Project Scope

1 Scope of Service

1.1 Task 1: Mix Design

1.1.1 Task 1.1: Material Research

1.1.1.1 Task 1.1.1: Aggregates

The team will look at various canoes from NAU and other schools to look at what types of aggregate were used, the particle distribution and the wall thickness of the concrete. The particle size used in the concrete helps to determine the biggest particle size used in the canoe to see how small particles will affect unit weight and concrete strength.

1.1.1.2 Task 1.1.2: Cementitious Material

The team will look at various mix proportions from NAU and other schools to see what ratios of cement to cementitious materials and the strength of the concrete. These mix proportions will be retrieved through past design papers that have been submitted to NCCC. The team will use this analysis to compare the ratios and concrete strengths from each school to determine an initial ratio to use for an initial mix design.

1.1.1.3 Task 1.1.3: Admixtures

The team will look at reports from NAU and other schools to determine what admixtures were used, the amount, and the type of cementitious material used in the canoe. The team will make relationships between the type of admixture used to the amount of different types of cementitious material used. These relationships will help to establish initial ratios for the initial mix design.

1.1.2 Task 1.2: Material Acquisition

Gathering all the materials needed requires coordinating with suppliers and manufacturers on how the material will be delivered and the quantity that will be available to be picked up. The team will also coordinate with a construction company to crush any material that is too large to be used in the canoe as its original size. Ensuring enough material is available for the duration of the project is critical to ensure the project stays on task.

1.1.3 Task 1.3: Initial Mix Design

The team will create a mix table with all of the proposed aggregates, cementitious materials, and admixtures along with the initial ratios and specific gravity of each material found from material research. The mix table will ensure that the concrete meets all the requirements from NCCC of at least 30% of concrete is natural aggregate by total volume and no more than 70% of expanded glass, cenosphere, or a combination of the two by total concrete volume.

1.1.4 Task 1.4: Initial Mix Testing

1.1.4.1 Task 1.4.1: Compressive Strength

To find the compressive strength of each concrete mix design the team will use ASTM C39 to find the compressive strength of each concrete mix. Compressive strength will be used to determine if the concrete mix design has enough strength to be used in the construction of the canoe.

1.1.4.2 Task 1.4.2: Tensile Strength

Each concrete mix design will be tested for tensile strength using ASTM C496. Using the tensile strength from each mix will help to determine how the quantities and ratios of materials in each concrete mix affect the tensile strength.

1.1.4.3 Task 1.4.3: Slump and Application of Concrete

Each concrete mix design will be tested for slump using ASTM C143. Slump will help to determine the workability of the concrete. The team will also spray the concrete mix onto a foam mold of the canoe to see how well the concrete sprays and how it sticks to the mold. Seeing how the concrete sprays will help to determine the max particle size that can be in the concrete and how much water needs to be in the concrete mix to allow for application on the concrete during and after spraying.

1.1.4.4 Task 1.4.4: Unit Weight

Each concrete mix design will be tested for unit weight following ASTM C138. Unit weight will be tested before each compressive strength and tensile strength test. Unit weight will be conducted to ensure that the mix design table is accurate and how the unit weight is changing for each concrete sample.

1.1.5 Task 1.5: Alternative Mix Design Testing

Due to the different amount of different aggregates, admixtures, and cementitious materials used within each mix, multiple test for each mix is needed to determine what ratios of what materials give the concrete the greatest strength without increasing the unit weight. The physical characteristics from the four tests from the above section helps to decide how each mix should be changed to improve strength and unit weight.

1.1.6 Task 1.6: Final Mix

The final mix will be designed by looking at all of the data from previous concrete mixes and deciding what mixes can be used to build the canoe without making the canoe excessive heavy. The final mix will also take into consideration the workability of the concrete mix to be placed. NCCC allows up to three mixes that can be used to make the canoe, even if color is the only thing changed within the mix, it counts as one mix.

1.2 Task 2: Hull Design

The canoe will be modeled and designed from a software called “MaxSurf”. This software will help determine performance measures of the canoe to increase efficiency and to ease the construction of the concrete canoe by minimizing design time between each hull concept. Redesigning the canoe will be based on the analysis from “MaxSurf” and construction of the practice canoe on practice pour day.

1.3 Task 3: Structural Design

1.3.1 Task 3.1: Calculation

Calculations will be made to determine various values that are crucial when designing the mix and hull. These calculations are made to ensure structural integrity of the canoe which will increase the performance and overall strength. An excel spreadsheet will be utilized when doing these

calculations so that all the variables are linked, and changes can be made easily and quickly. This excel sheet will improve the accuracy and precision of the design criteria.

