



NORTHERN ARIZONA
UNIVERSITY

College of Engineering, Forestry & Natural Sciences

CENE 476 Capstone Prep

Nitrification Column

Proposal Draft #2: Scope of Services

Authors: Adrian Biggs, Siwen Li, and Emily Sarah Wheeler
(ENE Students)

Technical
Adviser: Terry Baxter (PE, Ph.D., Assoc. Professor)

Client: Alarick Reiboldt (EIT, M.Eng, Lecturer)

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1.0 Project Understanding

1.1 Project Purpose

Urine is an unsterile, nutrient-rich resource that can be used to fertilize plants. Human liquid waste contains close to 88% nitrogen and 66% phosphorous, both of which is excreted from the body. Though urine is unsterile, it does not contain the same hazards, bacterial pathogens, which exist in the solid waste [1]. Separating urine at the source is an effective approach to recover nutrients from liquid waste. Taking full advantage of the benefits of urine is a good way of 'closing the cycle' in agriculture nutrient flows. This system could also possibly reduce sewage costs, ecological consequences, as well as improve sanitation in developing areas. It is surprising that the application of the benefits of urine for the growing of crops is relatively rare.

This proposal will focus on the nitrogen recovery from liquid waste on the scale of a household-nitrification column. Liquid waste is mostly in the form of ammonia species and must be oxidized to nitrate before plants can take it up through their root systems. Nitrogen compounds are reduced and are sequentially oxidized to nitrite and nitrate by nitrifying bacteria through nitrification process. The main purpose of nitrification column is to convert nitrogen compounds in urine to a form that can be used by plants directly. The nitrification column should provide suitable growth and living conditions for all bacteria to effectively operate. This system should also have a nitrate removal assembly to remove nitrate from water and provide that to plants.

1.2 Project Background

This project is primarily research oriented, and will require a lot of time and resources that will be provided by the NAU EnE Laboratory. The design work for this project will be located at the NAU greenhouse on the south most campus, which can be seen from the following figure [2]. The final design of this project could be implemented anywhere with Flagstaff conditions. However, the final design could be adjusted to be able to function at any living conditions.



Figure 1: NAU Southern Greenhouse

The design considerations this nitrification column will consider year-around commercial home use at standard Flagstaff conditions. This will include the recovery of nutrients at a household scale. For future work on this project, a similar design could be implemented to run in more rural or developing areas. The recovery of the nutrients in these areas could serve on a more industrial scale to be utilized for mass agriculture.

The following table describe standard Flagstaff climate conditions [3]:

Table 1: Standard Flagstaff Climate Conditions

	Avg. High Temp (°F)	Avg. Low Temp (°F)	Avg. Rainfall (in)	Avg. Snow (in)
January	43	11	2.13	18
February	45	14	2.32	17
March	50	20	2.24	15
April	58	25	1.26	7
May	67	30	0.63	0
June	77	36	0.43	0
July	81	46	2.36	0
August	78	46	3.46	0
September	73	37	2.56	0
October	63	27	1.89	2
November	52	18	1.81	7
December	43	11	2.05	11

The following table describes the average flagstaff weather conditions [3]:

Table 2: Average Flagstaff Climate Conditions

Annual High Temp (°F)	60.8
Annual Low Temp (°F)	26.8
Average Temp (°F)	43.8
Average Annual Rainfall (in)	23.14
Average Annual Snowfall (in)	77

The following figure describes the Flagstaff climate graph [3]:

