NAU Storm Water Improvement
and
Garden Implementation

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1.0 Project Understanding

Zirotti, Alqaoud, Betoney, and Swearingen (ZABS) Inc. propose to mitigate flooding from parking lot 46 at Northern Arizona University (NAU) and to collect the storm water for irrigation purposes. NAU's infrastructure has poor storm water management near Pine Knoll Drive, north of the turf soccer fields. The proposed storm water management system will reduce flooding and provide aesthetic benefits to the NAU campus. The final design will improve activity for any interested individuals from the university or the surrounding community.

1.1 Project Background

The proposed site is located in Flagstaff, AZ along Pine Knoll Drive next to the Arizona Public Service (APS) Substation. Figure 1 displays a vicinity map of the site [1]. Located at a lower elevation, NAU's parking lot 46 is at risk of flooding. An interview with NAU's facility services confirmed that this flooding problem occurs often during heavy storm events. With proper planning and execution, ZABS Inc. plans to redirect the storm water runoff in the attempt to minimize flooding in that area.

Figure 1. Water distribution area for proposed garden [1].

1.2 Technical Considerations

Technical considerations include site investigation, mapping, modeling, designing, and permitting in which are all essential for the project to succeed. A site investigation will be conducted to understand the topography, soil, and water quality of the area. The team will map and model the site's current conditions, develop a preliminary design and obtain necessary permits for implementation. Considerations to properly view and facilitate, the design for the storm water management system will be integrated with NAU's campus to maintain a safe and aesthetically pleasing environment.

1.3 Potential Challenges

The project faces challenges with the construction phase, codes and permitting phase, and the integration of the design with NAU's facilities. Concerning the construction phase, a professional engineer must oversee and stamp the final design. ZABS Inc. will follow the correct codes to meet NAU's, Flagstaff's, and Arizona's standards. It is an option to select pre-stamped designs if the designed structure is unable to receive an engineer's stamp. Integrating the new design with NAU's existing and future facilities is also of concern. To accommodate this change, existing data and software will be used to model the current storm water runoff.

1.4 Stakeholders

The clients for this project are Northern Arizona University's Facility Services and Sustainability. Stakeholders include Ellen Vaughan, NAU students and faculty, Flagstaff community, Arizona Public Service (APS), and the environment itself. Ellen Vaughan, Manager of the Office of Sustainability, would like a community/nectar garden implemented into the design. Vaughan is a member of the Green Fund Committee, which the team plans to apply later in the semester. Through Ellen Vaughan, the team must involve APS in some of the decisions made, so the substation does not negatively affected by the design. In addition, the constructed site is located near campus grounds, which may affect the students and faculty of the university. The storm water will irrigate a potential garden, thus affecting a possible ecosystem. As the storm water runoff comes from the south commuter parking lot, this increases potential contaminants thus requiring soil sampling, water quality testing, and eventually filtration.

2.0 Scope of Services

ZABS will be designing a storm water management system to mitigate flooding while providing grey water to a proposed community garden for NAU students, faculty, and the surrounding Flagstaff community to enjoy. The goal of the project is to bring life and utility to the selected area for the benefit of the environment and enjoyment of any interested individuals or groups. The services required for this project are explained below.

2.1 Site Investigation

2.1.1 Surveying

The team will survey the proposed site to obtain current topographic data. This will include setting up a total station with NAU's control points. The surveyed areas are the south fields on Pine Knoll Drive going west, NAU's parking lot 46, and the east side of Pine Knoll Drive from the fields to the APS Substation.

2.1.2 Geotechnical Analysis

Geotechnical analysis includes soil sampling, identifying soil types, evaluating engineering properties, etc., to comprehend the condition of the site and determine the methods to perform the analysis. An auger will take soil samples from the site. The core sample will help identify the different layers of soil. A dry sieve analysis following the ASTM D6913 − 04 standards will be performed [2]. This test determines the particle size distribution of coarse soils, thus will identify the proposed site's soil type. A hydrometer test following the ASTM D7928 standards will determine the clay content and silt content within the soil. The test analyzes the soil that are finer than #200 sieve [3]. These tests provide reliable information as the team will be able to determine the rate at which water will infiltrate the soil, helping to calculate the storm water runoff.

2.1.3 Water Quality

A water quality test will analyze possible pollutants in the storm water. ZABS will collect a sample of the water during a storm event giving a clear understanding of the storm water's properties and identifying additional tests that are appropriate to decontaminate the storm water for the purpose of possible irrigation.

Water quality classification requires multiple tests that will test for total solids, Turbidity, pH, alkalinity, hardness, oxygen, and nutrients. The DelAgua testing kit will perform a water quality test. Following the manual, this kit provides reliable information of possible bacteria, such as E. coli [4]. A nutrients test will test for nitrogen, sulfur, phosphorus, and additional nutrients, which provides quality information to determine the rate of algae growth. The YSI 9500 photometer, in accordance with the user manual, will measure the concentration of possible contaminants in the water [5].

2.2 Mapping and Modeling

2.2.1 Geographic Information System

The Geographic Information System (GIS) provides spatial data, which will analyze the proposed site's hydrology. The hydrology tools in ArcGIS will model the flow of water across the site's surface [6]. The software manipulates the data to better understand the site.

