To: Adam Bringhurst, CENE 476, Capstone Prep

From: SAS Engineering, Students - NAU CENE 476 - 01, Spring 2019

Date: Thursday, February 14, 2019

Re: CENE 476 - 01, Spring 2019, Letter of Transmittal

Letter of transmittal,

Attached please find the proposal to this project. The total cost of the project is $69,742. The project start date is August 8, 2019. The completion date is December 3, 2019.

If you have any questions or concerns, please contact Sara Page at sep259@nau.edu.

Regards,

SAS Engineering

Scott Bearchell
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NORTHERN ARIZONA UNIVERSITY

NAU COMPOST

SAS Engineering

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April 22, 2019

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1.0 Project Understanding

The Project Understanding consists of the project's purpose, background information, technical considerations, and knowledge on the site and project.

1.1. Project Purpose

The purpose of this project is to create a comprehensive management plan for Northern Arizona University's (NAU) composting piles, including analysis required to determine if the soils can be sold at Flagstaffs Community Market.

1.2. Project Location

The site is located within the City of Flagstaff next to Interstate 40. As shown in Figure 1-1 Project Location Map within the City of Flagstaff.

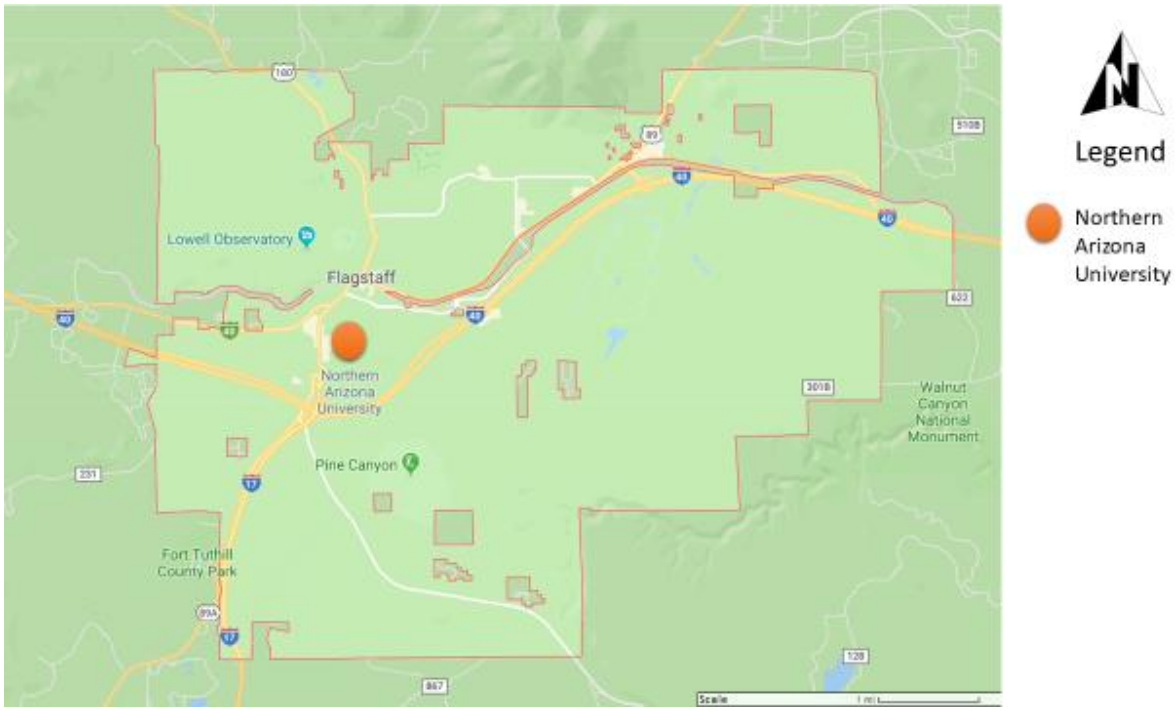

*Figure **Error! No text of specified style in document.**.1: Project Location Map within the City of Flagstaff [1]*

The compost piles are located on NAU's south campus adjacent to Interstate 40 and S Lone Tree Rd. Displayed in Figure 1.2. and Figure 1.3.

