Arizona Water Student Design Competition

Surprise, AZ

CENE 476, Fall 2024

Project Proposal:

Expansion of SPA 1 Water Reclamation Facility for the City of Surprise

Walnut Canyon Wastewater

Prepared by: Olivia Lara, Alec Layden, Andrew Shipley, and Tyler Wade

Prepared for: Dr. Jeffrey Heiderscheidt

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List of Abbreviations

AAC- Arizona Administrative Code

AZWA- Arizona Water Association

AZWA SDC- Arizona Water Association Student Design Competition

ADEQ- Arizona Department of Environmental Quality

ADMM- Average Day Maximum Month

ADWR- Arizona Department of Water Resources

BOD- Biochemical Oxygen Demand

CINT- Civil Engineer Intern

DENG- Design Engineer

EINT- Environmental Engineer Intern

EOPC- Engineer's Opinion of Probable Cost

EPA- Environmental Protection Agency

MGD- Million Gallons per Day

MLE- Modified Ludzack-Ettinger

MOPO- Manual of Permitted Operations

NAU- Northern Arizona University

SENG- Senior Engineer

SPA- Special Planning Area

SS - Suspended Solids

WEF- Water Environment Federation

WRF- Water Reclamation Facility

WWTP- Wastewater Treatment Plant

1 Project Understanding

1.1 Project Purpose

The main objective of the annual Arizona Water Association Student Design Competition (AZWA SDC) hosted by the Water Environment Federation (WEF) is to promote real world design experience for students pursuing careers within water and wastewater [1]. Through this competition students demonstrate their ability to evaluate alternatives, develop a comprehensive design, and present a solution to meet a unique and socially relevant problem [1].

The City of Surprise, Arizona has rapidly increased in population over the past decade resulting in an increase in wastewater design flow. To supplement the increase in design flow, this project will design an expansion of the Special Planning Area 1 (SPA 1) Water Reclamation Facility (WRF) to increase treatment capacity from 12.8 million gallons per day (MGD) to 16.3 MGD.

1.2 Project Background

The project site is located in the City of Surprise, Arizona which is northwest of Phoenix as seen in *Figure 1-1* [2]. The City of Surprise is divided into six special planning areas (SPA 1 through SPA 6); this project focuses specifically on expansion and improvements for SPA 1 WRF.

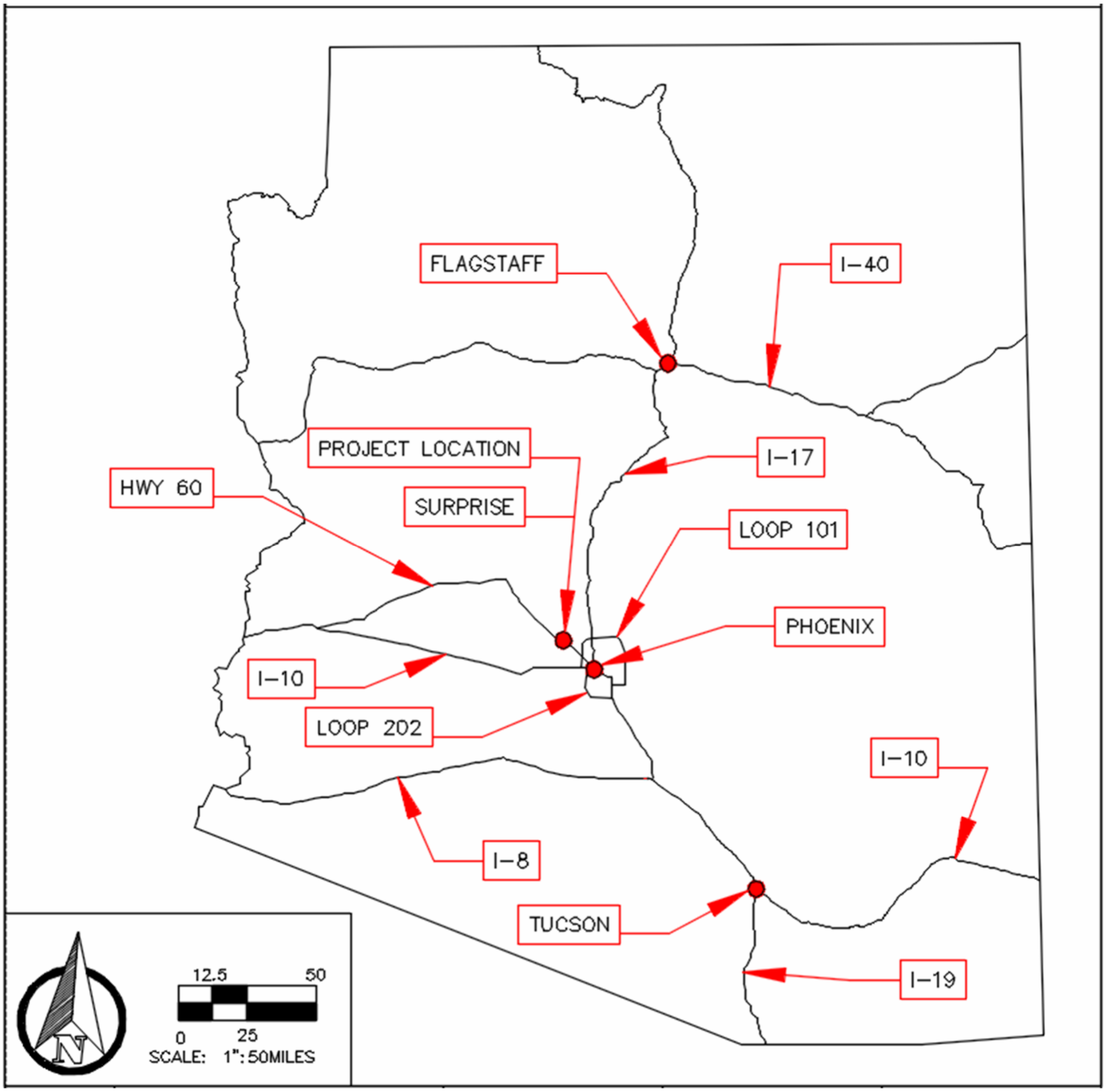

Figure 1-1: Location Map

More specifically, the project's address is 13663 Cactus Rd, Surprise, AZ. *Figure 1-2* shows the vicinity surrounding the project location.

