May 10, 2018

Client/Tech advisor
Northern Arizona University
Flagstaff, AZ

To whom it may Concern,

The Stormwater Utilization on NAU Campus Capstone Team is currently working on a project that will potentially be implemented on Northern Arizona University's campus. The project is a using a rainwater harvesting system that will be aimed to reusing the stormwater for certain purposes based on the client needs. This will be determined after meeting with you, the client and technical advisor.

The skills of the team consist of senior level engineering students who are actively working towards a solution that can help alleviate possible water issues on NAU and to reuse the water being harvested on NAU. Each of the team members have researched the background and uses of stormwater. After multiple meetings the team will start to work on the establishing the project's the design aspects based off the provided information from the client and technical advisor. Any technical advice and recommendations will be helpful into making this a successful project over the course. You may reach the team through our emails located below. We look forward to working with both of you again next semester.

Respectfully,

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Stormwater Utilization on NAU Campus

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CENE 476-EGR Design Capstone Prep

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1.0 Project Understanding

The project understanding is an overview of the whole project. The purpose, background, technical considerations, potential challenges, codes and regulations, and stakeholders of the project are found in the project understanding. Each aspect contributes towards the completion of the stormwater utilization project on Northern Arizona University.

1.1 Project Purpose

The purpose of the project is to develop a stormwater utilization plan using existing stormwater collected on Northern Arizona University's (NAU) campus, as well as submitting the proposal of the project to the Environmental Protection Agency (EPA) challenge. The project focuses on treating, conveying, and reusing the detained stormwater. The utilized stormwater will be treated before conveying it to the heating and cooling towers on North Campus and usage for irrigation purposes. The project will require surveying, hydraulic, analysis, design, preparation of site plans and hydrology reports. Coordination with NAU facilities is an important aspect in understanding the specific requirements to follow and know before designing. The project also requires a submittal of the project's final proposal to the EPA for the EPA Rainworks Challenge. The 2018 Campus Rainworks Challenge project submittal deadline is in December of 2018. The project is described as an innovative green infrastructure project to help NAU's campus by managing stormwater pollution while benefiting the campus community and the environment [1].

The first solution for the stormwater utilization project is to reuse the previously stored stormwater in the cooling tower for the heating and cooling plant located on North Campus of NAU. The water is currently being collected in the Science and Health Building (SHB) detention tanks. The water will be directly conveyed to the heating and cooling plant where it will be treated inside the plant then conveyed to the cooling tower. The harvested stormwater used in the heating and cooling process will reduce the cost of services and reuse a natural resource.

The second design solution is to utilize the harvested stormwater from the SHB's detention tanks for irrigation purposes on campus. The treatment is fairly basic since the regulations on irrigation water are not extensive. The stormwater will be filtered and minimally treated to prevent further spreading of pollution by removing any heavy metals present in the water. The reused water for the irrigation design on NAU campus will cut down the overall cost of serviced water and provide an environmentally friendly way of maintaining landscape vegetation and soil on campus.

1.2 Project Background

The location of the project is Northern Arizona University's campus located in Flagstaff, Arizona. NAU's campus is at an elevation of 6,950 feet surrounded by mountains, ponderosa pine forests, and the desert. Flagstaff experiences a four-season climate with an average annual precipitation of 23.14 inches of rainfall.

The North Campus Heating and Cooling Plant has three natural gas boilers shown in Figure 1 below. The heating and cooling towers produce about 50,000 pounds of steam per hour [2]. Figure 1 below demonstrates the North Campus Heat and Cooling Plant from the west side.

Figure 1. Heating and Cooling Plant (West View)

The Heating and Cooling Plant is located on north campus of NAU near the Science and Health Building. An aerial photo of the site location is demonstrated below in Figure 2 with the orange circles showing potential areas for irrigation purposes.

Figure 2. Aerial Photo of Science and Health Building [3]

The stormwater will be used in the area in front of the Science and Health Building for irrigation of the landscape pictured in Figure 3.

Figure 3. View the Front of the Science and Health Building showing potential use of irrigation [4]

Figure 4 below shows additional irrigation locations in front of the Science and Health Building shown in the abstract circles in front of the dark dashed line of a site plan in the Stormwater Hydrology Report provided by the client.

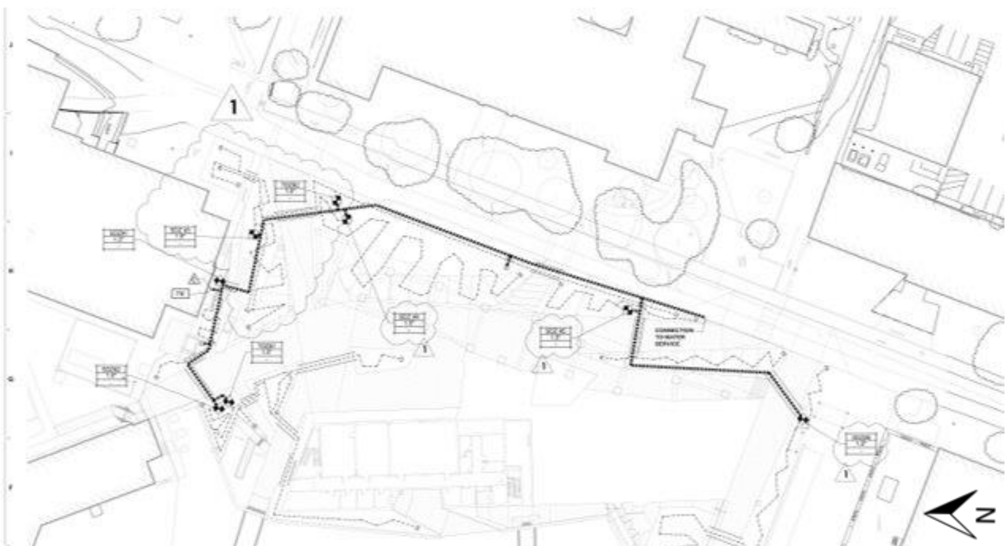

Figure 4. Possible locations for irrigation uses shown in the detailed plan of the piping in front of the Health and Science Building [2]