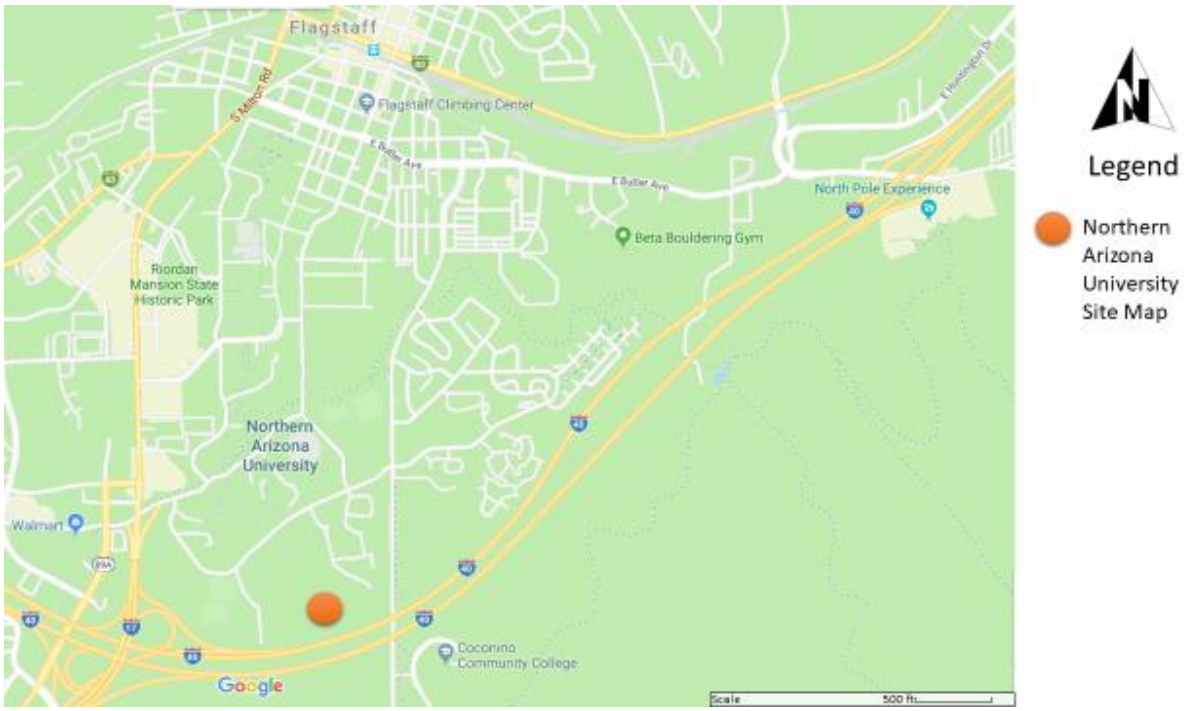

*Figure **Error! No text of specified style in document.**.2: Northern Arizona University Site map [1]*

*Figure **Error! No text of specified style in document.**.3: Site Located, North of Interstate 40 and West of S Lone Tree Rd. [1]*

A preliminary site visit was conducted on February 6th of 2019 shown in Figure 1.4. At that time of the site visit, 12 piles were observed at various stages of composting.

*Figure **Error! No text of specified style in document.**.4: NAU Compost Piles February 6, 2019 [2]*

NAU's composting program was created on April 30, 2012 [1]. Shortly after the composting program's creation, a composting study that spanned a year and a half, 2011-2012, was conducted by former forestry student in coordination with NAU, to develop the most effective means of composting on a large scale in Flagstaff [1]. According to an email exchange mentioned in the report from the City of Flagstaff Community Sustainability Specialist, McKenzie Jones, the amount of organic material deposited into Flagstaffs Cinder Lake Landfill made up ~28% of the City's waste stream [1]. The organic material being disposed into the landfill that could be turned into compost was estimated to be ~60,000 tons per year [1]. To combat the constant increase of waste produced per year, NAU created a compost recycling program that is intended to reduce the amount of total waste put into Flagstaff's Cities landfill. As a result, from this program the NAU compost piles processed 10,000 lbs. of composted material per week during the 18-month study period. At the production rate of 10,000 lbs. per week NAU is projected to produce a maximum of 520,000 lbs. per year or 260 tons of composted soil from the initial composting pilot study [1].

