Proposal for:

34th WERC Environmental Design Contest:

Task 1 – Stormwater Management for Community Resilience

Tiana Deloney, Matt Helms, Zach Lyon, Caroline Reed

Prepared For:

Dr. Jeffrey Heiderscheidt and Tom Loomis, PE

DRAFT 7

December 12, 2023

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

LIST OF ABBREVIATIONS

CJ	Climate Justice
EJ	Environmental Justice
ENG	Engineer
ESP	Experimental Safety Plan
NAU	Northern Arizona University
NMSU	New Mexico State University
RLS	Registered Land Surveyor
SENG	Senior Engineer
TECH	Engineering Technician
USGS	United States Geological Survey
WERC	Waste Management Education and Research Consortium

1.0 <u>Project Understanding</u>

To understand Task 1 of the 2024 WERC Design Competition [1] background information on the competition purpose, potential site issues, technical considerations, potential challenges, and stakeholders must all be defined and understood. The project understanding will help the team begin the process of solving a determined stormwater management issue within an underserved and underrepresented community.

1.1 Project Purpose

The primary goal of the project is to participate in the New Mexico State University (NMSU) 34th Waste Management Education and Research Consortium (WERC) Task 1: Stormwater Management for Community Resilience. Task 1 requires improving the existing stormwater management for a chosen underrepresented and underserved community by developing an innovative solution that is cost effective and can be widely implemented in similar communities.

1.2 Project Background

WERC is an innovative design competition aimed at providing student engineers with an opportunity to demonstrate their skills to solve environmental problems. The competition entails research and analysis of a specific site dealing with a stormwater management issue; ultimately preparing a technical report, flash talk presentation, and bench-scale model of the solution. WERC requests that the design must be low-cost, environmentally friendly, and unique; indicating that no typical solutions such as a detention basin or wetland should be used. An additional goal of this task is to passively treat any possible pollutants entering the community through the storm flows.

The project location is Joseph City, AZ, located within Navajo County. This site was selected based on guidance from WERC indicating that the site should be underserved and have a lack of stormwater infrastructure. Furthermore, Joseph City is designated by FEMA as being within a 100-yr floodplain. This location has dealt with overbank flooding issues due to the lack of adequate stormwater infrastructure and resources available. Climate change is causing a shift in extreme weather events, resulting in more extreme and more frequent storms. The disproportionate effects from climate change are observed closely in communities like Joseph City. The ensuing damages (economic, social, and environmental) to these communities emphasize the issues of environmental justice (EJ) and climate justice (CJ).

The following research and analysis will be completed for Joseph City. Joseph has historical flooding issues, primarily due to overbank flooding of the Little Colorado River and Joseph City Wash both waterways are depicted in Figures 1-2 and 1-3. Figure 1-1 shows the project location within the state of Arizona. Figure 1-2 locates the general area of flooding within Joseph City. Figure 1-3 highlights the determined residential location that has been most impacted from flooding and this location will be the focus of the project in addressing stormwater.