2.2.2 Topographic Surface

The survey data points will be imported to AutoCAD Civil 3D to create a topographic surface of the site [7]. This topographic surface is the foundation layer by demonstrating how the site's surface acts.

2.3 Design

2.3.1 3D Model

A 3D model of the site will be created using the software SketchUp, visually representing the changes to the proposed area [8].

2.3.2 Basin and Catchment Design

A retention basin will be designed to manage storm water and to improve water quality. The retention basin will reduce sediments and attached pollutants. A storage tank will store necessary amounts of water to provide the garden with enough water for all seasons. The results of the design will change accordingly from the results of the hydrological analysis.

2.3.3 Irrigation System Design

In order to provide water to the garden from the catchment design, ZABS is designing a drip irrigation system. Less water is used in the system, thus preserving water. The drip irrigation system manages the garden by keeping the soil moist in which will avoid drowning the plants due to extensive watering. To prevent the cause of clogging, a filter will be implemented removing possible debris and residue, extending the life of the system.

2.3.4 Landscaping Design

The team will design the garden and the landscape surrounding the garden. Designing the garden itself will help reduce storm water runoff. The landscape surrounding the garden will improve the area aesthetically.

2.4 Green Fund Proposal

The Green Fund proposal provides funds and grants to students who desires to design and construct a project in making an area on university campus a more sustainable place. ZABS is designing a system to manage storm water runoff and transfer the runoff to a possible irrigation system. Funds will be received by sending a completed proposal following the Green Fund's proposal format.

2.5 Permitting

The team will correspond with the City of Flagstaff, Arizona Public Service and Northern Arizona University on possible permitting acts. This will give the team the ability to proceed with the implementation process without any violations. Obtaining authorization gives the team a better understanding of the regulations involved in the project.

2.6 Exclusions

2.6.1 Implementation

The construction process will be excluded due to time constraints. Future capstone teams will take on the responsibility of implementing design to the proposed site.

2.6.2 Permitting

Future capstone teams will take the responsibility of corresponding with NAU, APS, and City of Flagstaff for possible permitting acts to start the construction process.

3.0 Project Schedule

A Gantt Chart, displayed in Appendix A.1, exhibits the timeline that ZABS plans to follow for the duration of Fall 2017. As indicated by the critical path, a site investigation must be completed prior to modeling and mapping the site's constraints. After the models and maps are developed, the design process may begin. Concurrently with all tasks, ZABS plan to meet weekly and obtain the necessary permits for the project.

4.0 Staffing and Cost of Engineering Services

The project includes a Senior Engineer, Junior Engineer, Licensed Surveyor, Design Engineer, and a Landscaping Architect. The members will take the responsibilities of multiple roles throughout the project design. With the availability of lab equipment, testing will be performed by the team themselves. Testing involving equipment that are unavailable will be taken to an outside source for full test results. Table 1, top of page 6, provides an overview of cost estimates for each staffing individual and the estimated hours each will spend on the project.

Table 1. Estimated hours and cost of staffing

Consulting Services	Quantity	Unit (hours)	Unit Cost ($)	Total ($)
Project Manager	1	160	120	19,200
Sr. Engineer (P.E.)	1	272	105	28,560
Jr. Engineer (E.I.T.)	1	304	90	27,360
Licensed Surveyor	1	72	75	5,400
	Total Hours	**808**	**Total Cost ($)**	**61,320**
Other Costs				
Contingency (10%)	NA	NA	NA	6,132
Supplies	NA	NA	NA	5,000
			Total Cost ($)	**72,452**

The summary table showing estimated cost and hours for the site investigation, mapping and modeling, and design tasks is displayed below in Table 2. See Appendix A.2 for a matrix showing task/subtask versus staff position, with estimated hours for each staff position for each task/subtask.

Table 2. Estimated hours and cost of major tasks

Task	Total Task Hours	Total Task Cost ($)
2.1 Site Investigation	232	26,400
2.2 Mapping and Modeling	1256	18,960
2.3 Design	248	33,480
	Total Cost	**78,840**

References

[1] "Google Maps", *Google Maps*, 2017. [Online]. Available: https://www.google.com/maps/search/maps/@35.179423,111.6558083,1528m/data=!3m1!1e3. [Accessed: 07- Feb- 2017].

[2] *Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*, 1st ed. Philadelphia, Pa.: ASTM International, 2010.

[3] *Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis*, 1st ed. Philadelphia, Pa.: ASTM International, 2017.

[4] *DelAgua Portable Water Testing Kit User Manual*, 2nd ed. Marlborough, Wilts.: World Health Organization Guidelines for Drinking Water Quality, 2015.

[5] *YSI 9300 and 9500 Direct-Read Photometers User Manual*, 1st ed. Yellow Springs, OH.: Environmental YSI, 2010.

[6] ArcGIS. Environmental Systems Research Institute, Inc. 2017

[7] AutoCAD Civil 3D. Autodesk Inc. 2017

[8] SketchUp. Trimble Inc., 2017.