1.3.2 Task 3.2: Mesh

Mesh lining will be placed in the canoe to increase the rigidity of the structure. This mesh requires calculations to ensure productivity of the material. These calculations are done to analyze the flexural capacity as well as the ductility. Like the general design calcs above, these calculations will be done in excel and will reference various support sources such as textbooks, journals, and professional engineers.

1.3.3 Task 3.3: Testing

Testing the mesh will ensure that the mix and mesh together provide a high enough tensile strength based on the design calculations. This testing will be done by placing a piece of mesh in the center of a square of concrete that will then be pulled to test the tensile strength. This test will be performed by applying an axial force that will pull the mess apart. The stress will be measured with a pressure gauge and will be considered successful once the desired tensile strength based on calculations has been exceeded.

1.3.4 Task 3.4: Post Tensioning

Agassiz plans to utilize post tensioning in the canoe this year for a variety of reasons. The main reason in to increase the overall strength of the canoe and to help minimize cracking. Post tensioning will put the canoe in compression which increases its ductility and durability in harsh conditions. The team plans to achieve this goal by placing six cables in the canoe and then utilizing a table and custom-built equipment to withstand the stress of post tensioning.

1.4 Task 4: Construction

1.4.1 Task 4.1: Setup

1.4.1.1 Task 4.1.1: Transportation Stand

The canoe stand will be utilized to help safely transport the canoe to the PSWC conference location. A steel stand will be erected utilizing 1” square tubing, and casters. Everything will be welded in place to ensure that the stand will hold up to the traveling strain. This stand will need to protect the canoe from any strains and stress it may experience as it is being trailered to the conference location.

1.4.1.2 Task 4.1.2: Pour Table

A pour table will help ensure a level surface to work on while also allowing team members to maneuver around the canoe with ease, especially when the time comes to pour the whole canoe. Post-Tensioning equipment will be built into the pour stand to allow for a streamline and efficient use of the pour table. The pour table will be constructed out of wood due to cheap material cost and ease of construction. The post-tensioning equipment will be constructed out of wood, and will hold the cables in place while a horizontal force in applied to the canoe.

1.4.1.3 Task 4.1.3: Mold Preparation

Acquiring the canoe mold is essential to the construction of the canoe because it will provide a surface to shape once the mold is acquired the pieces that it will come in will have to be glued together. The mold will be shadow sanded to see the various bumps and cracks that have formed

within the mold. Butcher paper will be used instead of a release agent to help cover the gaps between mold pieces to provide a smoother exterior canoe finish.

1.4.1.4 Task 4.1.5: Cure Chamber

Building a curing chamber that will utilize a PVC frame and plastic cover will help keep the humidity as high as possible. This will ensure the correct humidity levels for proper curing of the concrete. The curing chamber will be developed by construction of a PVC frame, with a heavy plastic wrap that will encase the PVC frame. This plastic wrap will be tapped together to help contain the humidity created for curing the canoe.

1.4.2 Task 4.2: Practice Pour

1.4.2.1 Task 4.2.1: Practicing Mixing and Placing

Practice pour day will consist of making the structural and finishing mixes to be placed on the canoe mold. The post tensioning strands, and fiber meshes will be placed in the mold with concrete placed on top. The concrete mixtures will be sprayed onto the mold to develop an Standard Operating Procedure (SOP). This will ensure consistency throughout the design.

1.4.2.2 Task 4.2.2: Wet Curing

The concrete canoe will be wet cured with a curing chamber. This curing process will help ensure that the concrete will reach its maximum 28-day compressive strength by making the humidity inside the curing chamber as close to 100% as possible. The curing chamber will be erected for this process, and humidifiers will be plumed into the chamber to create the humid environment.

1.4.2.3 Task 4.2.3: Removal

Removal of the canoe from the mold is very important for the whole canoe to cure properly. The removal of the canoe will be determined by the type of release agent used or other methods. It is important to remove the canoe with as little effort as possible to help reduce the risk of cracking or breaking the canoe.

1.4.2.4 Task 4.2.4: Post Tensioning

After approximately two weeks of allowing the canoe to curing in the curing chamber, post tensioning cables will be pulled adding more compressive strength to the canoe. Cylinders that were collected during the construction of the practice canoe will help determine the optimum time to utilize post-tensioning.

1.4.3 Task 4.3: Final Pour

1.4.3.1 Task 4.3.1: Mixing and Placing

Final pour day will consist of making the final structural and finishing mixes to be placed on the canoe mold. The post tensioning strands, and fiber meshes will be placed in the mold with concrete placed on top. The concrete mix will be sprayed onto the mold utilizing Shot-Crete spray guns.

1.4.3.2 Task 4.3.2: Wet Curing

The concrete canoe will be wet cured with a curing chamber. This curing process will help ensure that the concrete will reach its maximum 28-day compressive strength by making the humidity inside the curing chamber as close to 100% as possible. The curing chamber will be erected for this process, and humidifiers will be plumed into the chamber to create the humid environment.