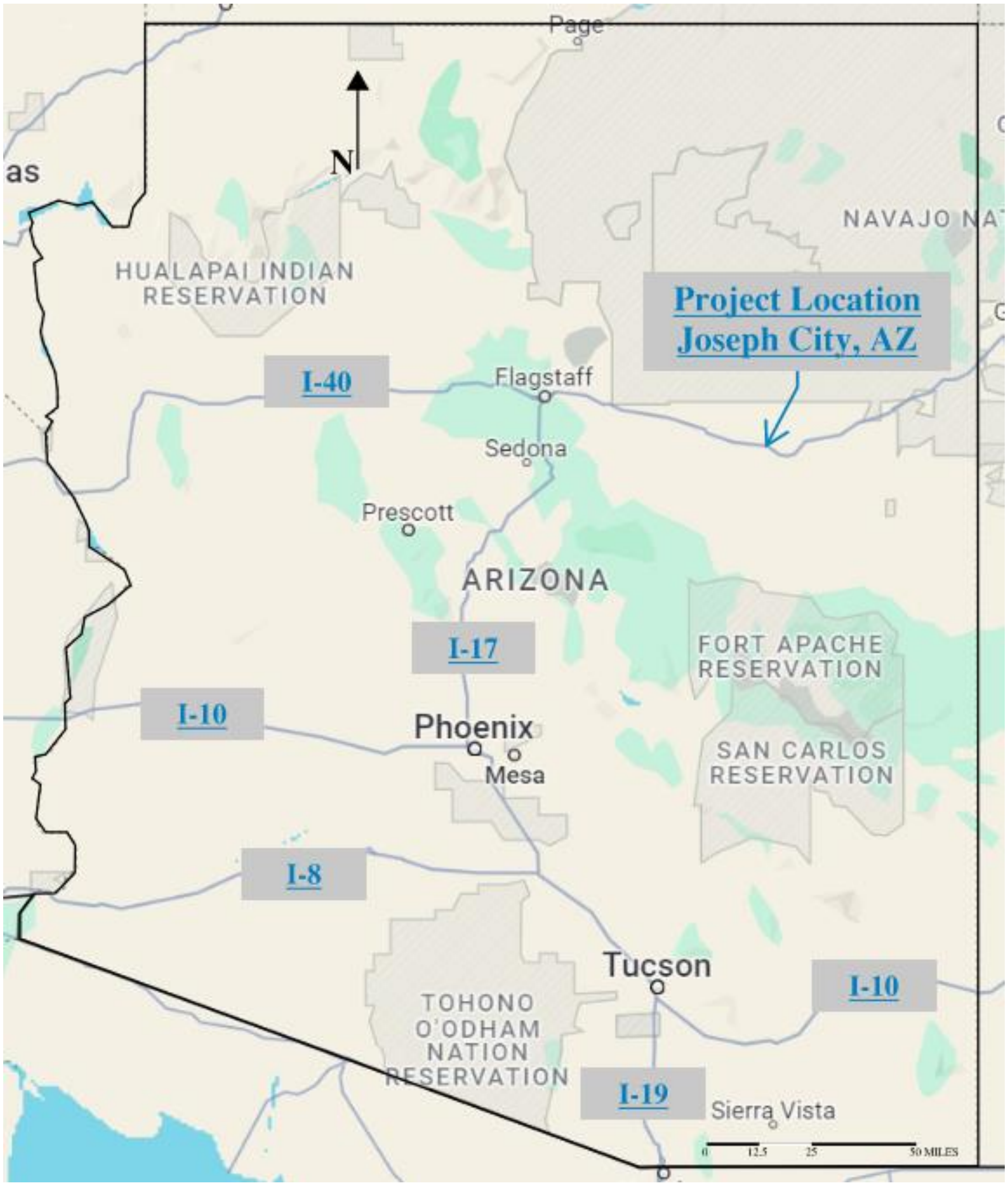


Figure 1-1: Location Map

Figure 1-2: Vicinity Map

Figure 1-3: Project Site

1.3 Technical Considerations

Technical considerations are the technical analysis and design methods required for this project. The technical considerations being addressed are as follows:

Understanding the Existing Conditions: Background research for the competition and project site will be required to gather an understanding of the current conditions of the site. This will include research on the existing conditions of the site to determine current stormwater management systems, along with the reasons for past failures in managing storm flows. Research will be conducted on determining codes and standards that apply to the project site. Open-source software from United States Geological Survey (USGS), such as StreamStats [3] and National Map [4], will be used for collection of precipitation, flow, and topographic data in the selected site.

After conducting research to understand the competition, project site, and problem to a basic level, a site investigation will be performed to gain a deeper understanding of the project site. This investigation will gather necessary dimensions, topographic data, and photographs that were not available via research.

Hydrologic and Hydraulic Analysis: A topographic map of the watershed will be created in Civil3D using data collected through USGS Lidar or a land survey. The watershed will then be delineated and analyzed using guidance from the Rational Method. The gathered storm flows will then be utilized as the design/ capacity storm flows for further hydraulic analysis done in HEC-RAS. The hydraulic analysis will serve as a guide for a successful design.

Techno-Economic Analysis: An analysis of how the alternative designs achieve the technical aspects of the task will be completed. An in-depth economic analysis will also be completed to include construction costs, operation & maintenance costs, as well as the general life-cycle cost of the design. Once these are both done for the designs, they will be combined for a techno-economic analysis: how well does the selected design mitigate economic, social, and environmental flood damages whilst being cost-effective.

1.4 Potential Challenges

The project begins at the end of monsoon season, so the likelihood of a critical storm occurring during design is slim. The inability to observe an actual storm event happening is going to limit the ability to convey a full site analysis. To overcome this challenge, the team will rely on previously recorded and published data related to the site’s history and use software that can accurately estimate the site’s existing conditions.

Lack of witnessing the storm event presents challenges in being able to timely and accurately collect stormwater samples. For this, the team will depend on known pollutants in the area and how they tend behave (transport & potential hazards) to make fact-based assumptions on the potential stormwater pollutants of concern.

The inability to visit the site due to inclement weather and client requests could pose an additional challenge. To overcome this challenge the team will prepare site visit safety plans that account for inclement weather adjustments. Furthermore, the use of visuals gathered from aerial data can be utilized for a virtual site visit.

1.5 Stakeholders

Joseph City, AZ: A successful project would benefit the community by providing a potential solution to manage stormwater that could be implemented at low cost. The town of Joseph City is depending on a design that can prevent current and future flooding issues that lead to social, economic, and environmental distress. Further, residents and businesses of this community have a strong interest since they will bear the cost of the solution as either taxes or stormwater management fees.

Underrepresented Communities Heavily Impacted by Stormwater Management Issues: A successful project will directly benefit other underrepresented communities with stormwater management issues by providing an example solution that could be implemented in those impacted communities.

Sponsors of the WERC competition (EPA Office of Research and Development, New Mexico Space Grant Consortium, NASA SMD Earth Science Division, CDM Smith, and Souder, Miller, and Associates): The Successful implementation of the project will provide a proposed solution that sponsors can use and benefit communities around the globe.

Northern Arizona University College of Engineering, Informatics, and Applied Science – Department of Civil Engineering, Environmental Engineering, and Construction Management: A successful project completion and project demonstration in the 34th WERC Competition would benefit the NAU engineering debarment by making the program look good through positive representation.

2.0 Scope of Services

The scope of services for the 2024 WERC Design Competition and CENE 486C requires the completion of nine tasks. All tasks, technical and non-technical, are necessary for the successful completion of the project. Tasks describe the components of designing and constructing a full-scale design and bench-scale model of a stormwater management system.

2.1 Task 1: Literature Review and Background Research

A literature and background review will be completed by the team based on the WERC competition rules and regulations, and general topics related to the project.

2.1.1 Task 1.1 Code and Standards Review

Navajo County & FEMA codes and standards will be reviewed to gather the necessary regulations and requirements for the site based on local and state governmental order. This will entail identifying the codes and regulations defaulted within the region where the project site is located.

2.1.2 Task 1.2 Soil Classification Review

The team will investigate current soil characteristics for the project site. The team will determine soil classification for the site using NRCS data.

2.1.3 Task 1.3.0 Typical Pollutant Research

The team will investigate current pollutants near and at the project site to characterize any potential pollutants that may need to be addressed.

2.1.4 Task 1.4 Existing Plans Research

The team will investigate if there are any previous or current stormwater management plans on the site through local and state databases. In addition, the team will review stormwater management topics, such as existing stormwater management technologies, issues with current stormwater management, and nature-based stormwater management practices. The team will use this as a starting place for the development of innovative stormwater management strategies and technologies.

2.1.5 Task 1.5 Existing Topography Data Review

The team will identify the available and current topography data on the site through local and state databases. The team will utilize USGS Lidar data for the chosen project site location.