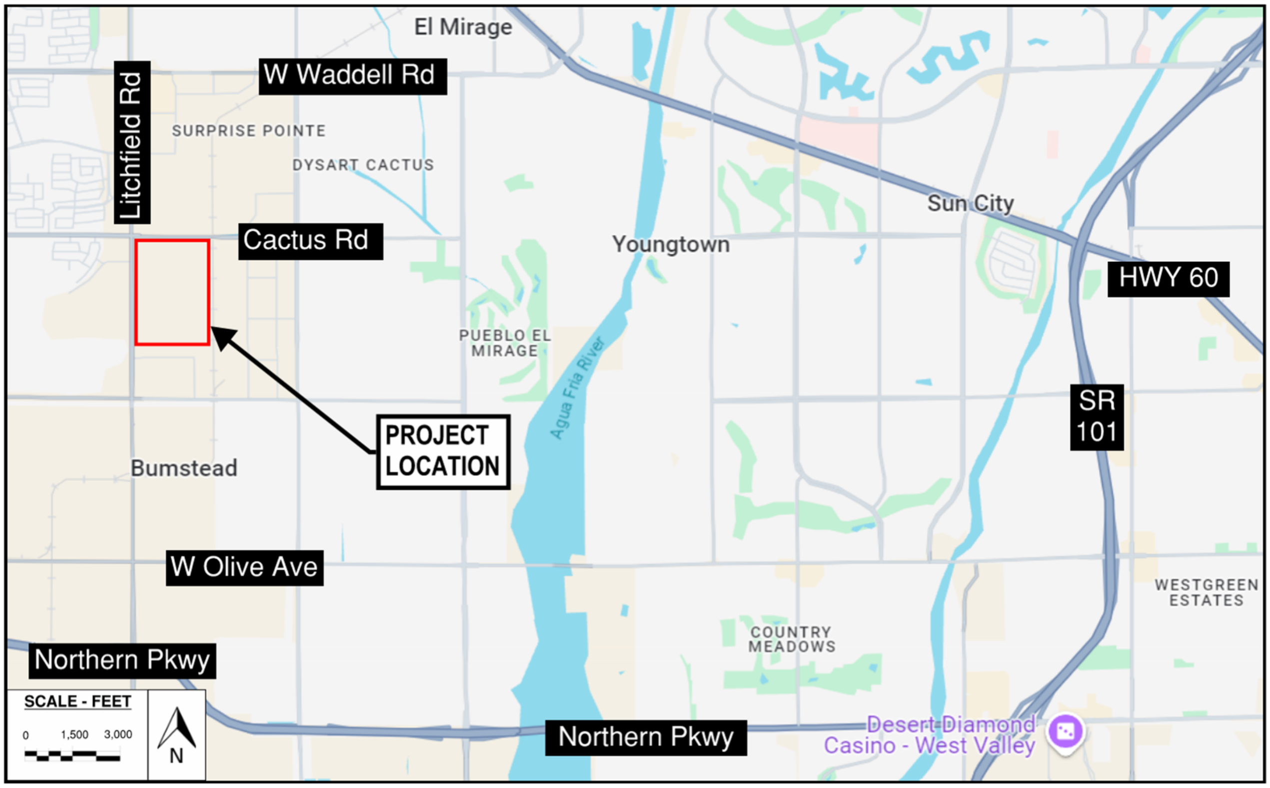

Figure 1-2: Vicinity Map [2]

Figure 1-3 is a satellite image showing the layout of the project site. The project site is surrounded by residential and industrial development.

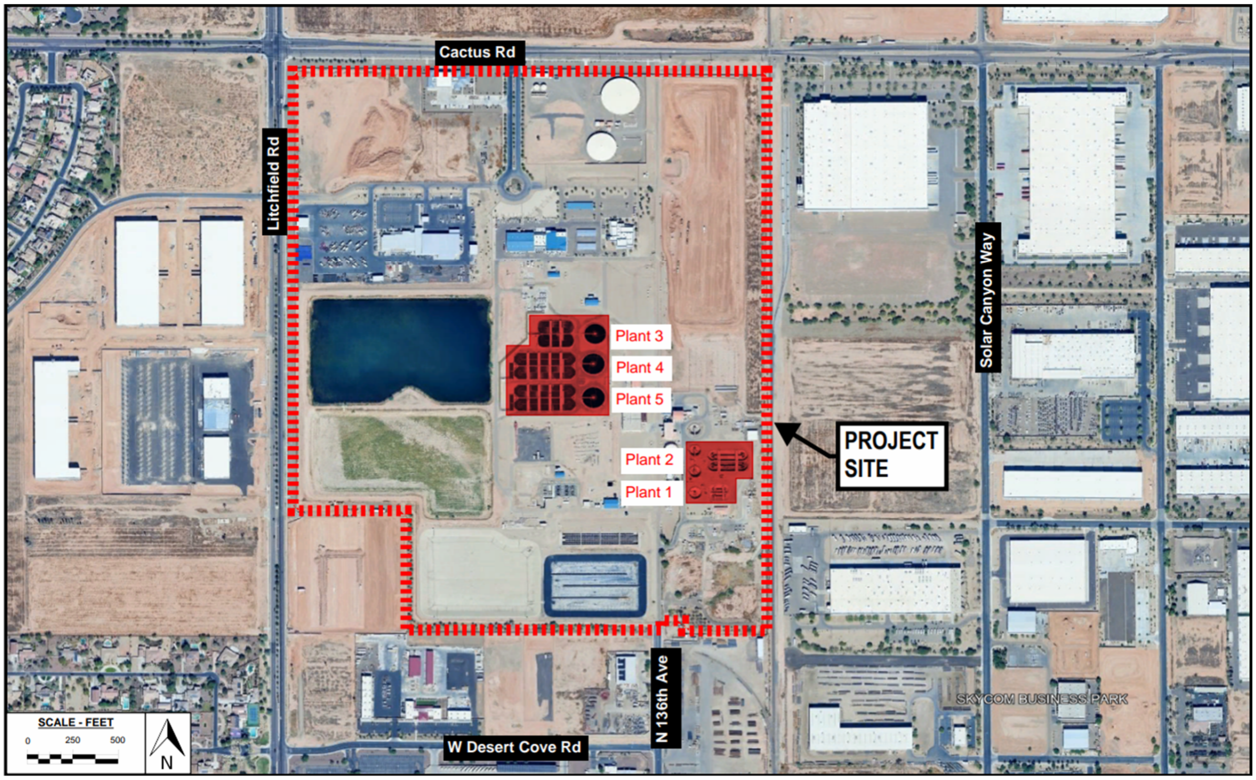

Figure 1-3: Site Map [2]

Originally constructed in 1995, the City of Surprise SPA 1 WRF has undergone many expansion projects to get to the present-day condition. The current functional capacity of SPA 1 is 12.8 MGD. SPA 1 produces Class A+ reclaimed water which is reused either directly for irrigation or through recharge via spreading basins or vadose zone recharge wells for later recovery [3].

SPA 1 WRF consists of five separate treatment systems. Plants 1 and 2 are largely non-operational [3]. Plants 3-5 share a preliminary and primary treatment system. For secondary treatment, each consists of two parallel oxidation ditches which alternate aerobic and anaerobic zones within the ditch to accomplish nitrification and denitrification along with BOD and phosphorous removal [3]. Each also has a secondary clarifier before the water is disinfected.