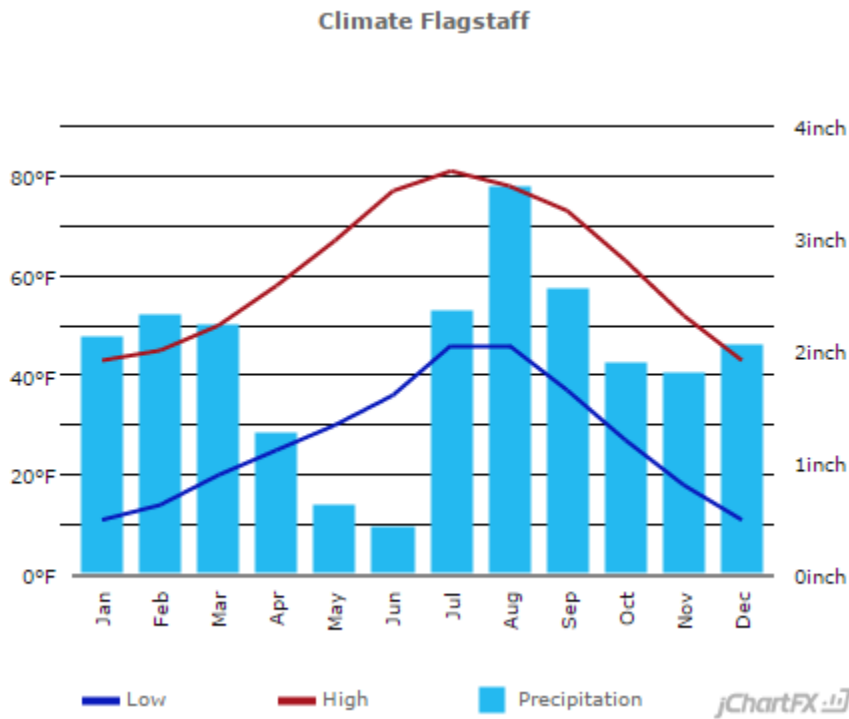


Figure 2: Flagstaff Climate Graph

The design of the nitrification column will be at a household level, which will required household statistics. These are included in the following table [4]:

Table 3: Flagstaff Household Statistics

	Mean # of People Under 18 years	Mean # of People Over 18 years
Family Household	0.97	2.24
Nonfamily Household	0.02	1.23

For the purposes of this project a household consist of 3 persons, each of which producing 800 to 2000mL/day of urine [4, 5].

1.3 Technical Considerations

There are multiple technical considerations required for this project. The first of these considerations consist of the conditions within the system.

There are numerous conditions which are listed in the following table:

Table 4: Preliminary Conditions Considered

Condition	Purpose for Consideration
Climate	To determine exterior conditions (temperature, humidity, sunlight etc.); Different year-round
Interior Climate	To determine interior conditions (temperature, humidity, sunlight etc.); should be relatively consistent year round
Inlet Flow Conditions	Sets the initial conditions for the system (Concentration, flow); based on average household statistics
Bacterial Growth Conditions	Sets the necessary conditions for optimum growth within the system; based on bacterial data
Designed Outflow Conditions	Sets the expected outflow conditions for distribution; based on mathematical modeling
Tested Outflow Conditions	Used to model the efficiency of the system; testing must be done

The most important technical consideration is the optimum growth conditions for nitrifying bacteria. These optimum conditions are the basis for the design of a nitrification column. All other considerations allow for an increased comprehension of the initial conditions of the system which then allows for more accurate design conditions (i.e. modifying the temp, pH, Concentration etc.). The closer to the optimum conditions for growth the column, the higher the efficiency of Nitrification. An important first step in designing accurate conditions is to compare the efficiencies of Aerobic and Anaerobic nitrifying bacteria. This creates a baseline for the necessary conditions.

Another important technical consideration is the exact location of the nitrification column. Questions like ‘will system be located inside or outside?’ will have to be answered. This has a large impact on the initial conditions of the system. Based on the bacteria chosen and the conditions necessary for growth, one of these locations will make the system more efficient.

The materials for construction and bacterial growth are the next considerations. There are many different forms of growth media that exist today, but this system will require a customized growth media. The media will need to contain all of the necessary components for nitrification bacteria growth. The system itself will need to be constructed of a durable, weather-proof material if designed for exterior housing or a thinner material that must be “smell-proofed” for indoor housing.

One of the most important technical considerations for this project are the required calculations. The following table describes these equations in detail.

Table 5: Preliminary Calculations Considered

Calculation	Description
Flow Rate	Determine optimum waste conveyance
Mass Transfer Rate	Aid in the understanding of urea flow and nitrate release for mass balance
Mass Balance	Aid in understanding system
Efficiency	Determine areas for improvement & Potential failures
Bacteria Growth	Predict bacterial growth within column & Aid in design of required cartridges
Column Design	Determine the parameters and dimensions of packed column design
Cost	Determine feasibility of design

Determining the exact urine composition, as well as the inflow & outflow of urine from the system is a critical technical consideration. The following table generally describes the average composition of urine [6].