2.1.6 Task 1.6 Competition Preparation

The team will prepare to compete in the WERC Environmental Design Competition and will prepare to design an innovative stormwater management solution. If applicable, the team will submit a request for equipment for the WERC competition by February 15th, 2024.

2.1.6.1 Task 1.6.1 Competition Registration

Complete online registration for the 2024 WERC Design Competition by December 31, 2023. Registration is required individually and will be completed by all team members.

2.1.6.2 Task 1.6.2 Short Course Enrollment

Registration for the WERC Safety and Environmental Topics and Preparing the Experimental Safety Plan (ESP) short courses. The team will complete the mandatory preparation for the ESP Course that starts December 1st, 2023, and is due February 20th, 2024.

2.1.7 Task 1.7 NAU Civil Water Lab Access

A safety memo binder will be made to properly request access to the use of the NAU civil water lab to be able to construct and test the bench scale model.

2.2 Task 2: Site Investigation

The team will visit the site to help characterize the conditions in which a storm water design will need to be addressed. This includes but is not limited to, an understanding of the existing topography, current stormwater infrastructure, runoff pathing, potential pollutants in the area, and existing storm related damages. Information collected will be used to identify the current conditions of the site to gather a more complete understanding of the issues at the site.

2.2.1 Task 2.1 NAU Field Safety Checklist

The required NAU field safety checklist will be filled out and submitted prior to every field visit.

2.2.2 Task 2.2 Land Survey

The team will complete a land survey of the site. The land survey of the project location will be done to gather all necessary elevation and station data points and measurements to characterize the watershed and project site. Additionally, the land survey will be used to determine site topography to create an existing site plan and to identify the condition of existing storm water management structures.

2.2.2.1 Task 2.2.1 Survey Preparation

The team will gather all the necessary equipment needed to perform a land survey. Prior to the survey the team will perform a site investigation to determine where the survey will be conducted, the target feature for the survey, and any additional essential information needed to complete a successful survey. All survey equipment borrowed from NAU will be approved by the NAU Survey Lab Manager.

2.2.2.2 Task 2.2.2 Survey Fieldwork

The team will conduct a survey in areas of the site where lidar data was not available.

2.2.3 Task 2.3 Observational Survey

The team will obtain photographic imagery of the existing conditions of the site and existing storm water management infrastructure. Furthermore, measurements will be taken of the existing stormwater infrastructure at the site.

2.3 Task 3: Site Analysis

The information collected from the site investigation will be processed to gather an understanding of the existing conditions to serve as a basis for design.

2.3.1 Task 3.1 Existing Topographic Map

Using data collected from the survey, or lidar assessment, the data will be processed accordingly. The data will be converted into a proper format for Civil3D, and then data will be analyzed in Civil3D. This data will be used to create a topographic map, which will be used to delineate a watershed and understand the existing watershed conditions of the site.

2.3.2 Task 3.2 Hydrologic Assessment

The rational method will be followed to perform the hydrologic assessment, assuming that this method will be applicable for the selected site. However, if the rational method is determined inappropriate for the site, a different hydrologic analysis method will be used such as the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS). Completion of a hydrological assessment will provide necessary data for determining the storm flow needing to be addresses for the project. The scope is based on the use of the rational method assuming that it is appropriate for the selected site location.

2.3.2.1 Task 3.2.1 Define Watershed

The site watershed will be delineated using the developed topographic map of the site using lidar data points obtained from USGS data. The team will first identify the point of concentration and then identify the highest points around it to delineate the watershed. The watershed is defined as the area where any potential water runoff could potentially reach the project location.

2.3.2.2 Task 3.2.2 Calculate Time of Concentration

The time of concentration will be determined by finding the longest time it takes for stormwater to travel through the watershed. This will be determined by calculating the time needed for water to flow from the most hydrologically distant location to the point of concentration. The equations that will be used are:

Equation 2-1: Time of Concentration

$$T_c = T_{t1} + T_{t2} \dots + T_{tm}$$

Where:
T_c = time of concentration, hr
T_{tm} = travel time segment, hr
m = number of flow segments

Equation 2-2: Travel Time

$$T_t = \frac{0.007(n * L)^{.8}}{(P_2^{0.5})(S^{0.4})}$$

Where:
T_t = travel time, hr
n = Mannings roughness coefficient
L = flow length, ft
P_2 = 2-year, 24-hour rainfall depth, in.
S = slope of the hydraulic grade line, ft/ft

2.3.2.3 Task 3.2.3 Determine Storm Intensity

The storm intensity will be determined using a design storm frequency that will be translated to an intensity using NOAA Atlas 14 intensity curve. The duration for this will be equal to the time of concentration calculated in the previous task. The design storm frequency will be determined from local codes and standards, based on background research.

2.3.2.4 Task 3.2.4 Calculate Runoff

Assuming the rational method is determined viable for the selected site, the runoff will be calculated for the site. The equation is as follows:

Equation 2-3: Continuity Equation

$$Q = C * i * A$$

Where:
Q = peak runoff rate, ft^3/hr
C = runoff coefficient
i = rainfall intensity, in/hr
A = size of area, acres

2.3.3 Task 3.3 Hydraulic Assessment

The team will perform a hydraulic assessment to determine the capacity of existing stormwater management structures and compare those to the peak flows determined in Task 3.2.0 (hydrologic assessment), using 2D modeling software, such as HEC-RAS.

2.4 Task 4: Design

All potential designs will be examined to determine whether they not only meet the requirements set forth by the WERC Competition, but also the requirements created by the team to best suit the needs of communities like that of the chosen site. The ideas that seem to be the best fit will then be judged in comparison to one another to determine which will be the final design.

2.4.1 Task 4.1 Define Requirements and Criteria

Requirements will be used to narrow down all potential ideas, keeping only the viable options that meet requirements. Criteria will be used to score all viable alternatives and then determine the best one.

2.4.2 Task 4.2 Develop Design Alternatives

The team will develop design alternatives to address the problems that meet the requirements.

2.4.3 Task 4.3 Analyze Alternatives and Select Best

All alternatives will be evaluated using a decision matrix to determine the best design alternative using the previously established criteria.