The focus of this project will be on modifying plants 4 and 5 to treat the increased capacity or deciding if a sixth system is required to treat the increased flow.

1.3 Technical Considerations

The following technical considerations will be analyzed for this project.

1.3.1 Regulations/Standards

Codes and regulations are placed on wastewater treatment and effluent at the federal, state, and local levels. The Environmental Protection Agency (EPA) sets federal codes related to wastewater. State and local regulation entities vary by location. Arizona is regulated by the Arizona Department of Environmental Quality (ADEQ). ADEQ regulates how effluent can be used and the required water quality needed for certain uses. SPA 1 WRF recharges the aquafers in the region, meaning acquiring proper recharge permits will be overseen by Arizona Department of Water Resources (ADWR). Standards set by the City of Surprise for wastewater will also be taken into account. [4]

Ensuring the redesign of SPA 1 WRF meets all regulation and codes is critical during final analysis. A proposed redesign that cannot meet all legal rules and requirements is unusable and must be redone.

1.3.2 Preliminary and Primary Treatment

Preliminary and primary treatment is a series of physical processes aimed at removing the bulk of solids from the influent stream. This typically includes three processes. Firstly, bar screening removes solids ranging between 1-150mm in diameter [5]. Secondly, grit removal settles out bulky particles such as sand, gravel, and glass [5]. Finally, primary sedimentation removes the bulk of suspended solids (SS) before the stream moves to secondary treatment [5].

This project will evaluate the current primary treatment systems of SPA 1 WRF to ensure the systems will be able to adequately handle increased capacity while maintaining treatment standards. Based on this evaluation, designs may need to be created to either replace, retrofit, or supplement these systems in the SPA 1 WRF expansion.

1.3.3 Secondary Treatment

Secondary treatment aims to decrease the nutrient and biochemical oxygen demand (BOD) concentrations within the water. Areas are created to facilitate cultivation of microorganisms that are capable of removing unwanted contaminants. Plants will typically have the following stages in secondary treatment: BOD removal, nitrification, denitrification, and phosphorous removal. Many different technologies are available for each stage of secondary treatment. However, there is usually an aeration step for nitrification and anoxic step for denitrification.

This project will focus on SPA 1 WRF's Secondary treatment. Options will be evaluated to either retrofit plants 4 and 5 or install a new system to handle the increased capacity. For the SPA 1 WRF, these options will be evaluated to meet or exceeded and City of Surprise requirements.

1.3.4 Advanced Treatment

Advanced treatment is intended to further remove contaminants secondary treatment cannot, making the effluent stream comply with more stringent regulations. Selection of treatment technologies depends on the intended use of effluent and composition of wastewater after secondary treatment. Water properties removed through tertiary treatment include organic ions, nutrients, suspended solids, pathogens, and microorganisms [6]. A variety of techniques can be used for each contaminant including disinfection, post-aeration, settling tanks, chemical precipitation, granular filtration, membrane filtration, and carbon adsorption.

Changes made to secondary treatment will be evaluated to understand what contaminants remain after secondary treatment. Secondary treatment ultimately affects what advanced treatment must accomplish.

1.3.5 Disinfection

The disinfection process for a WWTP is designed to deactivate any organisms that have survived the previous treatment processes. Disinfection aims to reduce microbial and bacterial numbers to regulated levels before the effluent is discharged from the WWTP. Physical and chemical treatment methods exist to disinfect the wastewater; common treatment methods include chlorination, ozonation, and ultraviolet light. [7]

Current disinfection systems will be evaluated for whether they can adequately handle increased capacity and changes made to secondary treatment. If they are found to be deficient, new systems will be designed.

1.3.6 Hydraulics

Hydraulic analysis for a wastewater treatment plant includes sizing infrastructure to accommodate the design flow and monitoring the hydraulic grade line throughout the system. Major and minor energy losses will be calculated as wastewater is transported throughout a series of pipes, channels, and basins. Pumps will be appropriately sized and selected by using a pump curve with the calculated design flow to ensure there is enough energy for fluid to move throughout each treatment process.

1.3.7 Solids Handling

During primary treatment large amounts of solids are collected in the form of organic and inorganic matter. Suspended solids settle and are also collected during primary and secondary sedimentation in the form of sludge. Solids handling is the processing of sludge for proper disposal or reuse.

Sludge is processed by dewatering it, disinfecting harmful bacteria, and reducing the overall amount of organic material. Dewatering is accomplished by using centrifuges or evaporation techniques, both being energy intensive. Organic material in sludge is reduced by anerobic or aerobic digestion. Anerobic digestion uses heated tanks to promote fermentation, methane is produced which can be collected and burned to offset energy costs. Aerobic digestion introduces oxygen to the system which allows for the micro-organisms to convert the organic material into carbon dioxide and water. Once sludge has been properly processed it is considered a biosolid which can be used for compost, fertilizer, or landfill cover. [8]

The solids handling capacity of SPA 1 WRF will be evaluated to ensure it can handle increased solids loading from increased capacity and any changes made to secondary treatment.

1.3.8 Cost Analysis

To understand the expected construction, operation and maintenance, and capital costs a complete lifecycle cost analysis will be performed. Included in a lifecycle cost analysis is an Engineer's Opinion of Probable Cost (EOPC) which analyzes historical unit prices and operational costs over the expected life span of the project [9].

1.4 Potential Challenges

During the course of this project, several challenges are anticipated. One anticipated challenge is the requirement to follow competition constraints in addition to typical project constraints. It will be important to emphasize competition requirements while ensuring that typical constraints are also met in a way that the two synchronize.

Additionally, site and space limitations are expected. SPA 1 is surrounded by adjacent properties. This increases the likelihood that stricter odor and noise controls will be required. It also makes it unlikely that additional land could be purchased for new facilities. SPA 1 WRF also contains several non-operational facilities that further squeeze the available space and may require additional costs to demolish.

Surprise lies in the Sonoran Desert which is known to experience high temperatures, particularly in the summer. High temperatures can affect the health and operation of machinery such as pumps, the efficiency of microbes during secondary treatment, and evaporation/volatilization rates. This proposes many challenges and some potential benefits that will need to be addressed.

SPA 1 is a WRF that produces effluent for direct non-potable reuse. Such facilities typically have higher quality effluent standards, and it will be important to ensure treatment technologies designed for this project are able to meet these higher standards.

1.5 Stakeholders

Stakeholders of this project include the City of Surprise, residential and commercial communities, the local agricultural industry, regulating agencies, Northern Arizona University (NAU), and the Water Environment Federation (WEF).

The City of Surprise has the largest stake in the project. City of Surprise will be responsible for facilitating capital cost, operation, and maintenance of the facility. Residents near the facility take on the risk of odor pollution and a decrease in property value, meaning proper environmental consideration is a high concern for the project.

Users of water services in the City of Surprise are stakeholders since water and sewer bills are a primary source of income for the WRF. Funds for capital cost, operation, and maintenance of SPA 1 WRF are passed off to residential, commercial, and agricultural communities.