1.2.1 Codes and Regulations

Various aspects of the project require compliance with regulations and codes as specified by Federal, State, and Northern Arizona University. The transportation and quality of the water must follow designated design requirements. Due to the project's location most of the regulations will be governed by Northern Arizona University's stormwater regulations, which is dictated by the land it is on, federal government. The following sections will address the codes and regulations used for the project according to the source of each.

1.2.2 Northern Arizona University

Northern Arizona University has a stormwater management program that complies with the Arizona Department of Environmental Quality (ADEQ) general permit [5]. The permit is for the discharge of the stormwater from the Municipal Separate Storm Sewer Systems on NAU's campus. The code for the implementing new piping is under Division 33. For the construction of the project it will follow the Division 1 based on the project's location on NAU.

1.2.3 City of Flagstaff

According to Title 13 of City of Flagstaff, under water plumbing, there are specified regulations that need to be followed when inserting piping. Title 13-09-001-0003, requires the depth of the piping at a maximum of 6 feet. The piping will be designed underground 3 feet. Along with two feet vertically to prevent cross contamination of the existing water lines [6]. Another code that will need to be followed is Title 13-09-001-0007 based on the piping to cross the existing pavement around the detention tanks to the plant. The piping will be designed to maintain six feet horizontal and one-foot vertical separation from storm drains due to the surrounding storm drains near the site based on Title 13-09-001-0005 [6].

1.2.4 Environmental Protection Agency

The guidelines for water reuse will follow EPA rules and regulations based on the water distribution for industrial or commercial use. The U.S. Environmental Protection Agency (EPA) finalized a regulation that requires small municipal systems to be separate from storm sewer systems (MS4s) to participate in the National Pollutant Discharge Elimination System (NPDES) program to obtain a stormwater permit. The EPA states that the program must establish a comprehensive Stormwater Management Program (SWMP) under the permit [7]. The purpose for this rule is to reduce pollutants in stormwater runoff through actions implemented by the operators of MS4s, such as the systems operated by NAU.

1.2.5 Arizona Department Environmental Quality

The stormwater will need to meet certain standards prior to conveyance for usage. The water treatment process used will accommodate for all water parameter standards set by the EPA. The stormwater treatment process will have to treat for specific pollutants and must be under the identified pollutant parameters. Stormwater usage regulations are determined by the Clean Water Act (CWA). The Arizona Department Environmental Quality provides information regarding the post treatment standards prior to conveying it to the heating and cooling plants.

1.2.6 Water Testing Methods

Water testing for the storm water inside the detention tanks, as well as after treatment will need to be completed in order to dentify the level pollutants, metals, and/or contaminants present in the water. The post-treatment testing will ensure that all codes and regulations are met for the heating and cooling tower water and/or irrigation reuse.

The water quality parameters that will be tested are demonstrated in Table 1. Through the standards and regulation that need to fit, the pH value, sulfate, chloride, bacteria, total hardness, turbidity, total suspended solids, and total dissolved solids will use the HACH methods to test. The pH value describes the water acid-base property. Sulfate includes the polyatomic action test is specifically needed for the heating and cooling system. Chloride testing will clarify the disinfection product residue. The fecal coliform concentration will determine the bacteria content of the water. Total hardness, turbidity, total suspended solids, and total dissolved solids will determine the cleanliness of the water. Knowing these parameters and concentrations in the water will ensure a full understanding of the water quality and aid in determining an appropriate water treatment process.

Table 1. Water Testing Methods

Requirement	Test Method
pH	HACH Method #8156: pH
Sulfate	HACH Method #10248: Sulfate
Chloride	HACH Method #8113: Chloride
Bacteria	HACH Method #8074: Coliform
Total Hardness	HACH Method #8266: Total Hardness
Turbidity	Standard Method #2130B: Nephelometric Method
Total Suspended Solids	Standard Method #2540 C: Suspended Solids
Total Dissolved Solids	Standard Method #2540: Total Solids

1.3 Location of Detention Tanks

The tanks underground are outlined in yellow next to the Science and Health building shown in Figure 5 below.

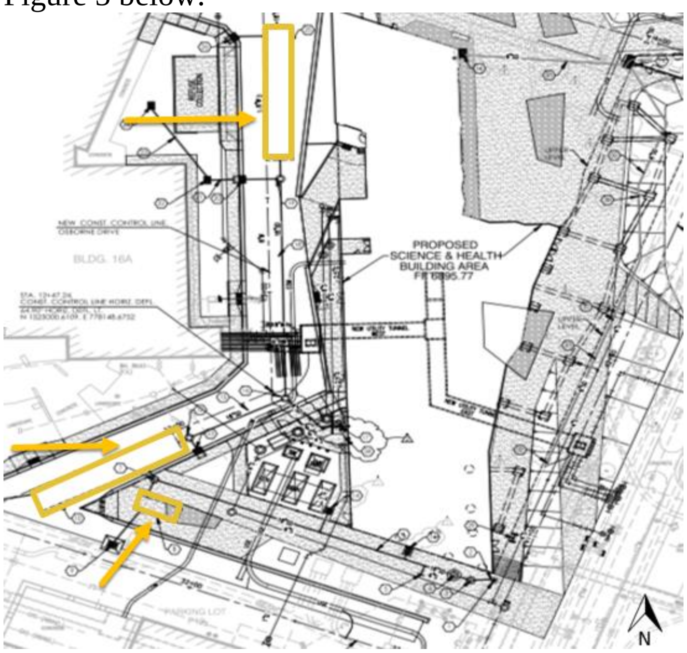

Figure 5. Location of the underground Detention Tanks near the Science and Health Building [3]