The feedstock used in NAU's composting program consists of food scraps from the following locations along with horse manure and carbon-based material such as tree trimmings and grass clippings. From NAU, the compost pile accepts food scraps from NAU dining, operated by SODEXO, pine needles, grass clippings, and woody material from tree trimmings. From Flagstaff, the compost pile accepts food scraps from the Flagstaff Medical Center (FMC) Hospital, Mother Road Brewery, and horse manure from nearby stables [1].

Currently the NAU compost piles are being operated by a NAU Facilities Employee, Howard Cowell who manages and turns the compost piles daily.

The piles are organized into different stages of composting on the site. The process consists of, Howard Cowell mixes in 24 yd^3 of food scraps and 24 yd^3 of bulking agents, consisting of wood chips and horse manure, into a pile every week. This continues for two months then a new pile gets started. When a new pile gets started, the older piles get turned once a week for a year. This phase is called curing, and the compost needs to be well aerated, temperature checked once every other week, and kept well moist at 60% moisture content. After curing for a year, the pile gets moved across the facility to the finished compost site. The compost is then utilized throughout campus and sold. The compost is currently sold to Flagstaff citizens who come to the compost site and buy the compost by weight at $24-28 per yd^3.

The Composting Pilot Study Research Report [1] examined the sources of feed to be used for a composting pile at NAU. The study also researched and tested the ideal range for soil nutrients in cured composted soil along with the various effects different types of composting methods have on the soil. The study selected the best method for composting in Flagstaff, turned piles with minimal watering. The Composting Pilot Study did not test for harmful bacteria such as e-coli and salmonella and the data graphs for thermophilic and mesophilic testing are unreadable because of missing axis labels.

1.3. Technical Considerations

The technical work that may be required is conducting a moisture content test, phosphorous test, Dewar self-heating test, potassium test, total nitrogen test, carbon to nitrogen ratio, pH test, and a pathogenic organism's indicator test (specifically Salmonella and E. coli.) [2]. To have a highly organic compost, nutrients must be present. Nutrients consist of nitrogen, phosphorous, and potassium [2]. Additional technical work may include technique evaluation of composting through bulking agents, including wood chips and horse manure, curing through windrow processes (turning the pile for other processes), and temperature and moisture regulating.

1.4. Potential Challenges

Handling compost is unsafe and hazardous. There are several diseases associated with compost. Diseases that are common to compost are pathogens, such as *E. Coli* and *Salmonella*, that comes from bird droppings, raw food scraps, and horse manure. To uphold safety, the personal protective equipment (PPE) should always be worn [3].

One of the challenges for the SAS engineering is sampling compost. The most critical component is access to the facility to collect samples. Samples cannot be collected during heavy weather such as high winds. This is because high winds can lead to exposure and

health risks. PPE should be worn when sampling to avoid any potential hazards. When sampling, there should always be excess air in containers, otherwise sample could become combustible [3].

1.5. Stakeholders

The SAS Engineering team has identified four stakeholders of the project. The four stake holders are NAU, NAU students, the City of Flagstaff, and the citizens of Flagstaff. NAU oversees the composting collection and processing, so therefore, NAU has a stake in the outcome of this project.

NAU students, faculty, and staff likely have an interest in composting on campus. How the waste is managed may affect what the students discard and may impact future compost programs.

The citizens of Flagstaff have an interest because the client wishes to sell the compost to the public. The city would care due to the compost may contain harmful components, such as *E. Coli*, and the containment would be spread and utilized around the city. This may affect the regulations and standards that the city checks for.