A portion of the reclaimed water is used for irrigation by the local agricultural industry and local golf courses. Providing a constant supply of reclaimed water that meets all codes and regulations is essential for these reclaimed water users.

The Arizona Department of Environmental Quality (ADEQ) will have a stake in the project by ensuring effluent codes and regulations are met. Regular permit renewal and approval for SPA 1 WRF is required as per ADEQ requirements. The Arizona Department of Water Resources (ASWR) also has a stake as portions of reclaimed water from SPA 1 WRF is used to recharge the local aquifers and ADWR is responsible for ensuring the protection of Arizona's groundwater supplies.

Due to this project being an annual competition between Arizona universities hosted by WEF, NAU is being represented as an institution. This team's performance will reflect on NAU and NAU's engineering program.

2 Scope of Services

The following scope outlines what work will and will not be done to complete the project.

2.1 Task 1: Research Preparation

The team will complete necessary background research to understand the scope of the project and competition.

2.1.1 Task 1.1: Regulation Research

Wastewater treatment facilities need to follow strict codes and regulations from federal, state, and local regulatory agencies. The team will evaluate regulations set by EPA, ADEQ, Maricopa County Environmental Service Department (MCESD), and more to ensure the design is in compliance.

2.1.2 Task 1.2: Wastewater Treatment Research

The team will acquire a base knowledge regarding wastewater treatment. Main areas of understanding include treatment processes and technologies, construction of treatment plants, and operation and maintenance of wastewater facilities.

2.1.3 Task 1.3: WEF Application

A team entry form will be filled out and submitted to AZWA. This form will identify a primary contact on the team to receive information from the competition coordinator. Contact information from all team members and the team's faculty advisory will also be provided. Additionally, final exam schedules for NAU for both Fall 2024 and Spring

2025 are required. The start date of the spring semester and the dates of any observed holidays in both semesters will also be given.

2.2 Task 2: Site Assessment

The team will visit and assess the existing conditions of the SPA 1 WRF to understand how the facility operates and what parts of the treatment operation need to be improved.

2.2.1 Task 2.1: Site Visit

A site visit will be completed to allow the team to get a better understanding of the layout of the site, the size and type of infrastructure used, take site photos to reference during analysis, and visualize how wastewater moves through the treatment process.

2.2.2 Task 2.2: Data Analysis

The team will analyze the existing data provided by the AZWA SDC. Existing data consists of record documents, existing mapping, existing capacity data, size and material of infrastructure, the existing flow diagram, and the existing hydraulic profile. This data will be referenced by the team during the design phase of the project for any new infrastructure or expansion of existing infrastructure. [3]

2.3 Task 3: Treatment Process Selection

The team will investigate each step of the treatment process and determine technologies that will accomplish contaminant removal and discharge requirements.

2.3.1 Task 3.1: Determine Plant Requirements

The team will determine the demand flows required for the redesign. In addition, SPA 1 WRF produces Class A+ quality reclaimed water meaning strict contaminant removal requirements will need to be met.

2.3.2 Task 3.2: Preliminary Treatment Selection

Preliminary treatment includes initial screening to remove large solids and larger particles from the influent. Proper evaluation of preliminary treatment alternatives will be accomplished by in-depth evaluation of the following tasks.

2.3.2.1 Task 3.2.1: Determine Criteria

The team will identify criteria to be used in scoring each alternative to determine the best alternative.

2.3.2.2 Task 3.2.2: Develop Preliminary Treatment Alternatives

The team will develop multiple treatment process options for preliminary treatment given the criteria and conditions.

2.3.2.3 Task 3.2.3: Select Best Alternative

The team will create a decision matrix that compares the identified criteria for each proposed preliminary treatment alternative. The decision matrix will present the best course of action.

2.3.3 Task 3.3: Primary Treatment Selection

Primary treatment removes material that floats to the surface or settles out at the bottom of the primary clarifier by gravity. The team will select a primary treatment system using information in the following sub-tasks.

2.3.3.1 Task 3.3.1: Determine Criteria

Criteria will be determined by the team to score and compare each primary treatment alternative.

2.3.3.2 Task 3.3.2: Develop Primary Treatment Alternatives

The team will develop multiple primary treatment process options to implement at the facility that can be scored using the developed criteria.

2.3.3.3 Task 3.3.3: Select Best Alternative

A decision matrix will be used by the team that compares each alternative using the identified criteria for this process in wastewater treatment. The best alternative will be identified based on decision matrix.

2.3.4 Task 3.4: Secondary Treatment Selection

Secondary treatment decreases the content of nutrient levels and BOD. This is performed using an oxidation ditch with three different zones.

2.3.4.1 Task 3.4.1: Determine Criteria

Criteria will be identified for use in the decision matrix that is used by the team to score each alternative and determine the best alternative.

2.3.4.2 Task 3.4.2: Develop Secondary Treatment Alternatives

Treatment alternatives will be developed including increasing the capacity of existing oxidation ditches and constructing a new oxidation ditch.

2.3.4.3 Task 3.4.3: Select Best Alternative

The best alternative will be chosen using a decision matrix that compares the identified criteria. The best alternative will be chosen with the highest score on the decision matrix.

2.3.5 Task 3.5: Advanced Treatment Selection

Advanced treatment will consider the additional removal of nutrients and contaminants that secondary treatment does not effectively handle.

2.3.5.1 Task 3.5.1: Determine Criteria

Criteria will be generated by the team to score each advanced treatment alternative in a decision matrix.

2.3.5.2 Task 3.5.2: Develop Advanced Treatment Alternatives

The team will develop different treatment process alternatives for advanced treatment given the criteria and conditions at the facility.

2.3.5.3 Task 3.5.3: Select Best Alternatives

The best alternative will be chosen through a decision matrix using the identified criteria to compare each alternative for advanced treatment.

2.3.6 Task 3.6: Disinfection Technology Selection

Disinfection consists of the final removal of pathogens and carbon containing material in the water. This is usually performed through UV-filtration or chlorination.

2.3.6.1 Task 3.6.1: Determine Criteria

Criteria will be determined by the team to assess the disinfection capabilities of the alternatives generated in this task.

2.3.6.2 Task 3.6.2: Develop Disinfection Treatment Alternatives

Disinfection treatment alternatives will be developed for use at the facility. These alternatives will consider the identified criteria and conditions at the facility.

2.3.6.3 Task 3.6.3: Select Best Alternative

The team will use a decision matrix containing the identified criteria, and the best disinfection alternative will be chosen from the output of the decision matrix.

2.3.7 Task 3.7: Solids Management Selection

The team will design a way to handle the amount of solid matter removed during the wastewater treatment process. Techniques to dewater the waste solids will be investigated using the information in the following sub-tasks.

2.3.7.1 Task 3.7.1: Determine Criteria

The team will identify the criteria that will be used to score each alternative to manage the solid matter removed during the treatment process in order to select the best alternative.

