the host board)
- Connection via: IEEE 802.11 b/g/n for up to 72 Mbps networks
- Encryption types: WEP and WPA2 Security Enterprise
- Connection with Arduino or Genuino on SPI port
- Onboard CryptoAuthentication by ATMEL
- Shield Dimensions (headers included in height): 53.5mm x 63.2mm x 23.6mm / 2.1" x 2.5" x 0.93"
- Weight: 20g
APPENDIX D– MOISTURE SENSOR SCHEMATIC

Figure 9: Moisture Sensor Schematic

Figures retrieved from