2.0 Scope of Services

The Scope and Services depict what will be expected of SAS Engineering and what will not be. The scope describes what the procedures and steps that will be taken to achieve the requests of the client.

2.1. Task 1.0 Research

The regulations research consists of researching the requirements that need to be met for composting in Arizona. These requirements are regulated through EPA, AZ Admin, and ADEQ.

2.1.1. Task 1.1 – Regulations Research

Further investigation of the current operations of composting process is required to obtain info on emulsifiers utilized in the du Bois Center and Union on NAU's campus.

2.1.2. Task 1.2 - Operations Research

Further investigation of the current operations of composting process is required to obtain info on emulsifiers utilized in the du Bois Center and Union on NAU's campus.

2.2. Task 2.0 - Work Plan

The work plan consists of health and safety plan, sampling analysis, and how to analyze the sample.

2.2.1. Task 2.1 - Sampling and Analysis Plan (SAP)

A sample plan will be developed and will indicate the proper mechanics on how to take thorough and concise samples of the compost to test and analyze.

2.2.2. Task 2.2 - Health and Safety Plan (HASP)

The Health and Safety Plan will be developed and include the proper procedures that will be conducted within sampling the compost, analyzing the samples in the lab, and disposal protocol.

2.3. Task 3.0 - Sampling

Samples will be collected according to the Work Plan.

2.4.Task 4.0 – Testing and Analysis

This task involves testing the finished compost for the elements listed below [4]. The TMECC (Test Method of the Examination of Composting and Compost) is required for the testing of the compost. TMECC provides specific testing parameters and procedures of each test. The tests are conducted to assure the compost is within standards and to fulfill the clients request of confirming nutrients are present. Sample testing will be conducted more than once. The tests conducted are C:N Ratio, E. Coli, pH, temperature, nitrite/nitrate, phosphorus, potassium, ammonia, density, moisture content, Salmonella, and XRF. Analysis of the samples will be conducted according to the SAP and will conclude analysis for the tests previously listed.

2.5.Task 5.0 - Operations Analysis

The current operations will be reviewed against best management practice to asses performance. Recommendations to improve processing, quantity, efficiency, and economics will be made.

2.6. Task 6.0 - Economical Analysis

The economic analysis consists of depicting the worth value of the compost with the amount of effort it takes of produce it.

2.7.Task 7.0 - Impacts

An impact analysis will be conducted to identify the impacts derived from the compost project. Impacts such as environmental, social, and economic impacts that are caused by the compost project will be identified and analyzed.

2.8.Task 8.0 - Project Management

A project manager will be selected from the members of SAS Engineering. The project manager will be responsible for scheduling site visits, lab times, client meetings, and team meetings. The project manager is also responsible for scheduling and due dates of deliverables, along with resource management.

2.8.1. Task 8.1 - Meetings

Meetings with the client will provide status updates to address client questions or concerns throughout the project. Biweekly meetings will be held with the technical advisor for guidance in soil testing and compost-related technical questions and project progress. Prior to submittals and to notify the progress of the project, the team will meet with the grading instructor for input and feedback of the deliverables.

2.8.2. Task 8.2 - Team Management

Team management includes scheduling meetings, adherence to due dates, and allocating resources that track the project. The team will meet weekly to discuss the progress of deliverables along with feedback from the technical advisor and grading instructor. A comprehensive schedule with specific due dates of deliverables, included delegated tasks to members of SAS Engineering will be followed. SAS Engineering will create a tabulated list of expenses for lab testing and equipment.

2.8.3. Task 8.3 Deliverables

The deliverables consist of milestones, required reports, and required materials throughout the project.

2.8.3.1. Task 8.3.1 Milestones

The milestones will be completed throughout the project to ensure completion, the project's success, and to ensure the project will be on time.

2.8.3.1.1. Task 8.3.1.1 30% Milestones

A 30% report will be written with the specific methods and recorded data from the compost samples. The 30% report consists of Tasks 1-3. The 30% presentation will be compiled to showcase the data and progress of Tasks 1-3 to the client.