2.3.7.2 Task 3.7.2: Develop Solid Management Treatment Alternatives

The team will generate solid management treatment alternatives that can be assessed using the identified criteria.

2.3.7.3 Task 3.7.3: Select Best Alternative

A decision matrix will be created to compare the treatment alternatives against one another using the identified criteria to select the best alternative.

2.4 Task 4: Final Design

The team will perform the work detailed in the following sub-sections once a final design has been selected. The selected alternatives from Task 3 will be further refined into a cohesive design.

2.4.1 Task 4.1: Final Treatment Process Design

The wastewater treatment process will consist of the following stages of treatment ordered as they typically appear in a WWTP.

2.4.1.1 Task 4.1.1: Preliminary Treatment Design

The team will conduct calculations to ensure the selected technology can handle the increased flow capacity while maintaining codes and regulations. Calculations relevant to preliminary treatment include flow rate capacity and contaminant removal.

2.4.1.2 Task 4.1.2: Primary Treatment Design

The team will conduct calculations to ensure the selected technology can handle the increased flow capacity while maintaining codes and regulations. The calculations relevant to primary treatment include tank sizes, flow rate capacity, and contaminant removal efficiency.

2.4.1.3 Task 4.1.3 Secondary Treatment Design

The team will conduct calculations to ensure the selected technology can handle the increased flow capacity while maintaining codes and regulations. Calculations relevant to secondary treatment include tank sizes, oxidation ditch sizes, flow rate capacity, retention time, and contaminant removal efficiency.

2.4.1.4 Task 4.1.4 Advanced Treatment Design

The team will conduct calculations to ensure the selected technology can handle the increased flow capacity while maintaining codes and regulations. Key calculations of advanced treatment include tank sizes, flow rate capacity, and contaminant removal efficiency.

2.4.1.5 Task 4.1.5 Disinfection Design

The team will conduct calculations to ensure the selected technology can handle the increased flow capacity while maintaining codes and regulations. Key considerations in design of disinfection will be flow rate capacity and pathogen deactivation effectiveness.

2.4.1.6 Task 4.1.6 Solids Management Design

The team will conduct calculations to ensure the selected technology can handle the increased solids loading while maintaining codes and regulations. Key considerations of solids handling will be designing enough redundancy on site for proper solids handling.

2.4.2 Task 4.2: Site Layout

The team will generate a new site layout reflecting the proposed improvements for the SPA 1 WRF. The site layout will reflect the analysis on whether an additional blower building is required to house new blowers for the aeration of wastewater during treatment, and a new secondary treatment tank if required.

2.4.3 Task 4.3: Hydraulic Analysis

Design parameters related to the movement of fluid within the wastewater treatment plant will be analyzed for the WRF.

2.4.3.1 Task 4.3.1: Existing Piping Analysis

Existing piping will be analyzed to determine if it can accommodate new plant flows within the head loss needs of the facility

2.4.3.2 Task 4.3.2: New Piping Design

Based on the flow and head loss needs of the facility, new piping location, diameter, and material will be determined.

2.4.3.3 Task 4.3.3: Pump Selection

The team will select a pump that can handle the flow and head loss requirements of the plant.

2.4.3.4 Task 4.3.4: Develop New Hydraulic Profile

A new hydraulic profile will be developed for the facility reflecting all the hydraulic changes from the proposed design. The water surface elevation will be shown for design flows.

2.4.4 Task 4.4: Construction Phasing

The team will phase the proposed improvements of the SPA 1 WRF to ensure continuous operation of the WRF during construction.

2.4.5 Task 4.5: Life Cycle Cost Analysis

Life cycle cost analysis will be performed for the final design in regard to construction cost, annual operation and maintenance cost, design life of each component, salvage value, discount rate, and inflation rate.

2.4.5.1 Task 4.5.1: Construction Cost

Construction costs will account for maintaining operation of the plant during construction (redundancy), materials, equipment, and personnel cost. The construction cost will be calculated using a created EOPC, where unit material, equipment, and personnel cost will reference "City of Phoenix Water and Wastewater Unit Design Study."

2.4.5.2 Task 4.5.2: Maintenance and Operation Costs

Operation costs account for the number of employees needed to operate a facility, the amount of power needed, and the cost to transport water to and from the facility. Maintenance costs account for equipment that exceeds their lifecycle during the operation of the plant and repairs they require. These values will be determined using previous studies by WWTP and their operational cost per employee and equipment costs and lifecycles. Potential energy savings will also be evaluated and deducted.

2.4.5.3 Task 4.5.3: Compute Life Cycle Cost

The design life of each component in the treatment process will be evaluated to determine how long each component will be expected to remain in operation. The team will also assess the resale value of certain structures and pieces of equipment once the design life is reached. The team will analyze the cost difference of the proposed alternative for future and present worth cost. The percent increase in prices for goods and services related to the SPA 1 facility will also be considered in cost analysis. The computed life cycle cost will be reflected in the Engineer's Opinion of Probable Cost (EOPC).

2.5 Task 5: Project Impacts Analysis

Project impacts account for the social, environmental, and economic impacts or the "triple bottom line" of the project. These impacts include the project's influence on the community and the overall impact of the facility within the respective Surprise area. Social impacts will be analyzed and assessed for each alternative. Social impacts consist of health, recreation, and labor impacts. Environmental impacts will be assessed by effluent quality, the effects of solids disposal, release of greenhouse gas emissions such as methane, and any offsets or reuse that the plant may employ. Economic impacts will be assessed by evaluating the cost analysis section found above in Task 4.5.

2.6 Task 6: Project Deliverables

The team will complete the following deliverables set by the AZWA SDC, WEF SDC, and NAU's CENE 486C class.

2.6.1 Task 6.1: 30% Deliverable

The 30% deliverable will incorporate all results from Task 1, Task 2, and Task 3. (research regulation, the site visit, data analysis, and treatment process selection). 30% deliverables will consist of a 30% project report and project presentation.

2.6.2 Task 6.2: 60% Deliverable

In addition to the results included in the 30%, the 60% deliverable will also include the designs of all treatment technologies from Task 4.1, as well as a site layout. 60% deliverables consist of a 60% project report and project presentation.

2.6.3 Task 6.3: 90% Deliverable

The 90% deliverable will include the rest of Task 4 and all of Task 5. 90% deliverables consist of a 90% project report, project presentation, and project website. All design and documentation will be complete, and minute editing will occur after this deadline.

2.6.4 Task 6.4: Final Deliverable

All tasks for the project will be complete when final deliverables are produced. Final deliverables consist of completed design reflecting revisions from the 90% deliverable with 100% project report, project presentation, and project website completion.

2.6.5 Task 6.5: Competition Final Report

The team will submit the final design report to the AZWA SDC Design Competition Chair prior to the specified deadline. The final design report will incorporate all required components from the WEF SDC guidelines.