Table 6: Composition of Urine Considered

Category	Quantity (mg/L)	Description
Inorganic Salts	14,157	Salt that is comprised of inorganic materials
Urea	13,400	Colorless crystalline compound and main nitrogenous by-product from the protein metabolism process
Organic Compounds	5,369	Chemical compounds whose molecules contain primarily Carbon and Hydrogen
Organic Ammonium Salts	4,131	Salt that is both comprised of organic material and ammonium

The safety of the project is another critical technical consideration. This will mostly focus on the sanitation of the project and any areas where this design may affect human health or the pollution of the environment.

Finally, the last consideration made is the use of the final effluent as fertilizer for the growth of plants and agriculture. A possible benefit of Urine is that it contains large quantities of nitrogen mostly in the form of urea. Urine also contains significant quantities of dissolved phosphates and potassium. The two main macronutrients required by plants. So urine has the potential to be an excellent fertilizer.

1.4 Potential Challenges

The first and most difficult challenge will be maintaining a functional bacterial level for an extended period of time. Nitrifying bacteria are extremely precise organisms, small changes in the surrounding conditions can have a huge impact on the health of the bacterial colony. These bacteria have a small range of acceptable conditions for growth. The entire colony could be exterminated if a change in conditions were to occur.

Wastewater, pre-treatment, contains a plethora of microorganisms. A challenge exists in the form of invasive species, or dangerous contamination. Many microorganisms in wastewater are deadly to nitrifying bacteria. The bacteria already present in urine, however, contains no microorganisms that are crippling to nitrifying bacteria. Contrary, human fecal bacteria are extremely dangerous, they rapidly outgrow and smother the nitrifying bacteria. The only other source of potentially dangerous contamination is through human contact. The average human hand has millions of species present that, though they are not harmful to humans, may be deadly to our bacteria.

The only challenge in the material design of the system will be the proper construction of a system that creates the conditions that are necessary. The system may have to be sealed for the creation of an anaerobic environment. A perfect seal is difficult to achieve, and if the seal is imperfect the efficiency of the system will decrease. Material strengths and abilities will need to be compared to produce the most efficient system.

A challenge that comes with choosing outdoor housing of the system is climate change. The continuously changing conditions of the outdoors will need to be isolated from the system if the changes are too drastic. These year-round conditions will need to be tested against our design.

Another potential challenge for our bacterial colony will be inactivity. If the user chooses to leave town, causing the system to be inactive for long periods of time, there may be a significant negative effect. Finding the maximum number of days without activity will allow us to construct a manual for restarting the system.

To allow for accelerated bacterial growth, the growth media will be inoculated with nitrifying bacteria. The challenge with inoculation will be restarting the system. After the first use, the effect of inoculation on growth becomes minimal. However, the ability to replace inoculated media easily will overcome this challenge.

The final challenge will be adding water flow to the system. The necessity of flowing water will be based on the dilution necessary to reach the selected concentration within the inflow for optimum growth. This water will not only be used to dilute the inflow but provide conveyance and distribution. The increased flow will allow for greater bacterial coverage and conveyance of waste products. The last use will be to spray the products and the water over soil.

1.5 Stakeholders

The following table describes the potential stakeholders of nitrification column project. The contribution to project of each stakeholder are listed below:

Table 7: Stakeholders

Stakeholder	Position	Contribution/ Impact	Investment
Alarick Reiboldt	Client	<ul style="list-style-type: none"> - Approve scope, resources and schedule - Provide design constraints and criteria - Provide financial support 	<ul style="list-style-type: none"> - Technical reliability - Recovery efficiency - Cost - Lifetime - Operability
Homeowner	Primary customer	<ul style="list-style-type: none"> - Purchase product - Direct user 	<ul style="list-style-type: none"> - Lifetime - Operability - Cost
Agriculture Company	Secondary customer	<ul style="list-style-type: none"> - Purchase product - Product development - Fertilizer production 	<ul style="list-style-type: none"> - Recovery efficiency - Technical reliability - Cost - Development potential
Design Team	Designer	<ul style="list-style-type: none"> - Design product - Strong drive of project success 	<ul style="list-style-type: none"> - Technical reliability - Recovery efficiency - Lifetime - Operability - Cost - Potential pollution - Development potential
Wastewater Treatment Facility	Beneficiary	<ul style="list-style-type: none"> - Reduction of urine concentration in wastewater 	<ul style="list-style-type: none"> - Recovery efficiency
Environment	Beneficiary	<ul style="list-style-type: none"> - Nitrogen recovery - Human waste recovery - Sanitation improvement 	<ul style="list-style-type: none"> - Recovery efficiency - Potential pollution

2.0 Scope of Services

This section establishes what will be provided by the consultant to meet client goals and needs. To clearly define these services we have split them into three sections: deliverables, tasks, and exclusions. The deliverables describe a list of completed elements of the project. The list of tasks describe, in detail, the methods used to complete those deliverables. Lastly, the list of exclusions provide information on what will be omitted from this year design project.