1.4 Technical Considerations

The technical work needed for the stormwater utilization project includes the following: surveying, hydraulics, water testing, and design. The project location will be surveyed to precisely measure angles and distances. The survey data will then be used in a software program, such as AutoCAD, to model the topography of the location. The changes in elevation determined from the topography will aid the understanding of the hydrology on site, for example how the stormwater moves in relation to the change in elevation.

1.4.1 Hydraulic Analysis

The hydraulic analysis needed for the project will include conveying stormwater from the storage tanks through treatment, then conveying the treated water to be used for irrigation or the heating and cooling process. Based on the existing system, some of the components that will be analyzed for water conveyance are the pipes, the existing detention tanks, and any necessary pumps for flow. The type of pipe and pump will be determined based on any codes and regulations, as well as a cost analysis. Based on the discussed hydrology analysis quantitative and qualitative data will be used to determine a system design for the treatment and transportation of the harvested stormwater. The pipe network is determined through choosing the material and the distance required to transport the water. The pump selection will come from the amount of water that needs to be conveyed to the plant or to irrigation, as well as the change in elevation.

The pipe analysis will determine the water flow and quantity. Different pipe materials will be considered based on efficiency and regulations. The pipes must be able to withstand external pressures and environmental factors. The length of each pipe segment will be determined through the manufacture that is making the pipes. Polyvinyl Chloride (PVC) of C9100 material will be used for conveyance to the heating and cooling plant. The pipes may come in longer lengths, which will produce a lower installation and transportation costs [8]. Finally, the connection of the pipes will be determined and analyzed for the possibility of any bends that will contribute to coefficients used in calculations.

1.5 Potential Challenges

Throughout the progress of the project there will be various challenges and constraints that will influence the outcome. The project constraints include the codes and regulations, as well as the specifiied pipe material set by the client. Following Northern Arizona University's rules and regulations of the design process of the project, as well as any city or state regulations. In further detail, NAU's rules and regulations of water reuse on campus can dictate the area and the quality of water. Such as, determining how much water we are designing for or being able to catch within the system. Another challenge presented is scheduling with NAU facilities for client needs and any potential questions or concerns. The client specified that the pipe material used for the pipe network be C-900, which is a type of PVC material.

The project challenges include coordination with multiple NAU facilities and lack of data on seasonal variations in rainfall data. Coordinating with multiple NAU facilities poses a challenge with time since various schedules need to be coordinated to meet and gather further data. The lack of data on seasonal variations in rainfall data minimizes the information known of the water quality in the detention tanks.

1.6 Stakeholders

The stakeholders for the stormwater utilization on NAU campus were evaluated by considering the triple bottom line framework, which evaluates social, economic, and environmental impact. Those affected or that have stake in the outcome of the project include the following: Northern Arizona University, the ecosystem, Professor Heidersheidt (technical advisor), and potentially the EPA if entered in the challenge.

1.6.1 Northern Arizona University

Northern Arizona University will be positively affected by the implementation of the project. The students and staffing of NAU are included in the stakeholders. The usage of utilized stormwater will economically impact the cost for serviced water on campus. It also leads to an increase in the campus's status of being known as a "green campus" by reusing stormwater.

1.6.2 Northern Arizona University Faculty and Students

The faculty and students on campus will benefit environmentally and economically from the stormwater utilization implementation on campus. By reducing our dependence on serviced water, NAU's community can protect the natural supply of water. The campus will positively impact the environment by using less water. As stated above, the usage of stormwater can economically impact the faculty and students of NAU by reducing the cost of serviced water.

1.6.3 Aesthetics

Reusing stormwater also enhances the aesthetics of the location, such as minimizing the negative appeal of excess flooding or water damage to current infrastructure. Due to the weather challenges of NAU, excessive amounts of rain and cold temperatures, the stormwater catchment system will reduce nearby roads and sidewalks from being icy.

1.6.4 Ecosystem

The utilized stormwater system environmentally improves the campus by preventing erosion and flooding. The nearby ecosystem will directly be affected by the stormwater project. Flooding in areas can often be destructive, since it can damage property and spread water borne pathogens. Reusing stormwater also reduces damage to local streams and creeks caused by the stormwater runoff. The environmental impact on the ecosystem includes improvement of soil moisture content and raising the ground water table due to the additional stormwater supply.

1.6.5 Technical Advisor

Professor Jeffery Heidersheidt is the team's technical advisor which holds social and economic stake in the project. The outcome of the project will reflect on his social standing, as well as his knowledge about rainwater harvesting. For example, if the project is successful the technical advisor will be known for his positive influence. Vice versa, if the project goes terrible, then people will question his credibility. The same concepts go for the economic impact if the project were an actual job it could possibly affect his income or job potential.

1.6.6 EPA

If the project wins the EPA Rainworks Challenge, then the EPA will hold economic and social stake in the project. The economic impact is the money grant which will be provided for the winning team from the EPA. The social impact will reflect the EPA's judgment in the project. If the project wins, that insinuates that the project is the best out of the competition. Therefore, the project needs to be successful, or it will reflect negatively on the EPA's judgement.

