NORTHERN ARIZONA UNIVERSITY

College of Engineering, Forestry, and Natural Sciences

City of Flagstaff Low Impact Development Bio-Remediation Soil Design

Scope of Services

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Table of Contents

1.0 Project Understanding

1.1 Project Purpose

Low Impact Development (LID) practices are storm water management systems which integrate natural components to collect, to store, and to remediate storm water while minimizing environmental disturbance. LID systems such as wetlands, detention basins, water harvesting/reuse, vegetated swales, and porous pavement among others offer solutions to conventional storm drainage systems that address storm water quality and improve groundwater recharge [1]. The city of Flagstaff, Arizona requires LID practices to be implemented on any site where storm water detention is required [1]. The purpose of this project is to design a soil matrix comprised of locally available materials that can effectively retain and remediate storm water according to local and federal standards and the City of Flagstaff LID system guidelines.

1.2 Project Background

One of the challenges of implementing a low impact development is the poor soil conditions in the City of Flagstaff. The soil in Flagstaff has a low hydraulic conductivity which prevents the storm water from infiltrating the storm water causing a high volume of storm water flood. Heavy storm water runoff, along with slow infiltration rate, causes the water to carry the pollutants of the area and become heavy polluted. The project aims to solve this problem by designing a soil matrix for the City of Flagstaff. The soil matrix will solve the infiltration problem within the city with an effective cost. Each soil matrix design will be submitted and reviewed by the technical advisor Adam Bringhurst to approve the design.

1.3 Technical Considerations

Soil and water quality testing will be required to design an effective bioremediation soil matrix. The water quality parameters to be tested include: fecal coliform, nutrients, oil, grease, hydrocarbons and turbidity. Required soil tests include: void ratio, hydraulic conductivity, organic content, particle size distribution, density, compaction and stability. The tests will require access to a geotechnical lab for soil testing, and an environmental lab for water testing. Each component of the soil matrix will be tested individually, as well as in combination with other soil components to form different layered matrices. The testing will determine which design is suitable for the City of Flagstaff.

1.4 Potential Challenges

During the design process of the soil matrix, several challenges that may impact the design process might be encountered. Challenges including: Budget, available resources, time and weather are potential challenges that the team might encounter.

1.4.1 Budget

Although the team can use the Norther Arizona University (NAU) lab facilities (soil and environmental labs), and a limited amount of soil materials are freely available from NAU, additional laboratory resources and soil materials may be needed. The American Society for

Testing and Materials (ASTM) and HACH methods for testing fecal coliform, nutrients, turbidity, and metals are followed in different environmental engineering courses at NAU [2]. Therefore, all needed materials for some of the necessary water quality testing are provided to the team through the university. Nonetheless, the materials and equipment for testing oil, grease, and petroleum hydrocarbons are not provided and possibly need to be purchased. The facility services department at NAU allows students to sample soil from the available soil piles in the university. However, the team will have to purchase landscaping materials from local providers if the university's soil piles do not provide enough or the necessary soils for testing. Additionally, the soil available at NAU may not be of consistent composition, and would not yield consistent test results. The research budget is considered a potential challenge because the overall water quality and soil testing research can be affected if the project's budget does not allot enough money for the necessary resources and materials.

1.4.2 Available Lab Resources

As mentioned in the section above, the team can use the NAU lab facilities to perform the water quality and the soil testing needed throughout the research. NAU lab facilities are equipped with most of the needed lab supplies to complete the different tests. However, some of the supplies can be unavailable for the team to use as other lab classes could be using them, they can be outdated, or they can be damaged because of their heavy use throughout the years. Available lab resources are considered a potential challenge because the university's limited laboratory equipment can have an impact on the team's research.

1.4.3 Time

The team is allotted a total of 16 weeks to complete the research, therefore, all testing should be planed and performed within the provided 16 weeks. Possible additional testing or long term testing (longer than 16 weeks) will not be performed by the team, which limits the breadth of matrix designs that can be assessed. The team considers time as a possible challenge because it constrains the research delivered to only methods that can be performed within the provided testing time.