2.1 List of Deliverables

The following table describes the deliverables that will be submitted for the completion of this capstone project.

Table 8: List of Future Deliverables

Deliverable	Completion Date
Lab Analysis Procedures and Lab Cost Requirements	April 29 th at 12:00 PM
Preliminary Design Specifications	October 1 st at 12:00PM
Final Design Specifications and Cost Requirements	October 20 th at 12:00 PM
Completed Nitrification Column Model	November 30 th at 12:00 PM
Final Presentation	TBA

2.2 List of Tasks

This section identifies all activities required for the completion of this project.

Task 1: Determination of Legality and Sanitation

Task 1.1 Determination and list creation of state, local, and federal regulations.

This will include detailed research into the regulations that influence the success of this project.

Task 1.2 Determination the regulations in regard to effluent quality.

This section will include the regulations in regard to the use of this effluent in house-scale gardens.

Task 1.3 Prediction of human health, sanitation, or negative impacts on the environment.

This will be an analysis of the potential consequences in regard to this project.

Task 1.4 Determination of water usage restrictions.

This will include the determination of what, if any, water restrictions or limitations that can be used in this type of system.

Task 2: Determination of Urine Samples

Task 2.1 Determination of surrogate or natural urine samples.

Determination on weather surrogate urine sample will be used. If surrogate urine is used, determination of the exact chemical composition. If natural urine samples are used, determination of how urine will be collected for testing.

Task 2.2 Collection/Creation of urine samples.

If surrogate urine is used, creation of sample. If natural urine samples are used, collection of samples.

Task 2.3 Determination of antibiotic residuals in urine sample.

If natural samples are used, research the effects of antibiotic residuals potential effect on system.

Task 3: Determination of Lab Analysis Procedures

Task 3.1 Determination of complete list of required standard methods.

Determination of all required lab analysis procedures required for the completion of this project.

Task 3.2 Acquire materials and summer lab access.

Submit request for access of NAU environmental labs. Submit request for necessary lab equipment, materials, and chemicals.

Task 4: Implementation of Lab Work

Task 4.1 Determination of bacterial effectiveness.

Compare and determination of most effective/optimal bacteria species. This stage will determine exact species used.

Task 4.2 Determine bacteria growth parameters.

This will include growth rate and habitat preferences. Habitat preferences consist of growth media,

inside versus outside, and anaerobic versus aerobic.

Task 4.3 Determination of antibiotics effect on bacterial growth if they exist in urine sample.

Record any effect antibiotics in urine samples will have on the success and effectiveness of the biological system.

Task 5: Preincubated Cartridge Analysis

Task 5.1 Determination of preincubated cartridge use.

This will include research on the feasibility, parameters, and requirements of the use of preincubated cartridge in the system.

Task 5.2 Creation of preincubated cartridge design specifications.

Create design specifications of preincubated cartridge if determined to be feasible.

Task 5.3 Construction of preincubated cartridge.

This will include the construction of the preincubated cartridge.

Task 5.4 Testing of preincubated cartridge.

This will include initiating the beginning stages of 'testing' of the design. The preincubated cartridge will be 'set-up' and running. All results from this will be recorded in detail.

Task 6: Design Concept Generation and Selection

Task 6.1 Design Concept Generation

Generation all multiple design alternatives.

Task 6.2 Design Selection

Follow the engineering design cycle and select design. Consideration of viability of growth media composting. Consideration of effectiveness and feasibility of all alternatives.

Task 6.3 Submit preliminary design.

Submit preliminary design to client and technical advisor and request feedback.

Task 7: Conduction of Field Evaluation

Conduction of analysis on environmental conditions of final design location.

Task 8: Conduction of Plant Evaluation

Task 8.1 Determination of the feasibility of edible plants.

Research the effects this system could have on edible plants. Determine the feasibility of edible plants in the system.

Task 8.2 Determination of the urine dilution required in system.

The system will require water dilution or the direct treated urine would burn plant roots, and be counterproductive.

Task 9: Preformation of Design Calculations

Task 9.1 Determination of the physical dimensions of column design model.