2.0 Scope of Services

The Scope of Services is intended to describe major tasks required to meet objectives, deliverables, and provide final product.

2.1 Task 1: Field Work

The fieldwork for the project will consist of any work done on site of the project location. The field work needed for the project is land surveying of the site and nearby locations that may be utilized or impacted.

2.1.1 Task 1.1: Surveying

Land surveying will be used to measure elevations, angles, and distances of the project location through the use of a total station. Land surveying is an important aspect of the fieldwork needed for the project, since it will ultimately provide a three-dimensional positioning of the site location, located existing features, and demonstrate the boundaries of the site. Geographic Information Systems (GIS) mapping may also be used to manage and analyze the survey data.

Once the site location has been surveyed, the data points from the land surveying can be inputted into a modeling software. The modeling software that will be utilized for this project is AutoCAD, which is a computer-aided design and drafting software application. The AutoCAD Survey Module referenced to process the field measurements utilizes the following steps: import field measurements, calculation of the coordinates, analysis of the results, and distribution of the coordinates [9]. The survey information will be used to demonstrate the distances and changes in elevation needed to develop the conveyance system designs.

2.1.1.1 Task 1.1.1 Topographic Maps

From that AutoCAD model, a site specific topographic map will be made. Topographic maps are used to identify and map out the contours of the ground and existing features on the surface of the earth or slightly above or below the earth's surface. Topographic maps can also demonstrate cross section cuts of the site. From the topographic map, the shape and elevations within the site will be demonstrated. The shape and elevations of the site demonstrated in AutoCAD are also known as contours. Contour lines are a series of lines that do not cross each other. Closely spaced contour lines represent steep slopes and contour lines spaced far apart represent gentle slopes. Contours with a 'V' represent peaks and valleys depend on the direction the 'V' points. Land contours can further be utilized to understand the direction of flow of water. The land slopes will be accounted for when consider the flow direction and volume of water flowing into the detention tank, as well as the slope needed for new pipe networks and pump selection.

Topographic maps can aid in identifying existing features on or below the earth's surface. The maps also demonstrate natural and man-made features of the site. Some of the natural features demonstrated include the following: hills, streams, and vegetation. The man-made features may include nearby buildings, streets, walkways, manholes, utility poles, and retaining walls. For the project site, the topographic map will be used to lay out the existing features, such as the detention tank and existing pipe networks. The topographic map will be utilized the project by demonstrating the changes in elevation between the detention tanks and the outflow for the irrigation system.

2.2 Task 2: Hydrology

The hydrology report provided by our client will be further analyzed with the demand flow given from the nearby drainage basins in the area. The following sections provides the hydrology data needed for our design aspects for both irrigation and Heating and Cooling plant designs.

2.2.1 Drainage Area

The drainage areas around the site of the project areas are shown in Figure 6. Figure 6 shows the areas of where all the water is coming from that is being collected in the detention tanks. The water included in the drainage basins includes the surface, rooftop, and rainwater.

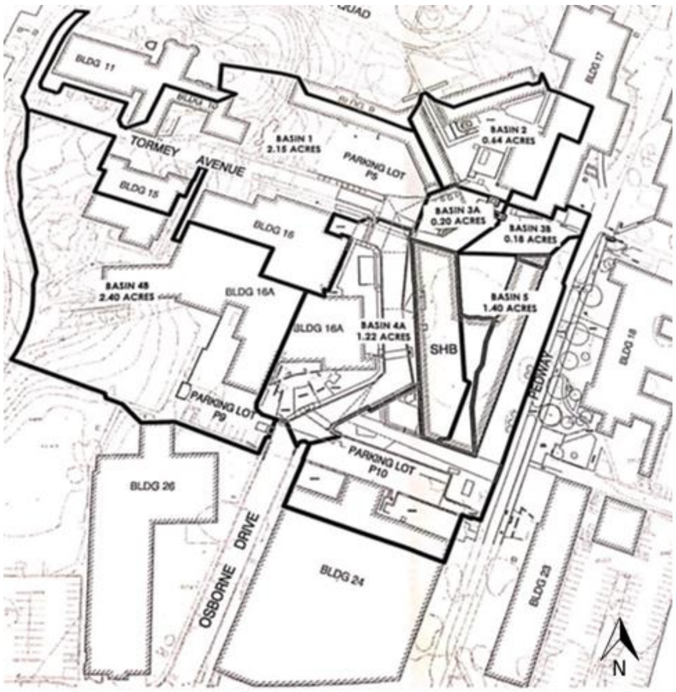

Figure 6. Figure 6. Drainage Basins of the Water Being Collected in the Detention Tanks [3]

Further analysis will be determined to look into the parameters of the stormwater hydrology report by going through more site and pipe line plans that are connected near the potential locations for irrigation.

2.2.2 Available Stormwater Quantification

Based on the drainage number Table 1 shows the flowrate of that basin number for the 100-year stormflow. The client requested the team to use the 100-year flow to design both solutions of reusing the stormwater for the worst-case scenario as defined in our criteria.

Table 2. Drainage Flowrate

Basin Number	Drainage Area (acres)	Flowrate-100 yr. (cfs)
1	2.15	14.29
2	0.64	4.01
3A	0.20	1.24
3B	0.18	1.22
4A	1.22	8.71
4B	2.40	9.75
5	1.40	9.32

The total available stormwater quantification is all of the basin numbers drainage flowrates summed. The total flowrate for the 100 year storm is 48.54 cubic feet per second (cfs.) [3].