1.4.4 Weather

The goals of LID are to protect water quality, reduce runoff, reduce impervious surfaces, encourage open space, protect significant vegetation, reduce land disturbance, and decrease infrastructure costs [3]. Storm water runoff can contain different contaminants such as sedimentation, bacteria, metals, oil, grease, and petroleum hydrocarbons that can affect the quality of water. Consequently, the LID soil matrix design should reduce or remove the different contaminants found in water to protect the City of Flagstaff's water quality. Storm water runoff testing, and sampling is needed to obtain the initial runoff quality. Therefore, precipitation throughout the allotted testing time is crucial. Weather is considered a possible challenge because, without precipitation, the team will have to perform other methods of obtaining water runoff which can affect the overall water remediation research results.

1.5 Stakeholders

The main stakeholder of the project is the client, the City of Flagstaff. By designing an effective LID soil matrix from locally available materials, the client will be compliant with local regulations and reduce expenditures by sourcing materials locally. The team's technical advisor, Adam Bringhurst, is a stakeholder as the quality of the work may reflect onto him as a professional in environmental engineering. Additionally, local landscaping companies have a stake in the outcome of this project. Successful design of an LID soil matrix using locally sourced materials can potentially increase business opportunities for landscaping material providers that carry the local materials used. Flagstaff customers and developers have a stake in the project outcome, as an effective and proven LID soil design tailored to the conditions of the area, and built from materials available in Flagstaff would be beneficial for future projects that must be built to LID standards. Finally, NAU has a stake in the project because a well-functioning soil matrix design that provides research information for other engineering students and engineering professionals can award positive academic recognition to the engineering program and the university.

2.0 Scope of Services and Research Plan

To successfully and efficiently design a soil matrix following the City of Flagstaff Low Impact Development criteria, the team will need to select and test locally available soils, assess qualifications of each soil matrix component, assess the infiltration rate of soil matrix design alternatives, assess the bioremediation efficacy of each alternative, and select the most effective and feasible design. The team will also consider the possible project impacts, project management components, and complete all required deliverables.

2.1 Task 1: Soil Identification

The first task to be completed is selecting local landscaping materials and testing for properties such as hydraulic conductivity, specific gravity, void ratio, and infiltration rate that can impact the outcome of the soil media design. Before conducting extensive soil testing, the team will collect landscaping materials from local providers or from the university’s facility services department. The team will obtain different types of soil such as fine and course sand, gravel, rock, and topsoil that are native to the city.

2.1.1 Task 1.1: Local Soil Selection

The team will identify the different types of soil native to the City of Flagstaff. The team will arrange phone or in-person meetings with local landscaping material providers and the Northern Arizona University (NAU) facility services department to obtain information about the local available materials such as prices and potential uses for the soils.

2.1.*2* Task 1.*2*: Obtain Local Soil

Lastly, local landscaping materials will be purchased or collected from local providers or facility services at NAU to perform the soil properties testing.

2.2 Task 2: Soil Testing

The soil properties will be assessed by multiple parameters including, hydraulic conductivity, specific gravity, void ratio, and saturated soil dry test. These tests will enable classification of the soil, after examination the soil and will help to determine the implementation improvement for LID soil basin.

2.2.1 Task 2.1: Hydraulic Conductivity

According to flagstaff LID manual the retention basin needs to collect the first one inch of rainfall runoff. Hydraulic conductivity testing will provide information on the rate that water will flow through the void space in the soil. The test will help to determine which soil can be used in the soil matrix. The test methods are measurements of the hydraulic conductivity of water saturated materials with a flexible wall parameter. The ASTM method will be used ASTM D5084-16a [4]. Three hydraulic conductivity tests will be conducted for each material type.

2.2.2 Task 2.2: Specific Gravity

Specific gravity can be defined as the ratio of a material's density to the density of water. ASTM-D854 will be used to assess specific gravity [5]. Three specific gravity tests will be conducted for each material type.

2.2.3 Task 2.3: Saturated Soil Dry Test

The saturated dry soil is the tests sets up standardized conditions for measuring the volume and mass of saturated peat. Which these data are saturated volume, mass, moisture-holding capacity dry peat volumes, and porosity can be determined [6]. ASTM will be used to assess saturated soil dry D2980-17. Three saturated soil dry tests will be conducted for each material type.