Determination of optimum waste conveyance flow rate. Preformation of required mass transfer rate, and mass balance calculations.

Task 9.2 Determine the overall efficiency of the system.

Task 10: Determination of Final Design

Task 10.1 Determination of materials needed for column.

This will include all a list of all required materials and a cost analysis of those materials.

Task 10.2 Determination of column size and dimensions.

Considerations of previously determine environmental conditions, human sanitation and safety.

Task 10.3 Final design will be submittal to technical advisor and client.

This will include all information about the model aspect of the design, including final specifications and cost.

Task 10.4 Feedback Consideration and Last Minute Adjustments

Consideration of feedback and preformation of minor adjustments to final design.

Task 11: Construction of Model Structure

Construction of model structure based on final design specifications.

Task 12: Conduction of Final Testing

Evaluation of effectiveness of final structure. Determination of the likelihood of salt buildup due to evaporation.

Task 13: Project Management

Project management will be completed throughout the entirety of project. This will include scheduling, final report submittal, determination of possible future work and potential for design alternatives, final presentation preparation, and website creation.

2.3 List of Exclusions

This section identifies all aspects of this project that are excluded.

Exclusion 1: Separation of Solid and Liquid Waste

The design of this system will only consider liquid waste fragments. This system will not consider any solid waste fragments, or the separation of the two types of waste.

Exclusion 2: Design for Nutrient Collection

The only nutrient that this system will be design to collect and utilize will be Nitrate.

Exclusion 3: Utility Scale

The scale of this project will only be considered at a household with home gardens. This will exclude utility scale projects and mass agriculture.

Exclusion 4: Design Model

Though this project will be designing for a household scale system, the only construction that will take place during the entirety of this project will be at a design model level.

3.0 Scheduling

The schedule that was created to describe the task list with durations, start/end dates, and some important milestones can be found in section 5.1 of the Appendix of this report. The figure describes the GanttChart create to manage this project. The critical path is identified to establish the inter-task relationships, this project includes the finish-to-start, start-to-start, and finish-to-finish relationships.

The schedule created is achievable. It does not overcommit or underperform resources. It communicated in a clear a concise manner the timeline of evens that will be completed. This schedule was designed to be flexible as well, to ensure the success of this project.

The following figure describes the network diagram. The orange circles represent the millstones. The grey squares represent the tasks, and the green squares represent the subtasks. The month timeline can be found at the top.