Appendix

A.1 Schedule – Gantt Chart

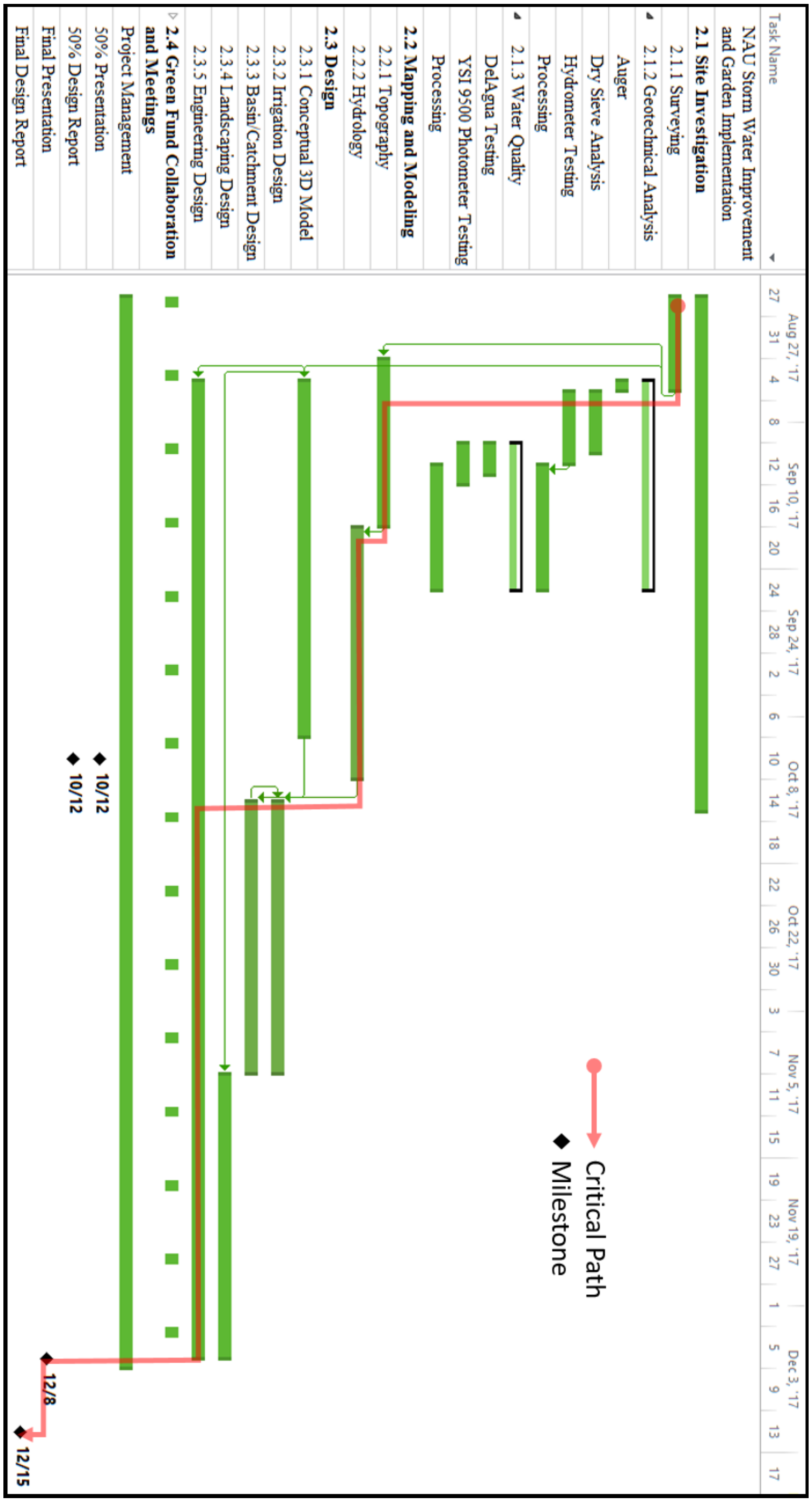

Figure 2. Gantt chart for fall of 2017 project schedule.

A.2 Estimated Hours for Tasks/Subtasks vs. Staffing Position

Table 3. Estimated hours for each staffing position correlating to tasks/subtasks

Task	Hours			
	Project Manager	*Sr. Engineer (P.E.)*	*Jr. Engineer (E.I.T.)*	*Licensed Surveyor*
2.1 Site Investigation				
2.1.1 Surveying	8	16	32	32
2.1.2 Geotechnical Analysis	16	32	40	0
2.1.3 Water Quality	16	32	48	0
2.2 Mapping and Modeling				
2.2.2 Topography	16	24	24	24
2.2.1 Hydrology	24	48	48	0
2.3 Design				
2.3.1 Conceptual 3D Model	8	8	16	0
2.3.2 Irrigation Design	24	32	24	0
2.3.3 Basin/Catchment Design	16	32	24	0
2.3.4 Landscaping Design	8	16	16	0
2.3.5 Engineering Design	8	16	16	0
2.4 Green Fund Collaboration and Meetings	16	16	16	16
Total Task Hours	**160**	**272**	**304**	**72**