2.8.3.1.2. Task 8.3.1.2 60% Milestones

A 60% report will include the 30% report along with recommendations on the best composting methods. The 60% report includes the 30% and Task 4. The 60% presentation will be compiled to showcase the data and progress of Tasks 1-4 to the client.

2.8.3.1.3. Task 8.3.1.3 90% Milestones

The 90% report will include everything from the 30% and 60% reports with the addition of an operations manual for optimum composting. The 90% report included both 30% and 60% as well as Tasks 6, 7, and 8.

2.8.3.1.4. Task 8.3.1.4 Final

A final report and presentation will be presented at the completion of the project on December 3, 2019.

2.8.3.1.4.1. Task 8.3.1.4.1 Presentation

The final presentation will include all the tasks and results from 30%, 60%, and 90%. The final presentation will also serve to answer any final concerns or questions from the client.

2.8.3.1.4.2. Task 8.3.1.4.2 Report

A final report will be written compiling the data gathered along with the recommendations and an operation manual for optimum compost treatment.

2.8.3.2. Task 8.3.3 Meeting Memo Binder

A catalogue of SAS Engineering team meetings will be compiled and recorded throughout the semester.

2.8.3.3. Task 8.3.4 Website

A website will be built to display and achieve the project information.

2.9. Exclusions

The exclusions consist of required actions that will not be performed by SAS Engineering. SAS Engineering team will not provide documentation as required by ADEQ and will provide permits.

3.0 Schedule

The schedule for the compost project will start on August 26th, 2019 and will be completed by December 13th, 2019. The project schedule will span 80 days from start to completion. The critical path for the project is detailed by a red path on the Gantt chart Figure 3.1. The critical path starts with Task 1.0 Operations Research, and Task 2.0 Work Plan. Then Task 3.0 Sampling comes next within the critical path, followed by Task 4.0 Analysis. Then Task 5.0 Impacts, Task 6.0 Operations Analysis, and Task 7.0 Economic Analysis happen last simultaneously. The major deadlines for deliverables are marked with their corresponding dates on the Gantt chart. The tasks in the Gantt chart are sequentially ordered for major deliverables to be completed from start to finish with subtasks being simultaneously tiered as to provide the optimal project completion time.

4.0 Staffing Plan

The Staffing Plan consists of depicting all the hours that are inputted into the project by the staff. The roles that make up the project are the Senior Engineer, Engineer, and Lab Technician. The Senior Engineer will be responsible for overseeing the project. This will include all team meeting scheduling, lab time scheduling, client meeting scheduling and monitoring of project timing and completion. The Senior Engineer will also be responsible for overseeing all work done and signing off on pre-reviewed documents. Qualifications for the Senior Engineer consist of PE Licenses, master's degree and 15 years of experience.

The Engineer will be responsible for many of all written documents including the written impacts assessment, the work plan, and economic analysis. The Engineer will be responsible for overseeing the pile sampling and testing performed by the Lab Technician. Qualifications for the Engineer consist of PE or has an EIT and are working towards a PE, bachelor's degree, with four years of experience.

The Lab Technician will be responsible for researching testing parameters and methods along with all pile sampling and lab testing. Qualifications for the Lab Technician consist of OSHA Certification, ASTM Certification, and 1-year experience.

The Tasks and Staffing Hours table will break down the total hours required by each position. The Senior Engineer will provide oversight on most tasks with a total amount of hours being 123 billable hours. The Engineer will provide most of the labor, with 241 billable hours, on all the tasks except for Task 4.0 Pile Sampling and Task 5.0 Testing Analysis where the Lab Technician will perform most of the labor with 224 total billable hours. The project hours reqnuired to complete the project is 588 work hours. This is displaced and broken down into tasks and sub tasks in the Table 4-1. below.