2.3 Task 3: Stormwater Testing

The stormwater from the detention tanks initially comes from roof top and surface runoff, therefore it may contain high levels of sediment and pH. Understanding the stormwater quality parameters is a significant part of the treatment process for the project. The water quality will be tested before treatment and after treatment to ensure that the water parameters have met the proper codes and regulations. The water testing will focus on any potential pollutants in the water such as pH, hardness, and sediments.

Based on which design the stormwater will be used for it will need to meet certain standards prior before use. The treatment of the water will go through a specific process that will treat and accommodate the standards set by the EPA. The stormwater treatment process will possibly treat for specific pollutants following the identified pollutant parameters according to which design the water will be used for. The stormwater usage regulations were determined by the Clean Water Act (CWA).

2.3.1 Task 3.1: Stormwater Quality/Initial Water Quality

The stormwater quality has two main parts that need to be considered before and after treatment, these parts should fit the ADEQ standard and NAU "Liquid Cooling Guidelines for Datacom Equipment Centers". Initial testing will be completed to receive a full understanding of the water quality prior to treatment. Due to the stormwater being used in the heating and cooling process or for irrigation, the initial water assessment needs to be completed to understand to water properties. The stormwater testing will test under the following parameters: pH, sulfate, chloride, bacteria, total hardness, turbidity, total suspended solids, and total dissolved solids. The test results will aid in determining a proper treatment process for the stormwater to meet adequate standards. The test methods discussed in section 1.2.6 Water Testing Methods will be applied during the testing. The sample that need to collect at the detention tank. Samples of the water will be collected several times based on the temperature influence of the contaminant dissolution in the water.

Through the testing, the pH value will be recorded in a table to make a graph to find the normal distribution and standard deviation. This will help confirm the pH value range. In addition, the hardness table will filled out to compare the standard of hardness. If the stormwater is in the range of 0-60mg/L $CaCO_3$, then it is considered soft. If the sample is between 61-120 mg/L $CaCO_3$, it is considered moderately hard. For the range of 121-180 mg/L $CaCO_3$, the water is hard. More than 180 mg/L CaCO3, then the water is very hard. For the Turbidity, TSS, and TDS testing, a table will be filled out to show the different equipment test results of turbidity part. This will make a graph of linear function which will include a trend line and R2 on the graph. The graph will help to observe how accurate the results were. In addition, it needs to include the relative percent difference of each data point. For the TSS and TDS this will require an equation to calculate the results and analyze the errors from the sample water. The fecal coliform part testing observes the different numbers of petri dishes to confirm the quantity of colonies in the sample of water.

2.3.2 Task 3.2: After Treatment Water Quality

After treatment, the water will be tested again to ensure it met the Arizona Department of Environmental Quality (ADEQ) reclaimed water quality standard and NAU "Liquid Cooling Guidelines for Datacom Equipment Centers". After the stormwater is fully treated, it will be used in the heating and cooling process amd irrigation system. In heating and cooling process, the water will need to fit the NAU liquid cooling guidelines. In Irrigation system, the water will need to fit the Class A standard. These requirements are explained below.

2.3.2.1 Task 3.2.1: Heating and Cooling System Water Quality

According to the Arizona Department of Environmental Quality (ADEQ) reclaimed water quality standards and the EPA guidelines for water reuse, the following water quality parameters need to be considered. The "Liquid Cooling Guidelines for Datacom Equipment Centers" which determines the proper water parameters to be within the following ranges. The pH value range of 7.0-9.0. The Total Suspended Solids (TSS) should be less than 25 ppm. The Total Dissolved Solids (TDS) requires to be less than 1,500 ppm. The calcium carbonate hardness (CaCO3) needs to be less than 200 ppm and the turbidity should be less than 20 nephelometric turbidity units (NTU). The sulfides requires less than 10 ppm while the sulfate is less than 100 ppm. The chloride needs to be less than 50 ppm. The coliform organisms is less than 1000 CFU/ml. These all require lab testing which follow the test methods set in Table 1. The corrosion inhibitor is required in heating and cooling system due to considering potential acids within the pipes.

2.3.2.2 Task 3.2.2: Irrigation Water Quality

According to the Arizona Department of Environmental Quality (ADEQ) reclaimed water quality standards, the water used in irrigation must be treated to a Class A standard. The turbidity of filtered effluent does not exceed 5 nephelometric turbidity units (NTU) at any time. The maximum concentration of fecal coliform organisms is less than 23 CFU/100 mL in the water. These also are lab test and the methods shown in section 1.2.6. The sample needs to be collected after the treatment process.

2.4 Task 4: Design Solutions

The two potential design solutions will include treatment, conveyance of stormwater from SHB detention tanks, reuse for irrigation and in the heating and cooling process.

2.4.1 Task 4.1: Water Treatment Process

Based off the initial stormwater quality testing the next steps of the water treatment process will be determined. Here is an overview of potential design aspects that might be needed for the treatment process. Through the EPA Water Recycling Treatment and Uses standard and Arizona Department of Environmental Quality (ADEQ) water quality standards, the water should fit the secondary treatment. The secondary treatment process may include the following treatment steps:

2.4.1.1 Task 4.1.1: Filtration

The filtration process will move trash, oil, and other dissolved particles, such as dust and other chemicals. Stormwater through the membrane filtration can be used in irrigation or the heating and cooling system. There are four main types of modules: plate-and-frame, tubular, spiral wound, and hollow fibred [10]. For the water treatment process, there are several types of membranes. They include microfiltration (MF), ultrafiltration (UF), reverse osmosis (RO), and nanofiltration (NF) membranes. The membranes materials include polyvinylidene fluoride (PVDF), polyacrylonitrile (PAN), cellulose acetate (CA), polypropylene (PP), polyether sulfone (PES), polysulfide (PS), or other polymers [11]. After the initial stormwater testing the right suitable filtration membranes will be determined.