2.5 Task 5: Final Design

The best alternative identified will be the final design and serve as the basis for a more detailed design to be constructed.

2.5.1 Task 5.1 Full-Scale Model

The full-scale model is the final chosen design that will be used for all further analysis, testing, and reporting.

2.5.1.1 Task 5.1.1 Hydraulic Design

Based on the existing hydraulic infrastructure and the hydrologic assessment completed for the site, new hydraulic infrastructure will be designed and created to help mitigate the current stormwater issues. This new hydraulic design will be designed and tested using HEC-RAS.

2.5.1.2 Task 5.1.2 Pollutant Treatment

The team will plan for a passive treatment system of the pollutants identified in background research.

2.5.2 Task 5.2 Bench-Scale Model

The team will construct a functional bench-scale model of the final design to present at the competition to show the functionality of the final design.

2.5.2.1 Task 5.2.1 Bench-Scale Model Scaling

The final hydraulic design will be scaled down to an appropriate size to create a bench-scale model of the design. The team will scale the model using dimensionless values such as Froude's number and Reynold's number.

2.5.2.2 Task 5.2.2 Model Design

The bench-scale model to be constructed will model the final design. The team will determine how to design the model to match the specified metrics determined in Task 5.2.1 (bench-scale model scaling) to mimic how the final design will function.

2.5.2.3 Task 5.2.3 Model Construction

The team will build the bench scale model based on the model design.

2.5.2.4 Task 5.2.4 Model Testing

The model that the team constructs will be tested by creating conditions that will mimic the storms the design will need to perform in.

2.5.3 Task 5.3 Construction Drawings Plan Set

The team will create a plan set of the final design to ensure that the design will be built properly and to its exact specifications.

2.5.3.1 Task 5.3.1 Cover Sheet

A typical cover sheet including site information, company information, and project information will be created.

2.5.3.2 Task 5.3.2 General Notes Sheet

The team will create a sheet with general notes regarding the current site conditions, the plan for the design, and construction notes.

2.5.3.3 Task 5.3.3 Details Sheet

The team will create a sheet with all details used in the design to ensure that construction is executed correctly.

2.5.3.4 Task 5.3.4 Existing Site Sheet

An existing site sheet will be created with the topographic map made in Task 3.1.0.

2.5.3.5 Task 5.3.5 New Site Sheet

If any changes are made to the topography of the site, an adjusted topographic map will be created with these changes.

2.5.3.6 Task 5.3.6 Schematic Plan Sheet

The team will create both a plan and profile schematic plan of the final design. These sheets will include material, sizes, and other necessary construction information.

2.6 Task 6: Techno-Economic Analysis

The final design will be analyzed based on cost and feasibility for the implementation of the design.

2.6.1 Task 6.1 Short Course Attendance

The team will attend and complete the short courses mentioned in Task 1.6.2; these will provide information necessary for the completion of the ESP and environmental safety for the competition.

2.6.2 Task 6.2 Techno Analysis

The technical performance of the final design will be analyzed. The final design will be analyzed for the efficiency of managing storm flows and mitigating flood damage.

2.6.3 Task 6.3 Economic Analysis

The costs associated with constructing and operating a full-scale final design will be analyzed.

2.6.3.1 Task 6.3.1 Engineering Opinion of Probable Cost

Cost of construction of the project will be determined, which encompasses materials, labor, and equipment. Previous bids for materials and construction will be found using RS Means.

2.6.3.2 Task 6.3.2 Operation and Maintenance Cost

The annual cost of operation and maintenance for the full-scale design will be determined. This estimate will be determined looking at current stormwater infrastructure costs.

2.6.3.3 Task 6.3.3 Life-Cycle Cost

The total life cycle cost of the full-scale design will be determined, including construction costs and operation and maintenance costs over the expected life of the design.

2.7 Task 7: Project Impacts

With the final proposed design in mind, the team will determine and understand the economic, environmental, and social impacts of implementing the design for the design's entire lifespan; regardless of whether they are negative or positive.

2.8 Task 8: Project Deliverables

2.8.1 Task 8.1 30% Submittal

The 30% submittal will contain the 30% report, presentation, and construction drawings that reflect the progress of the project up to that point. At this time, all of Task 1 and Task 2 will be complete and the completed construction drawings will include the cover sheet and the existing site sheet.

2.8.2 Task 8.2 60% Submittal

The 60% submittal will contain the 60% report, presentation, and construction drawings that reflect the progress of the project up to that point. At this time, Task 3 and Task 4 will be complete and the completed construction drawings will include the new site sheet and schematic plan sheet. The 60% will also include all changes made per feedback in the 30% submittal.

2.8.3 Task 8.3 90% Submittal

The 90% submittal will contain the 90% report, draft final presentation, construction drawings, as well as a draft of the project website. At this time, all technical tasks and construction drawings will be complete. The 90% will also include all changes made per feedback in the 60% submittal.

2.8.4 Task 8.4 Final Presentation

The final presentation will provide a complete summary of the project, highlighting the project background, tasks and work completed. The final presentation will provide information on the design of the project.

2.8.5 Task 8.5 Final Submittal

The final report, all construction drawings, presentation, and website will be submitted. The entire project will be reflected in these submissions and all feedback will be addressed.

2.8.6 Task 8.6 Competition Deliverables

The competition deliverables include the WERC oral presentation, bench-scale model, project poster, and flash talk all due that the start of the competition. These will be reviewed and judged at the competition based upon the WERC competition scoring system.

2.8.6.1 Task 8.6.1 Experimental Safety Plan

An experimental safety plan will be developed to ensure all individuals are following the safest possible methods to conduct an experiment.

2.8.6.2 Task 8.6.2 30% Project Review

The 30% Project Review will consist of a 4-page paper outlining the scope, schedule, progress, and any flaws of the project at that point. This will be reviewed for feedback, giving the competition judges an opportunity to suggest any modifications to be implemented for the final design.