2.6.6 Task 6.6: Competition Final Presentation

The team will prepare a 20-minute presentation detailing the design work performed throughout the course of the project leading up to the proposed final design. The team will create the PowerPoint in accordance to the WEF SDC guidelines.

2.7 Task 7: Project Management

Project management will assess the ability of the team to meet the project objectives through the proper use of time and resource management.

2.7.1 Task 7.1: Meetings

Throughout the course of the project the team will meet with the assigned grading instructor, technical advisor, and client to receive guidance. Team meetings will take place every week. Meetings with the grading instructor and technical advisor will take place once or twice a month. The team will meet with the client once a month. All meetings will be documented with agendas and meeting minutes.

2.7.2 Task 7.2: Schedule Management

The team will manage and update the schedule to stay on track to submit each deliverable prior to each deadline. The team plans to stay on schedule by meeting weekly to discuss the upcoming deliverables.

2.7.3 Task 7.3: Resource Management

Money and personnel will be managed within the team to ensure quality deliverables are submitted to the client. Tracking work hours and delegation of technical tasks are examples of how the team will manage its resources.

2.8 Exclusions

This project will focus on SPA 1 WRF and no other WRF or wastewater treatment plant will be considered. Responsibility for the operation of SPA 1 WRF will remain with the City of Surprise, including but not limited to: applying for an updated permit, maintenance of machinery and other systems, conveyance of wastewater, conveyance of reclaimed water to end users, proper disposal of solids, and the operation of groundwater recharge systems.

Additionally, several items are not included in the scope of work and will not be completed. No water quality data will be collected, including that of the influent, effluent, or of any process stream. Additionally, no field survey data will be collected. No lab work will be conducted. Any required water quality data or field survey data is expected to be provided by the client. No analysis will be done in regard to onsite groundwater recharge systems. No construction will be completed, nor will full construction plan sets be made.

3 Schedule

The team will manage time as outlined in the following sub-sections.

3.1 Schedule Overview

A project schedule was developed in Microsoft Project [10]. The amount of time required to complete each task from *Section 2: Scope of Services* and order in which they must be completed was determined. These durations and task dependencies were then plotted into a Gantt chart, refer to *Appendix A: Gantt Chart*.

The project will start on the 9th of December, 2024 and will end on the 25th of April, 2025. The total project duration including weekends is 137 days.

3.2 Major Tasks

Throughout the duration of the project certain tasks need to be completed for progress to continue; these are the major tasks of the project. The major tasks for the project include the site visit, treatment process selection, final design, and life cycle cost analysis. A site visit needs to be completed for a clear understanding of current conditions of SPA 1 WRF. The treatment process selection task will need to be completed for a full design of the water reclamation facility to be made. The final design will need to be completed in order for all components of the facility to be evaluated. All components related to treatment and hydraulics will need to be known for the life cycle analysis task to be completed. With each of the major tasks completed a full report can be presented reflecting all of the proposed changes.

3.3 Major Deliverables

This project has a set of deliverables for the WEF SDC and a set of deliverables for the CENE 486C capstone class.

The first deliverable chronologically is the 30% report for CENE 486C. This deliverable will be submitted on the 13th of February, 2025 and will include research preparation and the site assessment. The 30% deliverable will also include results of the plant requirement determination and the alternative selection for all treatment technologies.

The next deliverable is the 60% for the capstone class due on the 13th of March, 2025. In addition to the tasks completed for the 30% deliverable, the 60% deliverable will include the final treatment processes design.

The third deliverable due is the final report for the WEF SDC which will include all results from Tasks 3 and 4 which includes all treatment process designs, the site layout, all hydraulic analysis, and all cost analysis. This will be due the 28th of March 2025.

Next, a final presentation for the WEF SDC will be due the 16th of April, 2025.

The 90% for the capstone class is due the 17th of April, 2025 and will include all results for the competition report as well as project impacts and additional capstone requirements. The final report for the capstone class is due the 25th of April, 2025 and will include all work that will be performed by the team.

3.4 Critical Path

A critical path highlights tasks that determine the total length of a project. A delay in any task on the critical path will delay the total project duration. The critical path for this project is marked in red on the Gannt Chart found in *Appendix A: Gantt Chart*.

The critical path starts with research preparation. This needs to be started before the current site conditions can be evaluated, so that the team has adequate understanding of where to look for deficiencies and what requirements must be met when developing and selecting alternatives. The site visit will be completed at the end of research preparation and must be completed before secondary treatment alternative selection is finished since specific site considerations must be taken into account. Secondary treatment is expected to take longer than the other treatment technologies, and therefore would have a more significant impact on the schedule than advanced treatment, which will be designed in parallel with secondary.

All technologies must be selected before the final design task can begin, with the last technology selected being solids management. The final design will be designed starting with upstream systems and ending in downstream systems, due to effect that upstream systems may have on downstream ones. The sizing and design flowrates through the treatment systems will affect the hydraulic profile of the plant, and so all of the systems must be fully designed and sized before the hydraulic analysis can start. After the technical design is complete including the hydraulic analysis and site layout, then a life cycle cost analysis can be completed so that the cost of piping and pumps can be included. A large part of the project impact analysis includes the economic analysis; therefore, this cannot be complete until the life cycle cost analysis is complete. Finally, with the completion of all technical work, the 90% and eventually the final report can be written.

The timely completion of these critical deadlines will be ensured through internal deadlines set before official deadlines. This will allow sufficient time for internal review but will also provide some cushion time if needed. Additionally, the Gannt chart does not include weekends in task durations, which provides extra room to catch up on tasks if needed.

4 Staffing Plan

Project staffing is composed of four separate staffing positions. The four positions are: Senior Engineer (SENG), Design Engineer (DENG), Civil Engineer Intern (CINT), and Environmental Engineer Intern (EINT). Each position's qualifications and responsibilities are summarized below.

- SENG: The SENG has a P.E. in Civil Engineering and has 10 years of experience in wastewater engineering. A majority of client interphase-based work and client communication falls under the SENG. This position performs final review.
- DENG: The DENG is an E.I.T in Environmental Engineering and has four years of experience in wastewater specific design and four in engineering design. The DENG performs most of the design work. The DENG reviews work performed by the CINT and EINT.
- CINT: The CINT is an undergraduate student at Northern Arizona University entering into their senior year of college who is wanting to pursue a career in water and wastewater engineering. Background research and development of the proposed design are largely the responsibility of the CINT and EINT. This position performs most of the drafting in Civil 3D and aids in report writing.
- EINT: The EINT is an undergraduate student at Northern Arizona University entering into their senior year of college who is wanting to pursue a career in water and wastewater engineering. Background research and development of the proposed design are largely the responsibility of the CINT and EINT. This position aids in drafting, design calculation, and report writing.

Table 4-1, below, displays the summary of staffing hours by task with their respective positions.