2.4.1.2 Task 4.1.2: Biological

The biological process is able to remove the 90% organic matter during water treatment [11]. This includes aerobic and anaerobic reaction. The treatment relies on bacteria, nematodes, algae, fungi, protozoa, rotifers to break down unstable organic wastes using normal cellular processes to stable the inorganic forms.

2.4.1.3 Task 4.1.3: Oxidation

The Oxidation process includes conventional oxidation and advanced oxidation. This would use some metals species such as Fe (II) and Mn (II) to change to their oxidized forms Fe (III) and Mn (IV), which are insoluble [12]. The process can remove the hydrogen sulfide and other potential chemicals in the water. In addition, it can be used for odor control and color removal.

2.4.1.4 Task 4.1.4: Disinfection

Water disinfection means removing, inactivating or killing pathogenic microorganisms. Microbes are destroyed or inactivated, resulting in the termination of growth and reproduction. In this process, chemicals such as chlorine, chlorine dioxide, and ozone etc. can be used [12]. When team done the cost analysis of each chemicals, they can choose the suitable chemicals of disinfection process. They, the volume of chemicals used would through the calculation about the water quality standards and stormwater quality.

2.4.2 Task 4.2: Heating and Cooling Plant

The following sub sections address the process for designing the water treatment process, pipe network, as well as selecting a pump that will be used to implement a conveyance for the water to the heat and cooling plant.

2.4.2.1 Task 4.2.1: Pipe Network

The methods used for choosing the direction of the pipe network will be based off the existing pipes. A required plan of the piping in the area will be needed. Each of the pipe length will be selected through the distance from the detention tanks and the heating and cooling plants. Additional analysis will focus on the flow parameters of the system, which includes the detention tanks, pipes, and pump. The overall volume of the detention tanks will be considered to understand the max volume of stormwater it can hold. Furthermore, the average flow and velocity of the water entering the detention tank will be analyzed. These parameters will provide a basis of how much stormwater will be needed to be exiting the detention tank over a period. Given that the parameters above have been found, further analysis can be done to determine the friction coefficients. The system must be able to withstand turbulent flow.

The first step in designing the pipe network is to input the existing plans into AutoCAD software to create a map showing the existing features within the area. Then to determine the design flow in gallons per minute. Next is to look for a manufacture that creates C-900 pipe material to obtain the lengths the pipe. After that the existing features will be imported into WaterGems from the AutoCAD file. Through the WaterGems software the following will be taken into consideration of the design: differential elevation, static head, valves, and fittings. Lastly based off the design flow the program will be ran to make sure the pipe network works with the right parameters.

The purpose is to have the most cost efficient and durable pipe network to convey the stormwater to the heating and cooling plant. The durability of the pipe will be analyzed through the following: construction and installation, harm to the surrounding environment, longevity, quality, and suitability for purpose of the project.

2.4.2.2 Task 4.2.2: Pump Selection

Selecting the pump for conveying the stormwater to the heating and cooling towers will need to follow the codes and regulations described in the project background. The following factors are needed for selecting the right type of pump and size. The selection process of the pump includes the analysis of how much water it needs to convey which is the demand flow and how much horse power is needed. The pressure of the flow will also be found in gallons per minute to find the correct pump to be able to discharge the water. Both dynamic and static head are added to select the proper control valve operation and safety factor to determine the pump design point for the pump selection [13]. The change in elevation and pressure from the supply source to the destination is needed. The friction losses of the fluid in the pipeline at the design flow rate. After calculating the total head for the design condition, next select the pump meeting the required design point, and then evaluate the pump and system together. All the data will be entered in the PUMP-FLO program to select the correct pump for the design.

2.4.3 Task 4.3: Irrigation

The following sub sections address the process for designing the pipe network, as well as selecting a pump that will be used to convey water to be used for irrigation:

2.4.3.1 Task 4.3.1: Pipe Network

The pipe network for irrigation will be designed utilizing steps very similar to those in section 2.4.2.1 of the text. However, the distance and change in elevation will be different since the irrigation discharge location is further away. The surveying and plans of existing infrastructure will be utilized in the pipe network design.

2.4.3.2 Task 4.3.2: Pump Selection

The pump selection for the irrigation system will also utilize similar criteria for the heating and cooling pump selection (section 2.4.2.2). Since the distance and changes in elevation are different, the irrigation system may require a different pump to have adequate pressure.

2.5 Task 5: Cost Analysis

For this project, the team will do the cost analysis for the heating and cooling plant and irrigation system based on the materials used, pumps, and cost of construction. The cost analysis is a systematic approach to estimate the strengths and weaknesses of both design alternatives. The materials for the cost analysis includes C-900, diameter, and length of the pipe. The operation portion of the cost analysis will focus on the maintenance and power analysis. The cost of each pump needed in the design. The construction includes trenching for piping, installation, equipment, and labor. These parameters will help evaluate the budget of the overall design for our client.

2.6 Task 6: Project Management

The project management portion of the project will aid in planning, executing, evolving, and finalizing the work needed to achieve specified goals for the project. Project management includes the following sections: deliverables, meetings, and cost analysis.

2.6.1 Task 6.1: Deliverables

The CENE 486C deliverables include the system design and analysis, 30% report, 60% report, final report, website, and final presentation of the project. The 30% and 60% reports will build off the project design and analysis. After the 60% report the final report is written, the corrections will be addressed and finalized for the final report. Another major deliverable for CENE 486, is the project website, which will summarize and showcase the entire project.