2.3 Task 3: Soil Matrix Design

After assessing the properties of each potential soil matrix component, the team will design combinations to be tested in columns. The soil media design task consists of building six soil columns that were considered the best design from the 2017 CENE 486 LID Soil Matrix Capstone to pick the best matrix designed based on attenuation timing. The second part of the task includes building another six soil columns to assess the best topsoil to finally obtain the best design according to City of Flagstaff's LID criteria. All soil media will be tested following the CENE 486 Cap-Stone LID Soil Matrix Testing Method.

2.3.1 Task 3.1: Soil Media Design #1

Six soil matrices will be constructed with the different local materials based on the soil properties obtained from the testing and the information gathered from the 2017 CENE 486 LID Soil Matrix Capstone team to choose the best soil media design without topsoil.

2.3.*2* Task 3.*2*: Soil Media Design #2

After performing the first soil media design the team will determine what type and depth of topsoil can be implemented to improve the efficiency of the soil matrix by constructing three soil matrices with one type of topsoil and three with another type.

2.4 Task 4: Vegetative Coverage Testing

A protective, vegetative layer is a key component for stabilization of the topsoil. In addition to reducing erosion and compaction problems, roots naturally increase the porosity of soils and can increase water infiltration rates. Additionally, plants can be used to remediate water and soils through uptake and sequestration of contaminants. This applied process is known as phytoremediation.

2.4.1Task 4.1: Identify Native Species

Native plant species, specifically grasses, must be identified. The species to be used will be selected based on cost, availability, and cultivation times, with a fast growing, hardy grass being the ideal selection.

2.4.2 Task 4.2: Cultivate Vegetative Coverage

After obtaining native plants, the team will cultivate the representative species to obtain a top soil with vegetation.

2.4.3 Task 4.3: Assess Impact of Vegetative Layer

The impact of the presence of a vegetative layer will be assessed by testing soil matrices with and without a vegetative layer. All soil and water quality parameters will be compared. The team will build three soil matrices following the design obtained from task 2.3.2 without a vegetation layer and three with a vegetation layer.

2.5 Task 5: Matrix Selection

Based on the attenuation timing of the soil media created for tasks 2.3 and 2.4 the team will select the best soil matrix design.

2.6 Task 6: Stormwater Runoff Sampling

Water samples that are representative of local stormwater runoff must be obtained in order to demonstrate the efficacy of the LID soil matrix. Testing will be performed in the fall, which is typically a dry season in northern Arizona. As such, alternative sampling plans have been created.

2.6.1 Task 6.1: Alternative 1

In the event that significant precipitation events which produce sufficient natural storm runoff occur during the testing window, samples will be taken from a stormwater drain from Sinclair Wash on the Northern Arizona University Campus. A map showing this location can be seen in Figure 1 of Appendix A. This location collects runoff from both pervious and impervious surfaces, including a heavily trafficked road. The runoff in this location is expected to be representative in constituency of most runoff in urban areas surrounding Flagstaff.

2.6.2 Task 6.2: Alternative 2

If insufficient precipitation occurs during the testing window, water will be artificially contaminated. This can be done in two ways: one will be in the laboratory with known amounts of each contaminant such as coliform, nitrogen and phosphorous, oil and petroleum hydrocarbons, and sediments. Another way is introducing distilled water to tops of contaminated vehicles and collecting the water runoff to mimic the process of precipitation.

2.7 Task 7: Stormwater Testing

To assess the remediation efficacy of the soil matrix design, several water quality parameters will be analyzed. The initial contamination levels of the water will be determined and compared to contamination levels after bio-filtration. Parameters to be tested include fecal coliform, nutrients, oil, grease, petroleum hydrocarbons, turbidity, and metals. Water quality testing will be performed to the captured water that has traveled through the soil media designs as well. The quality of the captured water is tested for to get the total stormwater pollutant concentrations removed by the matrix. Like the stormwater testing, fecal coliform, nutrients, oil, grease, and petroleum hydrocarbons, turbidity, and metals tests will be performed. Six soil media will be used to assess the design's ability to remediate rainwater runoff.

2.7.1 Task 7.1: Fecal Coliform

Fecal coliforms are bacteria which are used as indicator organisms to detect the likely presence of pathogens. HACH Method 8074 is utilized to assess the total coliform in the samples. This method was developed in accordance with Standard Method 922D of the National Environmental Methods Index.