*Table **Error! No text of specified style in document.**-1: Staffing Hours*

Task	Staff (Hours)			
	Senior Engineer	Engineer	Lab Technician	Total
Task 1.1 Operations Research	2	4	8	14
Task 2.1 Sampling and Analysis Plan (SAP)	3	7	3	13
Task 2.2 Health and Safety Plan (HASP)	2	4	8	14
Task 3.1 Testing Parameters	3	22	22	47
Task 3.2 Testing Methods	3	22	22	47
Task 4.0 Analysis	45	65	118	228
Task 5.0: Impacts	3	15	12	30
Task 6.0: Operation Analysis	14	15	4	33
Task 7.0: Economic Analysis	22	35	0	57
Task 8.1: Meetings	3	3	3	9
Task 8.2: Team Management	10	10	10	30
Task 8.3.1: Milestones	7	15	4	26
Task 8.3.2: Presentations	3	6	2	11
Task 8.3.3: Meeting Memo Binder	0	8	8	16
Task 8.3.4 Website	3	10	0	13
Staff Total	**123**	**241**	**224**	**588**

5.0 Cost of Engineering Services

The cost of the project takes into consideration personnel and supplies. No travel is required. Cost of engineering services is shown below in Table 5-1. The total cost of the project is $69,742.

*Table **Error! No text of specified style in document.**-2: Cost Analysis*

Cost Estimate of Engineering Services				
1.0 Personnel				
Classification		**Hours**	**Rate, $/hr**	**Cost $**
SENG		123	200	24600
ENG		241	74	17834
LAB		224	63	14112
Total Personnel			N/A	**56546**
2.0 Supplies				
Item	**Cost per unit $**	**Unit**	**Quantity**	**Cost $**
NAU Lab Rental	100	120	1	12000
E.coli Broth Glass Ampules, pk/20	56	1	20	56
m-ColiBlue24 Broth, Plastic Ampules, PK/50	130	1	50	130
Total Organic Carbon (TOC) Reagent Set, HR	489	1	1	489
Nitrogen-Ammonia Standard Solution, 50 mg/L as NH3-N, pk/20 - 2 mL PourRite™ Ampules	54	1	20	54
NitriVer® 3 Nitrite Reagent Powder PIllows, 10 mL, pk/100	43	1	100	43
Nitrate TNTplus Vial Test, LR (0.2-13.5 mg/L NO3-N)	47	1	1	47
Phosphorus (Reactive and Total) TNTplus Vial Test, LR (0.15 to 4.50 mg/L PO4)	59	1	1	59
Potassium Reagent Set	210	1	1	210
Salmonella EPA Test Broth pk/15	108	1	15	108
Total Supplies	N/A			**13196**
Total				**69742**

The material cost was determined through calculation of what is needed per test. The lab will be accessible for the analysis however the materials will still be needed to conduct the tests. The pH, moisture content, temperature, XRF, and density will be done utilizing the NAU Lab equipment which will be provided within the NAU Lab $100/hour.

6.0 References

[1] P. Pfeifer, M. Gallo and B. Marbury, "NAU Composting Pilot Study Research Report, 2011-2012", *Cvcompost.com*, 2013. [Online]. Available: https://www.cvcompost.com/NAU-Compost-Research-Project.pdf. [Accessed: 14- Feb- 2019].

[2] "INTERPRETING WASTE & COMPOST TESTS", *WOODS END RESEARCH LABORATORY*, vol. 2, no. 1, pp. 1-6, 2005. Available: https://woodsend.com/pdf-files/compost.pdf. [Accessed 26 January 2019].

[3] N. Gromicko, "Compost Pile Hazards - InterNACHI", Nachi.org, 2019. [Online]. Available: https://www.nachi.org/compost-pile-hazards.htm. [Accessed: 14- Feb- 2019].

[4] "Test Methods of the Examination of Composting and Compost", Compostingcouncil.org, 2001. [Online]. Available: https://compostingcouncil.org/wp-content/plugins/wp-pdfupload/pdf/34/TMECC%20Introduction%20and%20Contents.pdf. [Accessed: 14- Mar- 2019].