1.4.3.3 Task 4.3.3: Removal

Removal of the canoe from the mold is very important for the whole canoe to cure properly. The removal of the canoe will be determined by the type of release agent used or other methods. It is important to remove the canoe with as little effort as possible to help reduce the risk of cracking or breaking the canoe. The mold will be removed by applying pressure to the foam mold and slowly removing sections of the mold from the canoe.

1.4.3.4 Task 4.3.4: Post Tensioning

After two weeks of allowing the canoe to curing in the curing chamber, post tensioning cables will be pulled adding more compressive strength to the canoe. The post-tensioning equipment will be set up, and the cables will be pulled to the desired tension. In line strain gauges will be used to determine the amount of force within the cable.

1.4.3.5 Task 4.3.5: Aesthetic (Sealing/Sanding/Stickers/Lettering)

Adding aesthetics to the finish product of the canoe will added to the presentation on the day of conference. The aesthetics involve wet sanding and sealing the canoe to get a nice smooth look and adding lettering to present the school and canoe names. Wet sanders will be used with different variations of grit sand paper to achieve a smooth finish. Sealant will be applied by brushing it on with paint brushes or a pressurized sprayer.

1.5 Task 5: Conference

1.5.1 Task 5.1: Presentation

A presentation will be created and practiced showing the results of the concrete canoe within the requirements of the PSWC rules. This will be presented to the judges of the PSWC conference. “PowerPoint” will be used to develop the presentation.

1.5.2 Task 5.2: Report

The final report will be completed and submitted with the research and findings that were finalized for the concrete canoe. These finding will include the data from the final concrete mix, construction drawings, structural calculations, a finalized budget, and a project schedule. This report will be reviewed by the judges of PSWC for accuracy and completeness. A report will developed utilizing “Word” processors.

1.5.3 Task 5.3: Races/Rowing

Training Paddlers to practice racing based on the courses for conference as fast and efficiently as possible to score as much points as possible. An older canoe will be used to help the paddlers train. The canoe will go through multiple different races that will illustrate different performance measures of the canoe.

1.5.4 Task 5.4: Display

For conference a display stand is needed to convey the team's theme for their canoe and helps promote the school that is competing in the conference. This stand will also serve as transporting the canoe to and from conference by allowing the team to roll the canoe into the lake without lifting the canoe. The display will utilize decorated wood pieces to illustrate the theme of the canoe. These wood pieces

1.6 Task 6: Capstone Deliverables

1.6.1 Task 6.1: 30% Report and Presentation

An initial report will be developed to provide an initial update on the findings and the progress of the project. The presentation will give a visual update for the project. The report will be developed in "Word" processors and the presentation will be developed in "PowerPoint".

1.6.2 Task 6.2: 60% Report and Presentation

A report will be developed to provide an update on the findings and the progress of the project since the 30% submittal. The presentation will give a visual update for the project . The report will be developed in "Word" processors and the presentation will be developed in "PowerPoint".

1.6.3 Task 6.3: 90% Report and Presentation

A rough draft of the final report will be developed to provide a final update on the findings and the progress of the project. The presentation will give a visual update for the completion of the project. The report will be developed in "Word" processors and the presentation will be developed in "PowerPoint".

1.6.4 Task 6.4: Final Report, Presentation, Website

The final report will be developed to provide the final findings and the completion of the project. The presentation will give a visual update for the project. The report and the presentation will incorporate any redlines changes that have been identified in the 90% submittal. The report will be developed in "Word" processors and the presentation will be developed in "PowerPoint". A final website will also be developed to illustrate the timeline if the project and the completed canoe itself. This website will be developed on an online platform.

1.7 Task 7: Project Impacts

The project impacts will be analyzed throughout the project. These impacts are: regulatory, health/environmental, economic, and social. These analysis will be analyzed on an as needed basis.

1.8 Task 8: Project Management

1.8.1 Task 8.1: Scheduling

A project schedule will be developed with Microsoft "Project". This schedule will ensure the project stays on task and deliverables are met.

1.8.2 Task 8.2: Meetings (GI/TA/Team)

Regular Team, Grading Instructor, and Technical Advisor meetings are necessary to ensure the project stays on track and that everyone involved within the project is up to date. Meetings will be formed over email, with an agenda and to follow 24 hours before the meeting time. Meeting minutes will be taken and distributed to all involved parties within 24 hours after the meeting has taken place.

1.8.3 Task 8.3: Fundraising

Funding for this project is needed to help buy materials for the mix design of the canoe, post tensioning cables, material for the canoe stand, mold and any other supplies that will contribute to the completion of the project.

Project Scope

1.9 Exclusions

An exclusion that this project has is the actual creation of the mold. The mold for the canoe will be made by an outside source and shipped to Northern Arizona University for the team to begin construction.