2.7.2 Task 7.2: Nutrients

Nutrient pollution including nitrogen and phosphorous in surface waters can have negative impacts on aquatic environments. A surplus of nutrients in surface waters promotes excessive algal growth, known as eutrophication. To determine nitrogen levels, HACH Method #10071: Test N' Tube Persulfate Method should be followed. Total Phosphorous is usually determined by following HACH Method #10127, Acid Persulfate Digestion Test N' Tube Procedure.

2.7.3 Task 7.3: Oil, Grease, & Petroleum Hydrocarbons

Oil, grease, and other hydrocarbons associated with automobiles are common pollutants in urban runoff. ASTM D3921-96(2011): Standard Test Method for Oil and Grease and Petroleum Hydrocarbons in Water is used to assess the samples.

2.7.4 Task 7.4: Turbidity

To assess the suspended solids removal efficacy of the soil matrix, ASTM D6855-12, Standard Test Method for Determination of Turbidity is followed.

2.7.5 Task 7.5: Metals

Common metal contaminants in stormwater runoff include lead, copper and zinc. Test methods depend on available resources. ASTM D1971-16 for determination of total metal content is preferred.

2.8 Task 8: Design Economics

Before choosing a final design, the team will perform an economic analysis on the different soil matrix alternatives based on their cost.

2.9 Task 9: Selection of Final Matrix Design

Once different soil matrices had been built, the team will choose the best design based on the infiltration rates, the ability of removing or reducing stormwater runoff pollutants, and their price.

2.10 Task 10: Project Impacts

The final soil matrix design along with the research performed throughout the project will have environmental, economic, and social impacts.

2.10.1 Task 10.1: Environmental Impacts

The application of the research conducted for this project can reduce negative environmental impacts of pollution by remediating stormwater runoff. Pollutants including sediment, nutrients (nitrogen and phosphorus), oil, grease, and petroleum hydrocarbons will be removed or reduced, mitigating contamination of ground and surface waters Flagstaff [7].

2.10.2 Task 10.2: Economic Impacts

The application of the research conducted can prevent negative economic impacts caused by stormwater. The project can improve the groundwater quality by filtrating the water from sediments, pollutants, bacteria and nutrients which leads to reducing the cost of groundwater treatment. Furthermore, the project prevents the formation of stormwater ponds which prevents any property damages or lack of land caused by the ponds. Additionally, the project can reduce the volume of stormwater runoff which prevent high volume floods and the damages that the flood causes to the properties.

2.10.3 Task 10.3: Social Impacts

Traditional stormwater management usually includes infrastructure with concrete channels, outfall, and fenced basing. Therefore, the implementation of the research and final design can enhance overall community aesthetics whilst being sustainable and wildlife friendly.

2.11 Task 11: Project Management

Project management is essential throughout the project. Project management will include: arranging and holding meetings, organizing and overseeing tasks and team management.

2.11.1 Task 11.1: Client Meetings

Client meetings will be held to update the client on the progress of the project and to discuss the expectations and the concerns of the client. Meetings with client will be held at a monthly basis.

2.11.2 Task 11.2: Team Meetings

Team meetings will be held regularly to discuss all the aspects related to the project and the tasks of the team. Meetings will include discussing and assigning tasks, organizing tasks and deliverables, and perform testing. Meetings will be held weekly.

2.11.3 Task 11.3: Technical Advisor Meetings

Meeting with technical advisor will be held to receive consultation and feedbacks on deliverables, testing and research. The technical advisor experience will provide necessary information and recommendations in regard of the project. Meetings will be held bi-weekly.

2.11.4 Task 11.4: Grading Instructor Meetings

Meetings with the grading instructor will be held to discuss the deliverables and receive feedbacks on them. Meetings will also be bi-weekly or as needed depending on deliverables.

2.11.2 Task 11.2: Meeting Minutes and Agendas

Meeting minutes and agenda will be used to record what have been discussing during meetings and will be used to organize information and act as a reference to what have been discussed.

2.12 Task 12: Project Deliverables

2.12.1 Task 12.1: 30% Report

The team will deliver three project reports, as each will contain information in regard o the team progress throughout the project. The first report is the 30% where only 30% of the final report will be turned in.

2.12.2 Task 12.2: 60% Report

The next technical report will be the 60% report where the team will update the client and grader on the 60% progress of the project.

2.12.3 Task 12.3: Final Report

Lastly, a final report will be delivered where all research and findings will be presented to the grader, technical adviser, and client.