2.8.6.3 Task 8.6.3 Technical Report Audits

External audits from respective professionals will be obtained for environmental health & safety, legal & regulatory issues, and economic & business plan aspects of the final technical report and product.

2.8.6.4 Task 8.6.4 Final Technical Report

The final technical report will consist of an executive summary, background research, solution description, process-flow diagrams, test data and technical evaluations, bench-scale model prototyping, business plan, waste report, safety and environmental adherence, waste report, community relations, and audits.

2.8.6.5 Task 8.6.5 Competition

The competition deliverables include the WERC oral presentation, bench-scale model, project poster, and flash talk all due that the start of the competition. These will be reviewed and judged at the competition based upon the WERC competition scoring system.

2.9 Task 9: Project Management

To ensure the success of the project's completion, the team will hold regular meetings, manage the design schedule, and manage resources.

2.9.1 Task 9.1 Project Meetings

The team will organize and host meetings of several types to ensure the project is moving along. These meetings will be held with the technical advisor (TA), grading instructor (GI), or just amongst the team members themselves. The meeting agenda and minutes will be recorded to better document the events that take place and objectives being discussed within a digital binder.

2.9.2 Task 9.2 Schedule Management

All scheduling with the TA, GI, and team will be recorded and updated as necessary to ensure milestones are completed on time. To better document the work being done to complete the project, the team will record the amount of time each task will take through the creation of a Gantt chart. The Gantt chart will encompass the entirety of the project.

2.9.3 Task 9.3 Resource Management

As one of the larger project goals is to be cost efficient, the cost and tracking of resources will be crucial to ensure this goal is being met. Resources are not limited to physical material but also the number of hours spent on the project which will be found in the Gantt chart as previously mentioned earlier. The team will also document the resources being used along with their cost within the binder as mentioned earlier.

2.10 Exclusions

This section details the parts of the project that will be excluded due to time constraints and limited site access.

2.10.1 Pollutant Sampling

The team is not responsible for sampling pollutants in the site location. Pollutants will be determined based on known conditions at the site.

2.10.2 Community Outreach

The team will not coordinate or seek public approval of the project. This will exclude holding public meetings, fliers, and other community engagement activities to gain approval from the community.

3.0 Project Schedule

3.1 Overview

The project duration has a total of 101 working days, based off a Monday through Friday work week; excluding NAU fall, winter, and spring breaks. The project will start on 11/8/2023 and end on 5/7/2023. This project start date is earlier than the anticipated start date (beginning of spring semester) due to the necessary competition analysis and deliverables. This schedule is seen in Appendix A.

3.2 Major Tasks & Deliverables

For the project to be completed successfully, the hydrologic and hydraulic tasks are considered to be major, because they are essential to characterize the flows needing to be addressed and will model the conditions of the site. The design task is a major task as it is the main purpose of the competition and is what the team will be judged on at the competition. These were decided upon due to the importance of performing these tasks early and well will be vital to remarkable competition and capstone deliverables. The major deliverables for the WERC competition are outlined in Task 8.6.0: the ESP, 30% project review, final technical report audits, final technical report, and competing. These are essential to keep the team on task and ensure proper completion of the WERC project. Additionally, the major deliverables for this project will include the CENE 486C submittals – 30%, 60%, 90%, & final – as well as the final presentation and final website.

3.3 Critical Path

The critical path is the minimum length of time that the project will be completed. The critical path can be found, highlighted in red, in the Gantt chart displayed in Appendix A. The critical path displays the time the chair of tasks that most contain the project. The tasks along the critical path must be completed on time and in proper order to finish the project within the designated time. These tasks are dependent on one another as they all require completion from a prior task to start. The critical path includes reviewing codes and standards, registering for the competition and the short course, completing a site investigation, analyzing the data from the site, designing the solution, and fabricating the bench-scale model, completing a techno-analysis, drafting the final technical report, final presentation, and the 90% submittal, and finalizing the final submittal. The team plans to follow the schedule by completing tasks by the set schedule finish date. The team will utilize float days built into the schedule, such as weekends to ensure tasks are completed on time.

4.0 Staffing Plan

4.1 Staff Positions

Senior Engineer (SENG): The senior engineer is responsible for managing the whole project. They will also conduct general reviews of all of the work that has been done on the project for quality assurance and quality control for all design work.

Qualifications include:

- Registered and Licensed Professional Engineer (PE)
- 5+ years of experience as a PE
- Bachelor of Science in engineering, from ABET accredited program

Engineer (ENG): The engineer is responsible for the bulk of the proposed work for the project. This position will primarily focus on design, evaluation, and development of the proposed product. Additionally, they will work with the senior engineer on evaluating and selecting the best proposed design. They are expected to present and analyze the design using applicable software.

Qualifications include:

- Fundamentals of Engineering Certification (FE)
- 3+ years of experience as an engineer in training (EIT)
- Bachelor of Science in engineering, from ABET accredited program
- Software proficiency; HEC-RAS, HEC-HMS, and Civil3D

Engineering Technician (TECH): The engineering technician will primarily focus on the collection and processing of data. This individual must have experience with technical software, surveying, and laboratory work. They are responsible for understanding standard field and laboratory methods.

Qualifications include:

- 1-3 years of experience in the engineering profession
- STEM related field associate degree
- Registered Land Surveyor (RLS)
- Software proficiency; HEC-RAS, HEC-HMS and Civil3D
- Proficient operating in a laboratory setting

4.2 Staffing Summary

The project hours were allocated among the designated positions as outlined above. The Engineer was assigned the greatest number of hours, totaling 456 working hours. This allocation is due to the Engineer's role in handling a significant portion of the project, particularly with the design process. The Senior Engineer was assigned minimal hours of 71 working hours as their primary focus is to review the project. The Engineering Technician was assigned 196 working hours and was designated to work on the bulk of the technical work which requires a large number of hours. Appendix B displays a more detailed work hours distribution for each position for all tasks and subtasks.