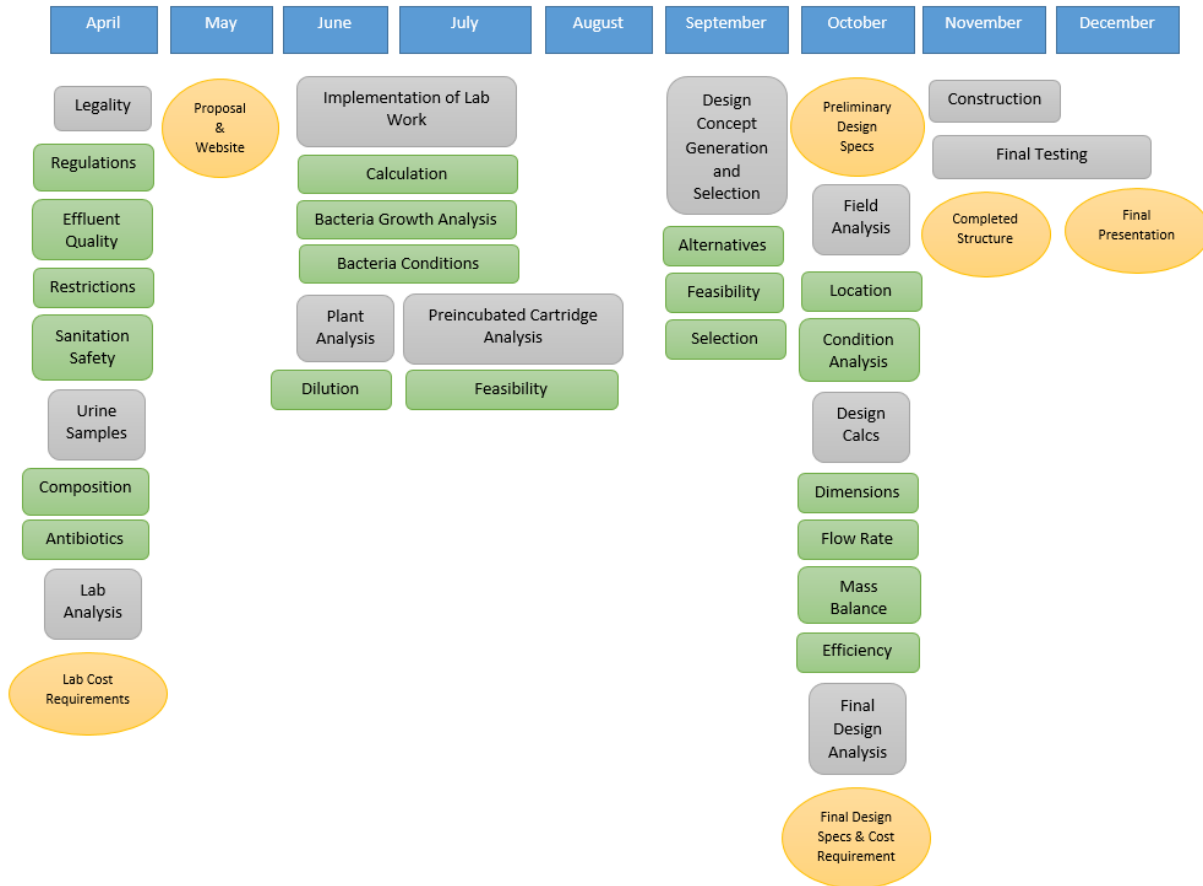


Figure 3: Network Diagram

2.3 List of Intended Standard Methods

The following list describes methods that are required for the success of this project. We have access to all of these standard methods in the HACH water analysis handbook in the environmental engineering lab. All interferences are listed in the associated standard method. The scope and application for all of the following methods is water and wastewater.

Temperature and pH

The data collection probe will analyze temperature and pH. These elements are necessary to determine the optimal temperature and pH ranges for the nitrifying bacteria. These ranges will aid in the survival of the bacteria as well as providing the highest nitrogen removal efficiency.

Alkalinity

Measuring alkalinity is important to determine the urine's ability to neutralize acid inputs. It is critical for the design of the nitrification column to operate in the optimal pH range. Therefore, it's necessary to

determine the buffer range that all the nitrifying bacteria can keep alive. It is also necessary to determine any possible pH fluctuations that can occur in the system.

Oxygen Demand, Chemical

The chemical oxygen demand (COD) test is used to indirectly measure the amount of organic compounds in the urine sample. The mg/L of COD results are defined as mg of O₂ consumed per liter of sample. COD commonly indicates the amount of oxygen required to oxidize soluble and particulate organic matter in the water. COD is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment. Higher COD levels mean a greater amount of organic material in the sample, which will reduce dissolved oxygen (DO) levels and could possibly have negative effects in our system and the environment. For nitrification column project, it is a necessary measurement to evaluate the quality of the urine sample.

Conductivity

Electrolytic conductivity is the capacity of ions in a solution to carry electrical current and is the reciprocal of the solution resistivity. In many cases, conductivity is linked directly to the total dissolved solids. The conductivity test is required for nitrification column to determine the urine quality before and after the nitrification process.

Oxygen, Dissolved

Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. For this project, it is an important parameter in assessing the urine quality because of its influence on the microorganisms in the system. The nitrification process is an aerobic process, both the ammonia oxidation and nitrite oxidation process are in need of oxygen. Therefore, it's necessary to find how much dissolved oxygen is available from the urine and is there any aeration needed to keep the nitrifying bacteria alive.

Nitrate

As we have discussed previously in this document, nitrate makes an excellent fertilizer for plants and agriculture. The purpose of this project is to exploit the benefits of this nutrient as a fertilizer, so the ability to collect nitrate data is critical for the success of this project.

Nitrite

Nitrite is an intermediate effluent that exists for this project. This effluent is oxidized in our sample to our final effluent, Nitrate. The ability to analyze this intermediate in the system is a critical aspect to the success of the column with regard to concentration and efficiency of our final design.

Nitrogen, Ammonia

The measurement of ammonia nitrogen in the system is important to determine the influent concentrations in the system. Ammonia is realized from the breakdown of urea. Ammonia is oxidized to nitrite, which is then oxidized to nitrate. The ability to analyze this influent in the system is a critical aspect to the success of the column with regard to concentration and efficiency of our final design.