2.12.4 Task 12.4: Website

The project website will contain all the information related to the project including: Reports, designs, data, results and details.

2.12.5 Task 12.5: Reflection Document

Each team member will submit a reflection document in which the project aspects are discussed.

2.12.6 Task 12.6: Final Project Presentation
A final presentation will be created by the team to be presented to the project's client, instructors, professional engineers and engineering students. The presentation will address the project elements and the design process.

3.0 Project Schedule
A project schedule chart was created using Microsoft Project software following the tasks identified in section two of the scope. Figure 2 found in the Appendix showcases the project's schedule with the corresponding tasks and the critical needed to complete the project.

4.0 Project Staffing and Cost
4.1 Staff Positions and Team Member Qualifications
Different staff positions were identified for the completion of this project including senior engineer, lab manager, lab tech, and field tech. The different staff positions are listed below with the engineering team qualifications listed.

4.1.1 Senior Engineer
Daniel'le DeVoss
- Three years of management experience
- Experience leading projects in project-based courses

Rebeca Robles
- President of an NAU student led organization.
- Experience in leading engineering student project in team-based courses.

Meshal Alomar
- 4 Years' experience in leading engineering and non-engineering projects in team-based courses.

Abdulrahman Alsubiei
- Experience in leading environmental projects

4.1.2 Lab Manager (P.E.)
Daniel'le DeVoss
- Holds an Associate of Science in Biotechnology
- One year full-time lab technician experience in microbiology and chemistry
- One year lab teaching experience
- Three years of management experience
- OSHA 40-hour HAZWOPER Certified

Abdulrahman Alsubiei
- Have an experience in leading in lab courses.

- One year full-time lab worker at Al-Rasheed company in Saudi Arabia in marine life research and protection lab
- OSHA 30 hours Health and Safety
- Lean Six Sigma Greenbelt Training 18 hours
- Risk Management and Analysis 20 hours
- Working Safely in an Engineering Environment 18 hours
- Working Effectively and Efficiently in Engineering 18 hours

4.1.3 Lab Tech

Daniel'le DeVoss

- Holds an Associate of Science in Biotechnology
- One year full-time lab technician experience
- One year lab teaching experience
- Significant coursework in lab classes

Rebeca Robles

- Three years experience in water and soil university level environmental labs.
- Two years experience in water resources and soil university level civil labs.
- One-year experience working with Western Technologies observing both water and soils testing methods and writing professional soil classification reports.

4.1.4 Field Tech

Daniel'le DeVoss

- Has field work experience for environmental sampling
- OSHA 40-hour HAZWOPER Certified

Meshal Alomar

- Has field experience for Geotechnical work and sampling
- Has field experience in land surveying

Abdulrahman Alsubiei

- Experience in Environmental engineering field work
- Experience in Geotechnical field work

Rebeca Robles

- One-year experience working with Western Technologies observing soil sampling methods and observing water sampling methods.

4.2 Billing Rates

Table 1 shows the staffing cost multipliers based on the Noble Midstream Services and Table 2 showcases the total billing rates obtained from Table 1 [8].

Table 1. Staffing Cost Multipliers

Staffing Multipliers							
Senior Engineer		**Lab Manager/P.E.**		**Lab Tech**		**Field Tech**	
Pay ($/hr)	$92.00	**Pay ($/hr)**	$38.00	**Pay ($/hr)**	$17.50	**Pay ($/hr)**	$17.50
Multiplier	1.9	**Multiplier**	2.5	**Multiplier**	3.7	**Multiplier**	3.7
Cost ($/hr)	**$175**	**Cost ($/hr)**	**$95**	**Cost ($/hr)**	**$65**	**Cost ($/hr)**	**$65**

Table 2. Billing Rates Chart

Billing Rates							
Senior Engineer		**Lab Manager/P.E.**		**Lab Tech**		**Field Tech**	
Cost ($/hr)	$175.00	Cost ($/hr)	$95.00	Cost ($/hr)	$65.00	Cost ($/hr)	$65.00

4.3 Staffing Matrix

Tables 3 and 4 show the staffing hour breakdown for the different project tasks according to the field work and the project management sections of the scope [9]. Table 4 demonstrates that the total staffing hours needed to complete all tasks for the project is 608.