Table 4-1 shows the distribution of hours for each main task across the various positions.

Table 4-1: Hours by Task

TASK NAME	SENG (hours)	ENG (hours)	TECH (hours)	TOTAL TASK HOURS
Task 1.0: Literature Review & Background Research	2	28	21	51
Task 2.0: Site Investigation	0	7	18	25
Task 3.0: Site Analysis	4	52	36	92
Task 4.0: Design	4	55	0	59
Task 5.0: Final Design	5	53	87	145
Task 6.0: Techno-Economic Analysis	7	57	0	64
Task 7.0: Project Impacts	4	14	0	18
Task 8.0: Project Deliverables	10	135	14	159
Task 9.0: Project Management	35	55	20	110
Total Hours	**71**	**456**	**196**	**723**

Table 4-2 depicts the expected division of total project work hours between all the positions.

Table 4-2: Staff Hour Summary

Position	Hours
Senior Engineer	71
Engineer	456
Engineer Technician	196
Total Hours	**723**

5.0 Cost of Engineering Services

5.1 Total Project Costs

Seen in Table 5-1, the total project cost is estimated to be $112,935. This accounts for all personnel, travel, and supply costs.

Table 5-1: Total Project Costs

Cost of Engineering Services				
1.0 Personnel	Classification	Hours	Rate ($/time)	Cost ($)
	SENG	71	$340	$ 24,140
	ENG	456	$140	$ 63,840
	TECH	196	$80	$ 15,680
Total Cost				$ 103,660
2.0 Travel			Cost per ($)	
Competition	Transportation	2 Vans, 5 Days	$65/day	$ 650
	Mileage	1,736 miles, roundtrip	$0.36/mile	$ 1,250
	Hotel	3 Rooms, 4 Nights	$98/night	$ 1,176
	Per Diem	5 People, 4 Days	$49/day	$ 980
Site Visit	Transportation	1 Van, 1 Day	$44/day	$ 44
	Mileage	154 miles, roundtrip	$0.23/mile	$ 35
Total Cost				$ 4,135
3.0 Supplies				
Lab Facilities	NAU Computer Lab	20 Days	$100/day	$ 2,000
	NAU Survey Lab	1 Days	$100/day	$ 100
	NAU Water Lab	10 Days	$100/day	$ 1,000
Materials	Bench-Scale Model Materials	LS		$ 1,000
	Competition Poster	LS		$ 40
Total Cost				$ 4,140
4.0 TOTAL				**$ 112,935**

The breakdown for each cost in Table 5-1 is found in the following sections.

5.2 Personnel Costs

The total staffing costs are based on each staff position and the rate per position. Each position is charging the client in relation to expertise on a specific engineering service. The billing rates also include payroll, benefits, overhead, and profit. The total staffing cost of this project is $103,660. The number of hours seen in this table were determined per amount of task. This breakdown can be found in Appendix B.

5.3 Travel Costs

For this project, there will be travel to the competition site as well as the project site. To travel to the competition, 2 passenger vans will be necessary for a total of 5 days. The competition is in Las Cruces, New Mexico-which is 434 miles from Flagstaff, AZ for a total of 868 miles round trip per vehicle (1,736 miles total). Since 5 people will be traveling to the competition, it was determined that 3 hotels room will be needed for the 4 nights that the team will be staying in Las Cruces. NMSU is more than 100 miles away from the Arizona border, so the nightly rate is an out of state rate. With this being overnight travel, each person is allowed per diem costs for the day to cover meals and incidentals. When traveling to the project site, it will be a one-day trip, meaning the only expenses will be the van rental and the gas costs; only 1 minivan will be needed for the site visit. Joseph City is 77 miles away from Flagstaff, AZ one way, resulting in a round-trip mileage of 154 miles. All the travel costs amount to an estimated $4,135. All travel costs were gathered from NAU reimbursement services.

5.4 Supplies Costs

To build and test the model, access to the NAU civil water lab will cost $1,000. During the field visit, it is assumed a survey will take place and the cost to rent and use NAU surveying equipment is estimated to be $100. Modeling will take place throughout the project duration in the NAU computer labs, allowing for an estimated cost of $2,000. Since the bench-scale model has not been designed yet, it is predicted that all equipment used to construct the bench-scale model will be no more than $1,000. For the competition, a poster of the final results is necessary, and is estimated to cost $40 to be produced. The supplies costs amount to an estimated $4,140.

6.0 References

[1] “WERC Environmental Design Contest.” Accessed: Oct. 26, 2023. [Online]. Available: https://wercdesigncontest.nmsu.edu/

[2] “Maps | Department of Transportation.” Accessed: Nov. 14, 2023. [Online]. Available: https://azdot.gov/maps

[3] “StreamStats.” Accessed: Oct. 26, 2023. [Online]. Available: https://streamstats.usgs.gov/ss/