Nitrogen, Total

There are three forms of nitrogen that are measured in this system: ammonia, nitrites, and nitrates. Total nitrogen is the sum of total kjeldahl nitrogen (ammonia, organic and reduced nitrogen) and

nitrate-nitrite. Because the design requires the application of nitrification, it is important to determine the sum of the nitrogen in the system.

Phosphorus, Total

This standard method is not critical for our project. This would be an optional method that would provide insight into another nutrient, phosphorus that this system will produce.

Salinity

Urine has a lot of dissolved salts in its composition. The exact measure of the concentration of these salts will provide important information in regard to how this salt will build up in the system.

4.0 Staffing

The estimated cost for a firm to complete the Notification Column Design is described in this section.

The following table describes the different types of services that would be provided by this firm. These services are divided into five classifications, and correspond to a code. The Project Manager is the person that is responsible for leading the project, this includes planning, resource management, as well as scoping the project. The Administrative Assistant is a broad job that provides various types of administrative support to the project. The Microbiologist would act as an employed scientist who studies microscopic life forms, they would investigate the growth and characteristics of the bacteria involved in this project. The Biochemical Engineer would focus on the design and construction of the unit process that involved biological organisms. Finally, we have the Environmental Engineer that would focus on the principles to improve and maintain the environment for the protection of human health and at risk ecosystems.

Table 9: Services Classifications

Classification	Code
Project Manager	PM
Administrative Assistant	AA
Microbiologist	MB
Biochemical Engineer	BENG
Environmental Engineer	ENENG

The total work days and work hours estimated from the Staffing Time Table in the Appendix are listed in the following table below. This table also shows the estimated work time for each staffing classifications. This table assumes a linear progression of project tasks, with no delays or overlaps. This project will require 180 days to complete, averaging about 2.5 hours each day.

Table 10: Estimated Classification Required Work Time

	Total Days	Total Hours	PM Hours	AA Hours	MB Hours	BENG Hours	ENENG Hours
Total Days	180		20.4	12.8	38.4	56.6	51.8
Total Hours		450	51	32	96	141.5	129.5

The analysis of financial data for projects at a firm can result with multipliers for each classification, these multipliers will aid in determining the billing rate for each classifications hourly base pay. The

specific way the multiplier was determined is not released to the client. A high multiplier does not always translate to high profit, it could simply be high overhead.

The building rates for this section are typical and reasonable rates that a firm would charge to conduct the same project. The table below lists the hourly billing rate for each position, which are inclusive of employee benefits, profit and overhead [7]. The overhead is considered the cost of running this project, the main overhead that exists for this project is the laboratory expenses, software, and professional registrations, and insurance.

It should be noted that the overhead for Project Manager and Administrative Assistant are higher. This is due to the use of computers, software and utilities. The overhead for Microbiologist, Biochemical Engineer and Environmental Engineer are mainly from lab testing materials.

Table 11: Provided Billing Rate

Classification	Base Pay \$/hr	Benefits % of Base Pay	Actual Pay \$/hr	OH % of Base Pay	Actual Pay + OH %/hr	Profit, % of Actual Pay + OH	Billing Rate \$/hr
PM	65	30	85	55	132	10	145
AA	16	60	26	45	38	10	42
MB	33	40	46	20	55	10	61
BENG	32	40	45	20	54	10	60
ENENG	38	60	61	20	73	10	80

The table below shows the total estimate cost for labor cost. This table simply calculated the estimated cost for the project and individual labor considering the billing rate and the number of hours each classification has dedicated for this project. The total labor cost of this project would be around \$35,745, which is not an unreasonable number for an engineering firm.

Table 12: Classification Labor Cost

1.0 Personnel	Classification	Hours	Rate, \$/hr	Cost
	PM	20.4*2.5=51	145	\$7,395
	AA	12.8*2.5=32	42	\$1,344
	MB	38.4*2.5=96	61	\$5,856
	BENG	56.6*2.5=141.5	60	\$8,490
	ENENG	51.8*2.5=129.5	80	\$10,360
	Total Personnel	450		\$33,445
2.0 Lab	Classification	Days	Rate, \$/Day	Cost
	Lab Rental	60	30	\$1800
	Lab Equipment and Materials			\$500
	Total Lab	60		\$2,300
3.0 Total				\$35,745

5.0 Appendix

5.1 Gantt Chart

*Please refer to the attached *Project Manager* document.

5.2 Staffing Time Table

The table below represents the estimated hour load for each task and sub task.