Table 3. Staffing Hours (1)

Staff Hours				
	Senior Engineer	**Lab Manager/P.E.**	**Lab Tech**	**Field Tech**
Task	**Hours**	**Hours**	**Hours**	**Hours**
1. Soil Identification				
1.1 Local Soil Selection	1	1	0	0
1.2 Obtain Local Soil	1	1	0	0
2. Soil Testing				
2.1 Hydraulic Conductivity	1	1	5	0
2.2 Specific Gravity	1	1	5	0
2.3 Saturated Soil Dry Test	1	1	10	0
3. Soil Matrix Design				
3.1 Soil Media Design #1	2	5	5	0
3.2 Soil Media Design #2	3	5	5	0
4. Vegetative Coverage Testing				
4.1 Identify Native Species	1	2	0	0
4.2 Cultivate Vegetative Coverage	1	3	15	0
4.3 Assess Impact of Vegetative Layer	1	5	15	0
5. Matrix Selection	2	5	48	0
6. Stormwater Run-off Sampling				
6.1 Alternative 1	1	5	0	20
6.2 Alternative 2	1	5	0	20
7. Stormwater Testing				
7.1 Fecal Coliform	1	1	1	0
7.2 Nutrients	1	2	1	0
7.3 Oil, Grease, & Petroleum Hydrocarbons	1	2	1	0
7.4 Turbidity	1	1	1	0
7.5 Metals	1	1	1	0
SUBTOTAL HOURS PER STAFF MEMBER	**22**	**47**	**113**	**40**

Table 4. Staffing Hours (2)

Staff Hours				
	Senior Engineer	Lab Manager/P.E.	Lab Tech	Field Tech
Task	Hours	Hours	Hours	Hours
8. Design Economics	3	10	0	0
9. Selection of Final Matrix Design	5	10	5	0
10. Project Impacts				
10.1 Environmental Impacts	1	2	0	0
10.2 Economic Impacts	1	2	0	0
10.3 Social Impacts	1	2	0	0
11. Project Management				
11.1 Client Meetings	8	8	8	8
11.2 Team Meetings	16	16	16	16
11.3 Technical Advisor Meetings	16	16	16	16
11.4 Grading Instructor Meetings	16	16	16	16
11.2 Meeting Minutes and Agendas	8	8	8	8
12. Project Deliverables				
12.1 30 % Report	4	4	4	4
12.2 60 % Report	4	4	4	4
12.3 Final Report	4	4	4	4
12.4 Website	3	3	3	3
12.5 Reflection Document	3	3	3	3
12.6 Final Project Presentation	4	4	4	4
SUBTOTAL HOURS PER STAFF MEMBER	**97**	**112**	**91**	**86**
			TOTAL HOURS	608

4.4 Design Cost

Table 5 shows the total cost for lab usage and the total cost for all needed field work. Table 6 demonstrates the total cost of engineering services including the staffing costs, the materials costs, the lab usage costs, and the field costs. The materials total costs were based on the 2017 CENE 486 LID Soil Matrix Capstone team's report [9].

Table 5. Lab and Field Costs

Lab and Field Costs				
Lab Usage Fee				
Item	**Unit**	**Unit Cost**	**Unit Total**	**Cost**
2.2 Soil Testing	Days	$100	2	$200
2.3 Soil Matrix Design	Days	$100	1	$100
2.4 Vegetative Coverage Testing	Days	$100	1	$100
2.5 Infiltration Rate Testing	Days	$100	2	$200
2.6 Stormwater Sampling Alternative 2	Days	$100	1	$100
2.7 Stormwater Testing	Days	$100	2	$200
		SUB TOTAL COST		$900
Field Work Fee				
Item	**Unit**	**Unit Cost**	**Unit Total**	**Cost**
2.6 Stormwater Sampling Alternative 1	Hours	$25	4	$100
		SUB TOTAL COST		$100
		TOTAL COSTS		**$1,000**

Table 6. Cost of Engineering Services

Staff Costs				
Staff	**Senior Engineer**	**Lab Manager/P.E.**	**Lab Tech**	**Field Tech**
Cost ($/hr)	$175.00	$95.00	$65.00	$65.00
Hours	119	159	204	126
TOTAL COST PER STAFF	$20,825.00	$15,105.00	$13,260.00	$8,190.00
			TOTAL STAFFING COST	$57,380.00
Materials Costs				
			TOTAL MATERIALS COST	$400.00
Lab Usage Fee				
			TOTAL LAB COST	$900.00
Field Work Fee				
			TOTAL FIELD COST	$100.00
			TOTAL COSTS	**$58,780.00**

References

[1] “City of Flagstaff LID Requirement,” *City of Flagstaff LID Requirement | City of Flagstaff Official Website.* [Online]. Available: http://www.flagstaff.az.gov/3736/City-of-Flagstaff-LID-Requirement. [Accessed: 04-Feb-2018].