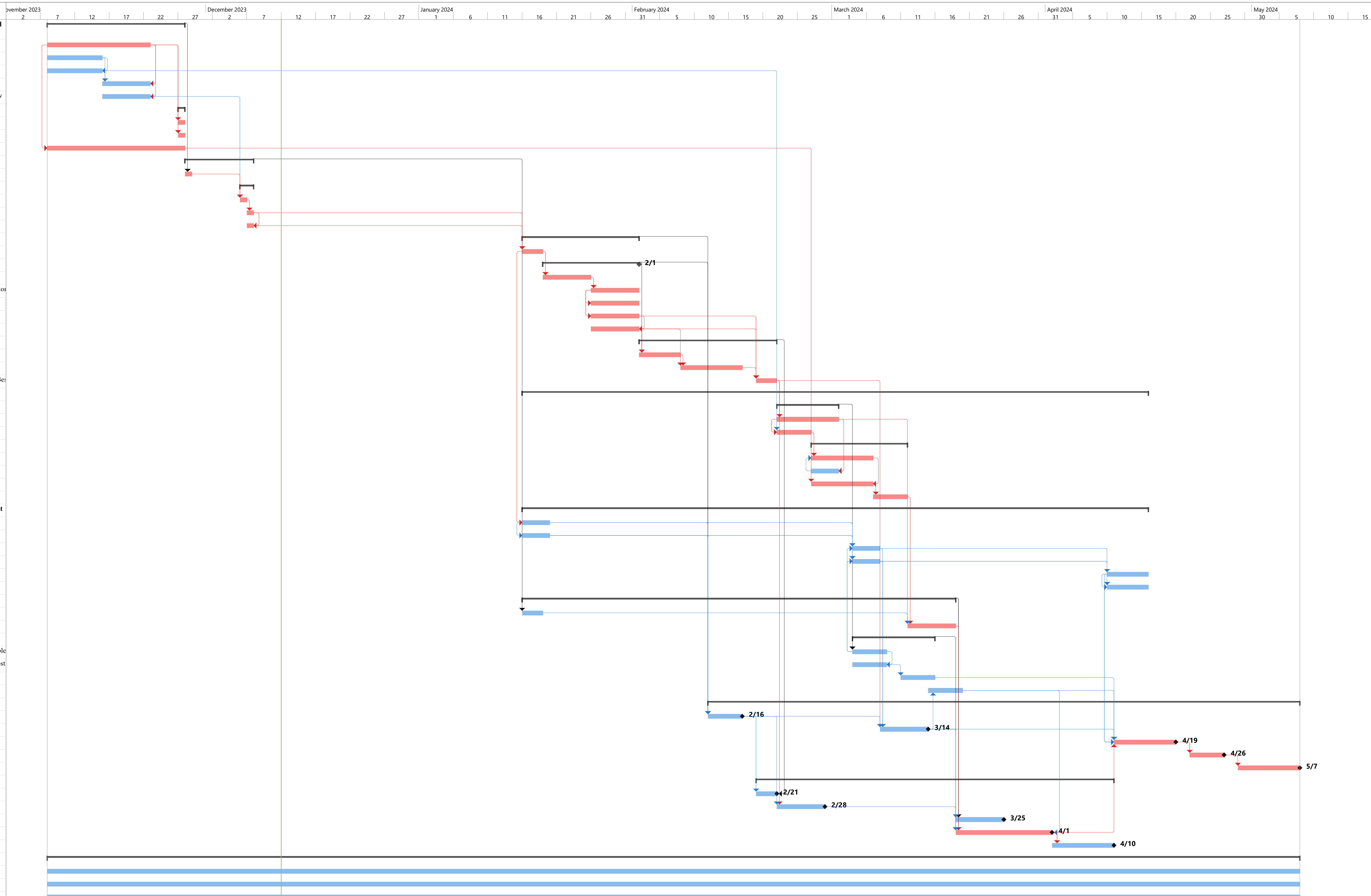
[4] “USGS Lidar Explorer Map.” Accessed: Oct. 26, 2023. [Online]. Available: https://apps.nationalmap.gov/lidar-explorer/#/

Appendices

Appendix A: Gantt Chart

WERC Schedule

ID	Task Name
1	**Task 1.0: Literature Review and Background Research**
2	Task 1.1.0 Code and Standard Review
3	Task 1.2.0 Soil Classification Research
4	Task 1.3.0 Typical Pollutant Research
5	Task 1.4.0 Existing Plan Research
6	Task 1.5.0 Existing Topography Data Review
7	**Task 1.6.0 Competition Preparation**
8	Task 1.6.1 Competition Registration
9	Task 1.6.2 Short Course Enrollment
10	Task 1.7.0 NAU Civil Water Lab Access
11	**Task 2.0: Site Investigation**
12	Task 2.1.0 NAU Field Safety Checklist
13	**Task 2.2.0 Land Survey**
14	Task 2.2.1 Survey Preparation
15	Task 2.2.2 Survey Fieldwork
16	Task 2.3.0 Observational Survey
17	**Task 3.0 Site Analysis**
18	Task 3.1.0 Existing Topographic Map
19	**Task 3.2.0 Hydrologic Assessment**
20	Task 3.2.1 Define Watershed
21	Task 3.2.2 Determine Time of Concentratio
22	Task 3.2.3 Determine Storm Intensity
23	Task 3.2.4 Calculate Runoff
24	Task 3.3.0 Hydraulic Assessment
25	**Task 4.0: Design**
26	Task 4.1.0 Define Requirements and Criteria
27	Task 4.2.0 Develop Design Alternatives
28	Task 4.3.0 Analyze Alternatives and Select Bes
29	**Task 5.0: Final Design**
30	**Task 5.1.0 Full-Scale Model**
31	Task 5.1.1 Hydraulic Design
32	Task 5.1.2 Pollutant Treatment
33	**Task 5.2.0 Bench-Scale Model**
34	Task 5.2.1 Model Design
35	Task 5.1.2 Bench-Scale Model Scaling
36	Task 5.2.2 Model Construction
37	Task 5.2.3 Model Testing
38	**Task 5.3.0 Construction Drawings Plan Set**
39	Task 5.3.1 Cover Sheet
40	Task 5.3.2 Existing Site Sheet
41	Task 5.3.3 New Site Sheet
42	Task 5.3.4 Schematic Plan Sheet
43	Task 5.3.5 Details Sheet
44	Task 5.3.6 General Notes Sheet
45	**Task 6.0 Techno-Economic Analysis**
46	Task 6.1.0 Short Course Attendance
47	Task 6.2.0 Techno-Analysis
48	**Task 6.3.0 Economic Analysis**
49	Task 6.3.1 Engineering Opinion of Probable
50	Task 6.3.2 Operation and Maintenance Cost
51	Task 6.3.3 Life-Cycle Cost
52	**Task 7.0: Project Impacts**
53	**Task 8.0 Project Deliverables**
54	Task 8.1.0 30% Submittal
55	Task 8.2.0 60% Submittal
56	Task 8.3.0 90% Submittal
57	Task 8.4.0 Final Presentation
58	Task 8.5.0 Final Submittal
59	**Task 8.5.0 Competition Deliverable**
60	Task 8.5.1 Experimental Safety Plan
61	Task 8.5.2 30% Project Review
62	Task 8.5.3 Final Technical Report Audits
63	Task 8.5.4 Final Technical Report
64	Task 8.5.5 Competition
65	**Task 9.0: Project Management**
66	Task 9.1.0 Project Meetings
67	Task 9.2.0 Schedule Management
68	Task 9.3.0 Resource Management