Table 4-1: Summary of Staffing Hours

Task	SENG	DENG	CINT	EITN	TOTALS
Task 1: Research Preparation	1	0	12	12	**25**
Task 2: Site Assessment	8	8	12	12	**40**
Task 3: Treatment Process Selection	25	40	70	70	**205**
Task 4: Final Design	13	174	46	44	**277**
Task 5: Project Impact Analysis	4	16	2	2	**24**
Task 6: Project Deliverables	17	14	46	46	**123**
Task 7: Project Management	30	30	15	15	**90**
Summary	**98**	**282**	**203**	**201**	**784**

Appendix B: Staffing Estimates contains a more detailed breakdown of hours associated with each task and subtask as well as how many hours each staff position works for each task and subtask.

5 Cost of Engineering Services

Table 5-1, below, details project costs for personnel, supplies, and travel. Personnel costs are comprised of the billing rates for the Senior Engineer, Design Engineer, Civil Engineer Intern, and Environmental Engineer Intern. Personnel billing rates are based on employee hourly rates, employee benefits, company overhead costs, and profit. The labor costs were calculated by multiplying staffing hours for each position by the corresponding billable rate. Labor costs were found by researching existing job listings near the location of the project. The cost of supplies for this project includes membership for AZWA for each team member and computer lab rental so that the team can access software such as Civil 3D and Revu Bluebeam for design. Travel costs for the team include car rental, gas, per diem, and hotels for overnight trips; these costs were obtained from NAU's comptroller website [11].

Table 5-1: Personnel, Supply, and Travel Cost

Category	Sub-Category	Classification	Quantity	Unit	Rate	Unit	Cost ($)
1.0 Personnel		SENG	98	hours	250	$/hour	$ 24,500
		DENG	282	hours	150	$/hour	$ 42,300
		CINT	203	hours	50	$/hour	$ 10,150
		EINT	201	hours	50	$/hour	$ 10,050
		Subtotal:					**$ 87,000**
2.0 Supplies		Membership	4	memberships	20	$/subscription	$ 80
		Computer Lab Rental	10	days	100	$/day	$ 1,000
		Subtotal:					**$ 1,080**
3.0 Travel	**3.1 Site Visit**	Car	1	day	38.93	$/day	$ 39
		Gas	286	miles	0.455	$/mile	$ 127
	3.2 Competition	Car	2	day	38.93	$/day	$ 78
		Gas	286	miles	0.455	$/mile	$ 127
		Per Diem	8	day*person	36.75	$/day*person	$ 294
		Hotel	3	night-room	156	$/night-hotel	$ 468
	Subtotal:						**$ 1,133**
Total Cost of Engineering Services:							**$ 89,213**

Personnel costs make up approximately 98% of the total cost for personnel, supplies, and travel. Travel costs being the second highest cost, and supplies are the lowest cost.

6 References

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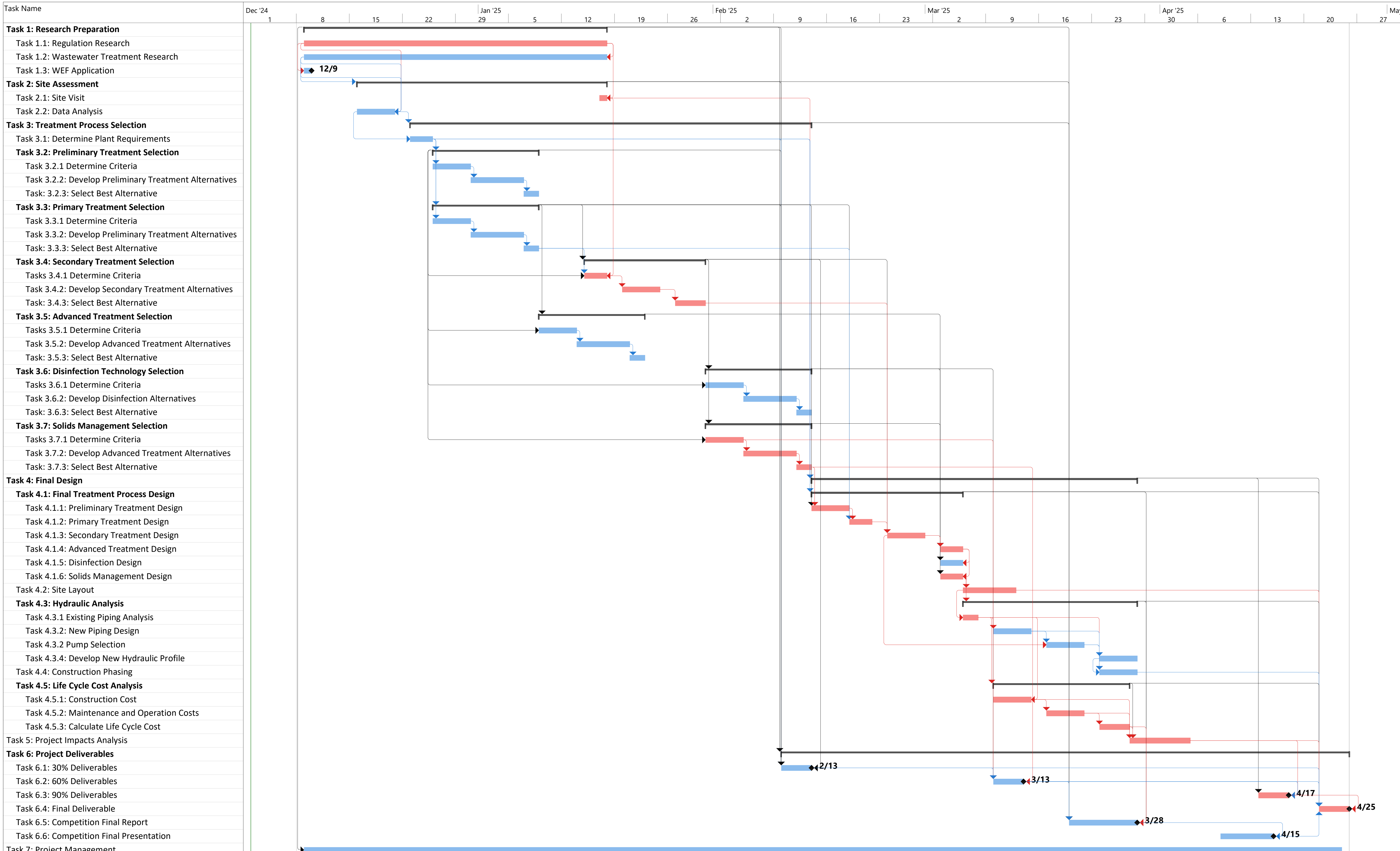
7 Appendices

7.1 Appendix A: Gantt Chart

Chart on next page.