[2] “Civil Engineering, Bachelor of Science in Engineering: Academic Catalog. *Northern Arizona University.*[Online]. Available: https://catalog.nau.edu/Catalog/details?plan=CIEGRBSEX. [Accessed: 09-Feb-2018].

[3] “Low Impact Development: Guidance Manual for Site Design and Implementation.” *City of Flagstaff: Storm water Management Section.* Jan 2009.

[4] Compass.astm, "Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter,". [Online]. Available: https://compass.astm.org/download/D5084.22702.pdf

[5] Compass.astm.org. (2018). Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer. [online] Available at: https://compass.astm.org/download/D854.26525.pdf

[6] Compass.astm.org. (2018). Standard Test Method for Saturated Density, Moisture-Holding Capacity, and Porosity of Saturated Peat Materials. [online] Available at: https://compass.astm.org/download/D2980.18160.pdf

[7] “Benefits of Low Impact Development,” Environment Protection Agency. [Online]. Available: https://www.epa.gov/sites/production/files/2015-09/documents/bbfs1benefits.pdf

[8] “PROFESSIONAL CONSTRUCTION MATERIALS ENGINEERING & TESTING SERVICE FEE SCHEDULE FOR NOBLE MIDSTREAM SERVICES, LLC,” p. 2016, 2016.

[9] Zhinghan Z., Pott, R., Di Fiore, F., Alhamidi, T. Low Impact Development Bio-Remediation Soil Design. Northern Arizona University. December 14, 2017.

Appendix

Figure 1. Map of proposed sampling site: Sinclair Wash on NAU Campus

ID	WBS	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1	2.1		Soil Identification	11 days	Thu 8/30/18	Thu 9/13/18	
4	2.2		Soil Testing	2 days	Sat 9/15/18	Mon 9/17/18	3
8	2.3		Soil Matrix Design	6 days	Thu 9/20/18	Thu 9/27/18	7
11	2.4		Vegetative Coverage Testing	37 days	Thu 8/30/18	Fri 10/19/18	
15	2.5		Soil Matrix Infiltration Rate Testing and Alternatives	6 days	Tue 10/16/18	Tue 10/23/18	14
16	2.6		Stormwater Runoff Sampling	7 days	Wed 10/24/18	Thu 11/1/18	15
19	2.7		Stormwater Testing	16 days	Thu 11/1/18	Thu 11/22/18	18
25	2.8		Design Economics	6 days	Fri 11/23/18	Fri 11/30/18	19
26	2.9		Selection of Final Matrix Design	2 days	Mon 12/3/18	Tue 12/4/18	25
27	2.10		Project Impacts	3 days	Wed 12/5/18	Fri 12/7/18	26
28	2.11		Project Management	71 days	Thu 8/30/18	Thu 12/6/18	
29	2.12		Project Deliverables	71 days	Thu 8/30/18	Thu 12/6/18	

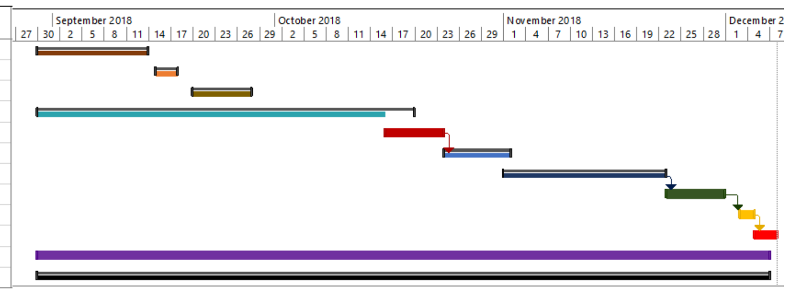

Figure 2. Project Schedule