Project: WERC Schedule
Date: Tue 12/12/23

Task	Milestone	Project Summary	Inactive Milestone	Manual Task	Manual Summary Rollup	Start-only	External Tasks	Deadline	Critical Split	Manual Progress	
Split	Summary	Inactive Task	Inactive Summary	Duration-only	Manual Summary	Finish-only	External Milestone	Critical	Progress		

Appendix B: Staffing Hours Breakdown

TASK NAME	SENG (hours)	ENG (hours)	TECH (hours)	TOTAL TASK HOURS
Task 1.0: Literature Review & Background Research	**2**	**28**	**21**	**51**
Task 1.1.0: Code & Standard Review	0	8	3	11
Task 1.2.0: Soil Classification Research	0	4	4	8
Task 1.3.0: Typical Pollutant Research	0	4	4	8
Task 1.4.0: Existing Plan Research	0	9	4	13
Task 1.5.0: Existing Topography Data Review	0	3	4	7
Task 1.6.0: Competition Preparation	**2**	**0**	**0**	**2**
Task 1.6.1: Competition Registration	1	0	0	1
Task 1.6.2: Short Course Enrollment	1	0	0	1
Task 1.7.0: NAU Civil Water Lab Access	0	0	2	2
Task 2.0: Site Investigation	**0**	**7**	**18**	**25**
Task 2.1.0: NAU Field Safety Checklist	0	1	4	5
Task 2.2.0: Land Survey	**0**	**4**	**12**	**16**
Task 2.2.1: Survey Preparation	0	0	4	4
Task 2.2.2: Survey Fieldwork	0	4	8	12
Task 2.3.0: Observational Study	0	2	2	4
Task 3.0: Site Analysis	**4**	**52**	**36**	**92**
Task 3.1.0: Existing Topographic Map	0	1	8	9
Task 3.2.0: Hydrologic Assessment	**0**	**24**	**12**	**36**
Task 3.2.1: Define Watershed	0	6	3	9
Task 3.2.2: Determine Time of Concentration	0	6	3	9
Task 3.2.3: Determine Storm Intensity	0	6	3	9
Task 3.2.4: Calculate Runoff	0	6	3	9
Task 3.3.0: Hydraulic Assessment	4	27	16	47
Task 4.0: Design	4	55	0	**59**
Task 4.1.0: Define Requirements & Criteria	0	6	0	6
Task 4.2.0: Develop Design Alternatives	2	40	0	42
Task 4.3.0: Analyze Alternatives & Select Best	2	9	0	11
Task 5.0: Final Design	**5**	**53**	**87**	**145**
Task 5.1.0: Full-Scale Model	**2**	**33**	**0**	**35**
Task 5.1.1: Hydraulic Design	2	25	0	27
Task 5.1.2: Pollutant Treatment	0	8	0	8
Task 5.2.0: Bench-Scale	**3**	**10**	**61**	**74**
Task 5.2.1: Bench-Scale Model Scaling	2	8	0	10
Task 5.2.2: Model Design	1	2	6	9
Task 5.2.3: Model Construction	0	0	40	40
Task 5.2.4: Model Testing	0	0	15	15

TASK NAME (cont.)	SENG (hours)	ENG (hours)	TECH (hours)	TOTAL TASK HOURS
Task 5.0: Final Design (cont.)	**5**	**53**	**87**	**145**
Task 5.3.0: Construction Drawings Plan Set	**0**	**10**	**26**	**36**
Task 5.3.1: Cover Sheet	0	1	3	4
Task 5.3.2: Existing Site Sheet	0	1	5	6
Task 5.3.3: New Site Sheet	0	2	5	7
Task 5.3.4: Schematic Plan Set	0	2	5	7
Task 5.3.5: Details Sheet	0	2	5	7
Task 5.3.6: General Notes Sheet	0	2	3	5
Task 6.0: Techno-Economic Analysis	**7**	**57**	**0**	**64**
Task 6.1.0: Short-Course Attendance	2	2	0	4
Task 6.2.0: Techno-Analysis	2	16	0	18
Task 6.3.0: Economic Analysis	**3**	**39**	**0**	**42**
Task 6.3.1: Engineering Opinion of Probable Cost	1	13	0	14
Task 6.3.2: Operation and Maintenance Cost	1	13	0	14
Task 6.3.3: Life-Cycle Cost	1	13	0	14
Task 7.0: Project Impacts	**4**	**14**	**0**	**18**
Task 8.0: Project Deliverables	**10**	**135**	**14**	**159**
Task 8.1.0: 30% Submittal	1	23	1	25
Task 8.2.0: 60% Submittal	1	23	1	25
Task 8.3.0: 90% Submittal	1	23	1	25
Task 8.4.0: Final Presentation	1	8	1	10
Task 8.5.0: Final Submittal	1	23	1	25
Task 8.6.0: Competition Deliverables	**5**	**35**	**9**	**49**
Task 8.6.1: Experimental Safety Plan	1	2	6	9
Task 8.6.2: 30% Project Review	1	4	0	5
Task 8.6.3: Final Technical Report Audits	1	3	0	4
Task 8.6.4: Final Technical Report	1	22	0	23
Task 8.6.5: Competition	1	4	3	8
Task 9.0: Project Management	**35**	**55**	**20**	**110**
Task 9.1.0: Project Meetings	10	25	18	53
Task 9.2.0: Schedule Management	10	15	1	26
Task 9.3.0: Resource Management	15	15	1	31
Subtotal Hours	**71**	**456**	**196**	**723**
Total Hours	**723**			