Task Name
Dec '24
Jan '25
Feb '25
Mar '25
Apr '25
May '25
1 8 15 22 29 5 12 19 26 2 9 16 23 2 9 16 23 30 6 13 20 27
Task 1: Research Preparation
Task 1.1: Regulation Research
Task 1.2: Wastewater Treatment Research
Task 1.3: WEF Application
12/9
Task 2: Site Assessment
Task 2.1: Site Visit
Task 2.2: Data Analysis
Task 3: Treatment Process Selection
Task 3.1: Determine Plant Requirements
Task 3.2: Preliminary Treatment Selection
Task 3.2.1 Determine Criteria
Task 3.2.2: Develop Preliminary Treatment Alternatives
Task: 3.2.3: Select Best Alternative
Task 3.3: Primary Treatment Selection
Task 3.3.1 Determine Criteria
Task 3.3.2: Develop Preliminary Treatment Alternatives
Task: 3.3.3: Select Best Alternative
Task 3.4: Secondary Treatment Selection
Tasks 3.4.1 Determine Criteria
Task 3.4.2: Develop Secondary Treatment Alternatives
Task: 3.4.3: Select Best Alternative
Task 3.5: Advanced Treatment Selection
Tasks 3.5.1 Determine Criteria
Task 3.5.2: Develop Advanced Treatment Alternatives
Task: 3.5.3: Select Best Alternative
Task 3.6: Disinfection Technology Selection
Tasks 3.6.1 Determine Criteria
Task 3.6.2: Develop Disinfection Alternatives
Task: 3.6.3: Select Best Alternative
Task 3.7: Solids Management Selection
Tasks 3.7.1 Determine Criteria
Task 3.7.2: Develop Advanced Treatment Alternatives
Task: 3.7.3: Select Best Alternative
Task 4: Final Design
Task 4.1: Final Treatment Process Design
Task 4.1.1: Preliminary Treatment Design
Task 4.1.2: Primary Treatment Design
Task 4.1.3: Secondary Treatment Design
Task 4.1.4: Advanced Treatment Design
Task 4.1.5: Disinfection Design
Task 4.1.6: Solids Management Design
Task 4.2: Site Layout
Task 4.3: Hydraulic Analysis
Task 4.3.1 Existing Piping Analysis
Task 4.3.2: New Piping Design
Task 4.3.2 Pump Selection
Task 4.3.4: Develop New Hydraulic Profile
Task 4.4: Construction Phasing
Task 4.5: Life Cycle Cost Analysis
Task 4.5.1: Construction Cost
Task 4.5.2: Maintenance and Operation Costs
Task 4.5.3: Calculate Life Cycle Cost
Task 5: Project Impacts Analysis
Task 6: Project Deliverables
Task 6.1: 30% Deliverables
2/13
Task 6.2: 60% Deliverables
3/13
Task 6.3: 90% Deliverables
4/17
Task 6.4: Final Deliverable
4/25
Task 6.5: Competition Final Report
3/28
Task 6.6: Competition Final Presentation
4/15
Task 7: Project Management

7.2 Appendix B: Staffing Estimates

Table on next page.

Task	SENG	DENG	CINT	EINT	Total Work Hours
Task 1: Research Preparation	**1**	**0**	**12**	**12**	**25**
Task 1.1: Regulation Research			6	6	
Task 1.2: Wastewater Treatment Research			6	6	
Task 1.3: WEF Application	1				
Task 2: Site Assessment	**8**	**8**	**12**	**12**	**40**
Task 2.1: Site Visit	8	8	8	8	
Task 2.2: Data Analysis			4	4	
Task 3: Treatment Process Selection	**25**	**40**	**70**	**70**	**205**
Task 3.1: Determine Plant Requirements	4	12			
Task 3.2: Preliminary Treatment Selection					
Task 3.2.1 Determine Criteria	1	1	1	1	
Task 3.2.2: Develop Preliminary Treatment Alternatives	1	2	10	10	
Task: 3.2.3: Select Best Alternative	1	1			
Task 3.3: Primary Treatment Selection					
Task 3.3.1 Determine Criteria	1	1	1	1	
Task 3.3.2: Develop Preliminary Treatment Alternatives	1	2	10	10	
Task: 3.3.3: Select Best Alternative	1	1			
Task 3.4: Secondary Treatment Selection					
Tasks 3.4.1 Determine Criteria	2	2	1	1	
Task 3.4.2: Develop Secondary Treatment Alternatives	2	4	14	14	
Task: 3.4.3: Select Best Alternative	2	2			
Task 3.5: Advanced Treatment Selection					
Tasks 3.5.1 Determine Criteria	1	1	1	1	
Task 3.5.2: Develop Advanced Treatment Alternatives	1	2	10	10	
Task: 3.5.3: Select Best Alternative	1	1			
Task 3.6: Disinfection Technology Selection					
Tasks 3.6.1 Determine Criteria	1	1	1	1	
Task 3.6.2: Develop Disinfection Alternatives	1	2	10	10	
Task: 3.6.3: Select Best Alternative	1	1			
Task 3.7: Solids Management Selection					
Tasks 3.7.1 Determine Criteria	1	1	1	1	
Task 3.7.2: Develop Advanced Treatment Alternatives	1	2	10	10	
Task: 3.7.3: Select Best Alternative	1	1			
Task 4: Final Design	**13**	**174**	**46**	**44**	**277**
Task 4.1: Final Treatment Process Design					
Task 4.1.1: Preliminary Treatment Design	1	18	4	4	
Task 4.1.2: Primary Treatment Design	1	18	4	4	
Task 4.1.3: Secondary Treatment Design	1	28	2	6	
Task 4.1.4: Advanced Treatment Design	1	28	2	6	
Task 4.1.5: Disinfection Design	1	22	2	6	
Task 4.1.6: Solids Management Design	1	22	2	6	
Task 4.2: Site Layout	1	4	4	6	
Task 4.3: Hydraulic Analysis					
Task 4.3.1 Existing Piping Analysis		4	8		
Task 4.3.2: New Piping Design		12			
Task 4.3.2 Pump Selection		4	4		
Task 4.3.4: Develop New Hydraulic Profile		2	8		
Task 4.4: Construction Phasing	2	12	2	2	
Task 4.5: Life Cycle Cost Analysis					
Task 4.5.1: Construction Cost	1		2		
Task 4.5.2: Maintenance and Operation Costs	1			2	
Task 4.5.3: Compute Life Cycle Cost	2		2	2	
Task 5: Project Impacts Analysis	**4**	**16**	**2**	**2**	**24**
Task 6: Project Deliverables	**17**	**14**	**47**	**47**	**125**
Task 6.1: 30% Deliverables	4		12	12	
Task 6.2: 60% Deliverables	4		12	12	
Task 6.3: 90% Deliverables	2		5	5	
Task 6.4: Final Deliverable	2		5	5	
Task 6.5: Competition Final Report	1	4	12	12	
Task 6.6: Competition Final Presentation	4	10	1	1	
Task 7: Project Management	**30**	**30**	**15**	**15**	**90**
TOTAL HOURS	**98**	**282**	**204**	**202**	**786**