Table 13: Detailed Estimation Classification Required Work Time

Task	Total Days	Total Hours	PM Hours	AA Hours	MB Hours	BENG Hours	ENENG Hours
1.0 Determination of Legality and Sanitation	4	10	-	-	-	-	-
<i>1.1 Determination and list creation of state, local, and federal regulations.</i>	1	2.5	-	2.5	-	-	-
<i>1.2 Determination the regulations in regard to effluent quality.</i>	1	2.5	-	2.5	-	-	-
<i>1.3 Prediction of human health, sanitation, or negative impacts on the environment.</i>	1	2.5	-	2.5	-	-	-
<i>1.4 Determination of water usage restrictions.</i>	1	2.5	-	2.5	-	-	-
2.0 Determination of Urine Samples	13	32.5	-	-	-	-	-
<i>2.1 Determination of surrogate or natural urine samples.</i>	3	7.5	7.5	-	-	-	-
<i>2.2 Collection/Creation of urine samples.</i>	6	15	-	15	-	-	-
<i>2.3 Determination of antibiotic residuals in urine sample.</i>	4	10	-	-	-	-	10
3.0 Determination of Lab Analysis Procedures	6	15	-	-	-	-	-
<i>3.1 Determination of complete list of required standard methods.</i>	3	7.5	7.5	-	-	-	-
<i>3.2 Acquire materials and summer lab access.</i>	3	7.5	-	7.5	-	-	-
4.0 Implementation of Lab Work	30	75	-	-	-	-	-
<i>4.1 Determination of bacterial effectiveness.</i>	10	25	-	-	8.4	8.3	8.3
<i>4.2 Determine bacteria growth parameters.</i>	10	25	-	-	8.3	8.4	8.3
<i>4.3 Determination of antibiotics effect on bacterial growth if they exist in urine sample.</i>	10	25	-	-	8.3	8.3	8.4

Task	Total Days	Total Hours	PM Hours	AA Hours	MB Hours	BENG Hours	ENENG Hours
5.0 Preincubated Cartridge Analysis	70	175	-	-	-	-	-
<i>5.1 Determination of preincubated cartridge use.</i>	5	12.5	-	-	-	-	12.5
<i>5.2 Creation of preincubated cartridge design specifics.</i>	20	50	-	-	25	-	25
<i>5.3 Construction of preincubated cartridge.</i>	23	57.5	-	-	-	57.5	-
<i>5.4 Testing of preincubated cartridge.</i>	22	55	-	-	25	10	20
6.0 Design Concept Generation and Selection	12	30	-	-	-	-	-
<i>6.1 Design concept generation</i>	5	12.5	3	-	3.5	3	3
<i>6.2 Design selection.</i>	5	12.5	3	-	3	3	3.5
<i>6.3 Submit preliminary design.</i>	2	5	5	-	-	-	-
7.0 Conduction of Field Evaluation	3	7.5	-	-	5	2.5	-
8.0 Conduction of Plant Evaluation	4	10	-	-	-	-	-
<i>8.1 Determination of the feasibility of edible plants.</i>	2	5	-	-	-	-	5
<i>8.2 Determination of the urine dilution required in system.</i>	2	5	-	-	2.5	2.5	-
9.0 Preformation of Design Calculations	4	10	-	-	-	-	-
<i>9.1 Determination of the physical dimensions of column design model.</i>	2	5	-	-	-	2.5	2.5
<i>9.2 Determine the overall efficiency of the system.</i>	2	5	-	-	-	2.5	2.5
10.0 Determination of Final Design	8	20	-	-	-	-	-
<i>10.1 Determination of materials needed for column.</i>	2	5	-	-	.5	2	2.5
<i>10.2 Determination of column size and dimensions.</i>	2	5	-	-	.5	2	2.5
<i>10.3 Final design will be submittal to technical advisor and client.</i>	2	5	-	-	.5	2	2.5
<i>10.4 Feedback Consideration and Last Minute Adjustments</i>	2	5	-	-	.5	2	2.5

Task	Total Days	Total Hours	PM Hours	AA Hours	MB Hours	BENG Hours	ENENG Hours
11.0 Construction of Model Structure	9	22.5			5	7.5	10
12.0 Conduction of Final Testing	7	17.5				17.5	
13.0 Project Management	10	25	25				
Total Days	180		20.4	13.0	38.4	56.6	51.6
Total Hours		450	51	32.5	96	141.5	129

6.0 References

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