2.6.2 Task 6.2: Meetings

The technical advisor, Jeffery Heiderscheidt is a great resource towards our stormwater harvesting project due to his expertise. His knowledge and stormwater management experience provides useful information towards the completion of the project. The meetings with the technical advisor will occur roughly four times per semester or once a month. The client, Jon Heitzinger, will provide the objectives and goals for the project. The group will meet with the client a total of four times throughout the semester to address progression and questions regarding the project. Meetings with the grading instructor, Alarick Reiboldt, are used for constructive feedback on current and future deliverables. The grader meetings will occur roughly once every two weeks.

Team meetings will occur weekly to discuss previous and upcoming deliverables, as well as reflect on individual tasks. Agendas for the meetings will be provided two days in advance and meeting minutes will be sent promptly after meetings. Meetings with the grading instructor, Alarick Reiboldt, are used for constructive feedback on current and future deliverables. The grader meetings will occur roughly once every two weeks.

2.6.3 Task 6.3: Benefits Towards NAU

The benefits of using an irrigation design for NAU campus follows: maintaining wetness of the irrigated land that surrounds the SHB during summer, aesthetically pleasing, and a design environmentally friendly. The benefits of heating and cooling plant design towards NAU follows: providing the north campus buildings with cold and hot water. This is for keeping the buildings cooler during summer and warmer during winter.

3.0 Project Schedule

The project schedule includes the following information: major task, deliverables, critical path, and timing. Each section below describes the items within the schedule and reasons of why all the sections are implemented into the project schedule.

3.1 Major Tasks/ Deliverables:

The schedule is broken down into the following major tasks: field work, codes and regulations, data, hydraulic analysis, and project management. Each of the five tasks were given a deadline, which is demonstrated below in Figure 4 and 5. Each deliverable within the scope served as a major task. The major tasks were spread out over the duration of 65 days representing how much time is in next semester. The major tasks were organized for the project to be completed on time and for the most efficient results for the project. Each major task was given a longer duration to complete the identified sub-section task.

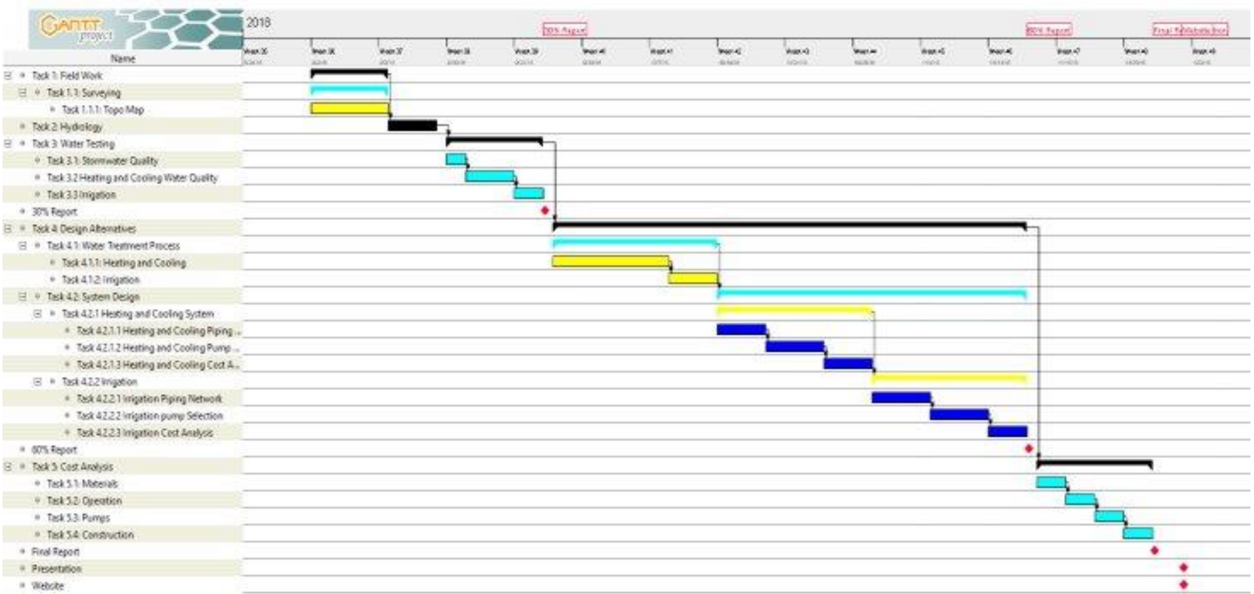

Figure 7. Schedule of Project

3.2 Critical Path

In order for the project to finish on time, it has to have a critical path for the important tasks that needed to be done on time and that would benefit the team to stay on track. The project critical path is as follows: working in the field that includes surveying has to be done by early September because it is the base of our project, codes and regulation for the treatment and designing is considered after the field work until late November which constraints our project, then the hydraulics part, which would take at most 40 days to complete. For instance: complete the piping network for irrigation and heating and cooling plant within 10 days maximum, the cost analysis wouldn't take more that 3 days to gather the needed data, and pump selection for the design needed to be done within 10 days.

3.3 Timing

Adequate time management throughout the whole project will maintain the allowed time for each task. Each member of the group will need to communicate and be responsible for completing their assigned parts within the project. To be able to stay on track with completing the project, weekly meetings are required to give status updates on project progression. Staying on track accordingly with the critical path and time duration for each task will aid in smooth progression until project completion. The timing durations for each task was scheduled based off previous knowledge of working with similar projects of how long each deliverable took. At each of the weekly meetings, specified tasks will be assigned based on the expected deadline. Maintaining the timing of each task on the critical path will result in finishing the project accordingly for the calculated total duration of 65 days.

4.0 Project Staffing and Cost of Engineering Services

The following section provides a detailed description of the employee titles and positions involved with the project. Staffing also includes the total number of hours each of the staff is working towards the project, which will give the total number of hours expected to work. Qualifications for the Senior Personnel is listed in this section as well.

4.1 Staff Titles and Positions

The following describes the positions and roles of employee working on the project:

Project Manager (PM)-The Project Manager will plan, budget, oversee, and document the progression of the project. They will work closely with the Senior and Junior Engineer to ensure the scope and progression of the project are on schedule.

Senior Engineer (Sn. Engineer)-The Senior Engineer is the lead engineer on the project. The Sn. Engineer is a licensed PE and with the most work experience as an engineer on the project. They will manage, direct, and coordinate the work of assigned technical and clerical personnel. Monitor progress and quality of work produced assigned to others. Inform the Project Manager of the performance of assigned staff. Analyze and optimize internal and external processes. Conduct site visits, identify potential engineering problems and propose solutions and alternatives and provide recommendations to Project Manager. If needed the Sn. Engineer will adjust workload to changes and work to meet deadlines.

Junior Engineer (Jr. Engineer)-The Junior Engineer is the entry level class in the professional engineering work field. They are in charge of self-managing project tasks and maintain active communication with Project Managers. Also, the Jr. Engineer is responsible for effectively managing multiple assignments and prioritize with input from Project Managers. They will normally perform responsible yet less difficult types of professional engineering office and field work.

Engineer in Training (EIT)-The EIT is the engineer who pass the Engineer in Training Exam, also known as the Fundamentals of Engineering Exam. They will complete the basic work for the whole project under supervision of the Jr. Engineer and PM.

Administration-Administration will be utilized for filing and organizing information regarding the project. They may also schedule meetings.
Table 3 demonstrates a matrix with the task and subtask versus staff position along with the estimated hours for each staff position for each task.

Table 3. Staff Hours

Task	STAFF					Task Total (hr)	Cost ($)
	Project Manager	Senior Engineer	Junior Engineer	EIT	Administration		
1.0 Field Work	12	8	11	10	10	51	3560
2.0 Water Testing	0	8	0	0	10	18	1210
2.1 Initial Stormwater	12	0	11	10	0	33	2350
3.0 Design Solutions	0	8	0	0	10	18	1210
3.1 Heating and Cooling	12	0	10	10	0	32	2260
3.2 Irrigation	12	0	10	10	0	32	2260
4.0 Cost Analysis	10	8	11	10	10	49	3400
5.0 Project Management	20	8	29	10	15	82	5945
Staff Total (hr)	78	40	82	60	55	315	22195

The following table is a summary for each staff position with justification of total:

Table 4. Staff Positions

Staff Position	Justification
Project Manager	The Project Manager will work closely with the Senior and Junior Engineer to ensure the scope and progression of the project are on schedule. They will be on the job a majority of the time that the Junior Engineer is there.
Senior Engineer	The Senior Engineer will oversee and check on the progression of the project. Therefore, they will not be there as often as the Junior Engineer.
Junior Engineer	The Junior Engineer will oversee the progression of the project from start to completion. They will be on the job a majority of the time to manage project tasks and maintain active communication with Project Managers. They will work alongside the PM.
EIT	The EIT will work under the supervision of the PM and Jr. Engineer to complete the basic work for the whole project.
Administration	This project need the administration to schedule the meeting and other organization work. Simple yet very necessary work.

Table 5. Equipment Fee

Equipement	Cost ($/hr.)	Hours	Cost
Total Station	100	12	1200
Water Testing	80	25	2000
Total	-	-	3200

Table 6. Position Rates

Staff Position	Cost ($/hr.)
Project Manager	80
Senior Engineer	120
Junior Engineer	90
EIT	40
Adminstration	25

4.2 Qualifications

The following section describes all Senior Personnel working on this project:

Madi Marcolina-Having previous experience as a practicing engineer has allowed me to develop my skills as an ambitious team worker. My degree and work experience have also allowed me to acquire skills with the following systems: Microsoft Word, PowerPoint, and Excel, MATLAB, SolidWorks, Revit, Civil3D, and AutoCAD. Additional strong suits of mine include my abilities to pay close attention to detail, coordinate various activities simultaneously, and organize schedules/ work accordingly.

Dorshanna Coolie- Over the years as a practicing engineer the following skills were attained and can be implemented in this project. I have experience in surveying, AutoCAD drawing, hydrology/hydraulics analysis, rainfall calculation, and pump analysis. Additional skills that have obtained over past experiences are professionalism, responsibility, time management, and leadership. The knowledge required from past projects I am capable of working well with clients and collaborating many ideas to achieve a certain goal. Other skills I have acquired are being able to make schedules to break down any project to create subtasks to get all major tasks completed, great communication skills and open-minded. With these abilities and an experience background of working on past engineering projects makes me a good fit to complete the project.

Jiayu Zhang-Through the education and previous experience of practicing environmental engineer, the skills such as surveying, AutoCAD, Civil3D, and MATLAB etc. can be used in team project. In addition, the knowledge of wastewater treatment, drinking water treatment, air pollution controlling, solid and hazes management, and environmental biotechnical have been understood and can be applied in any project. These skills and knowledge can help the group to solve the problems which connect with environmental engineering. The previous experience about another project can help to find the solution for problem fast and make a good schedule.

5.0 References

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