Final Proposal for the Drinking Water Stabilization Project

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RAVA Fontus Engineering Inc.

-Environmental Engineers-
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1.0 Project Understanding

1.1 Purpose of Project

RAVA Fontus Engineering Inc. is a small environmental engineering firm that focuses on the treatment of drinking water. Dr. Bridget Bero has hired the company to find an innovative way to stabilize drinking water that uses Reverse Osmosis (RO) treatment method. The purpose of this project is to fortify RO bottled water with minerals that will improve the taste and odor, while preventing leaching of minerals from the skeletal system. Another objective of this project is to analyze and research the mineral composition of popular, local bottled water, and their benefits, in terms of taste and odor. Those results will then be compared to the optimum mineral composition.

The main focus areas for this project are:

- Nutritional requirements for humans;
- Nutritional requirements for livestock;
- Reducing the corrosion impact in the water distribution system due to RO bottled water;
- The development of a marketing plan to sell the optimum mineral additive to the public;
- Development and completion of a cost analysis that takes into account the implementation of adding the supplementary minerals into the bottling process for future bottled waters, and the cost of the added minerals to production.

The company is also entering the drinking water stabilization project into the 2014 Environmental Design Contest sponsored by the Waste-management Education and Research Consortium (WERC): An Organization for Environmental Education and Technology Development[2].

1.2 Background Information

1.2.1 Task Description

The drinking water stabilization project entails investigating the use of minerals in bottled water which uses RO process. During RO, all the particles that are larger than a water

molecule, including the minerals, are removed through a pressurized membrane. Therefore, when RO bottled water is consumed, the minerals from the skeletal system replace the ones that were lost in the RO process[3]. Thus, there is a need to reinstitute minerals into the pure RO water for many beneficial reasons. For the project, it is helpful to know what the variance of minerals in bottled RO water are and how they compare to the Environmental Protection Agency (EPA) and Food and Drug Administration (FDA) standards for bottled water. These standards will be discussed further in the regulations portion of this proposal.

1.2.1.1 Human Health

For the human health portion, there needs to be the consideration of multiple age groups which are children, adults and elderly. Each age group has a specific list of minerals that are needed for daily nutritional health requirements. The minerals for each age group are shown below in Table 1: Daily Mineral Levels by Age:

Table 1: Daily Mineral Levels by Age

Children	Adults	Elderly
Calcium (600 mg/day)*	Calcium (1200 mg/day)*	Calcium(≤ 2,500 mg/day)*
Zinc (3.5 mg/day)*	Chromium (1.5 mg/day)*	Iron (10 mg/day)*
Iron (9.5 mg/day)*	Copper (2 mg/day)*	Zinc(2.5 mg/day)*
Sodium (460 to 920 mg/day)*	Iodine (150 micrograms/day)*	Magnesium (320 to 42 mg/day)*
	Iron (18 mg/day)*	Copper (700 to 900 micrograms/day)*
	Magnesium (40 mg/day)*	
	Phosphorus (1000 mg/day)*	
	Potassium (10 mg/day)*	
	Selenium (50-200 micrograms/day)*	
	Zinc (15 mg/day)*	

* All values and minerals were retrieved from http://www.webmd.com/vitamins-supplements/default.aspx

Within each of these groups there are certain minerals that are represented throughout. These minerals are calcium, copper, iron, magnesium, sodium, and zinc. The six minerals will be taken into consideration for the optimum mineral composition.

1.2.1.2 Livestock Nutritional Requirements

Similar to the human health, the minerals for the nutritional requirements of livestock were needed. The daily nutritional mineral values vary from animal to animal. However, the common minerals that are required for the nutritional health of livestock are as follows[3]:

- Calcium
- Phosphorus
- Magnesium
- Potassium
- Sodium
- Chlorine
- Sulfur

1.2.1.3 Water Distribution System

The water distribution system is the "piping system that delivers potable water from the treatment plant to consumers"[5]. Since RO water is demineralized, it has similar effects on the water distribution system to the effects on the skeletal system. Demineralized water is also considered soft water, which means that "it contains only small amounts of dissolved minerals such as calcium and magnesium"[3].When RO water flushes through the pipes, it does not only corrode them, but it leaches metals and other materials from the pipes. Chemicals such as calcium carbonate or limestone must be added to reduce corrosion on the piping system[3].

1.2.2 WERC Competition

The Environmental Design Contest sponsored by WERC started in 1991 in Las Cruses, New Mexico and has been held there annually ever since. The competition is planned to test groups in the design of real world problems that have to do with the environment. This year five tasks are open for the competition. They are as follows: open design,

drinking water stabilization, power point tracking for solar energy, solar brine concentrator, and floating solar cells. The task assigned for this project is the drinking water stabilization [4].

1.3 Stakeholders

Key stakeholders are individuals and institutions who sponsor or invest in a specific project so it meets their goals or requirements. The specific stakeholders for this project are as follows: the client, Dr. Bridget Bero; WERC; and potential consumers, which include children, adults, and elders.

1.4 Existing Conditions

Currently, the bottled water industry profits from advertisements that claim their water is as fresh as natural spring water, or their water is pure and enhanced with minerals and electrolytes[4]. Many of these statements can be misleading because of the lack of nutritional labeling.

1.4.1 Current Water Companies

The RAVA Fontus Engineering Inc. team decided to look into the following three RO bottled water brands for future comparison purposes and lab work. The three brands are shown below in Table 2: RO Bottled Water Brands.

Table 2: RO Bottled Water Brands.

Brand	Description
Aquafina® by PepsiCo®	This specific brand uses RO for their purification process which makes it potentially unhealthy, but yet they claim their water is "pure with a perfect taste"[6].
Dasani® by Coca-Cola®	This bottled water company claims to sell water enhanced with minerals for a "pure and fresh taste"[6]. Yet, they also use the RO process to remove contaminants from the water which makes the water soft.
365 Spring Water ® by Whole Foods®	Whole Foods® uses RO water, but they do add minerals back into it[6]. The firm wants to analyze the concentrations of each of the minerals they added. This information will help to the design of the final optimum mineral additive.

1.4.2 Regulatory Requirements

Bottled water is considered food under the FDA. Currently there are regulations about the maximum chemical concentrations allowed in bottled water in the Code of Federal Regulations (CFRs) under Title 21: Food and Drugs, part 165-beverages, subpart B-requirements for specific standardized beverages. Since the company is only looking at commercial bottled water there is no needed to apply for any permits for this project.

1.5 Technical Considerations

The main goal of the project is to have an optimum mineral composition which will be added to current RO bottled waters. To meet the deliverables for this project, lab analysis will be performed on the bottled waters previously mentioned. The lab analysis will include tests to determine the physical and chemical qualities of the water, these are specified in CFR 165.110(a-b) for bottled water. The physical qualities under these regulations include turbidity, color, and odor. The chemical quality regulations include the composition and concentration of the cations and anions in the water sample. The testing will be further explained in the scope of services section of this proposal.

After the lab analysis is concluded a bench scale model will be designed. The bench scale model is a demonstration of how the optimum mineral composition will be added to RO bottled waters and what effects the additive will have.

A marketing plan needs to be completed to advertise the "enticement" of the use of supplemental minerals in bottled water. The target market will include people and livestock, as well as the water distribution system.

Finally, the production costs of RO bottled water with the optimum mineral composition added will need to be estimated. A complete economic analysis will also need to be finished for the WERC competition. The technical work for the project will be discussed further in the scope of services.

1.6 Potential Challenges

In this project, there is a potential that problems may be encountered and could have a major impact on the progression of the project. The main challenge is the unavailability of

equipment needed for some of the testing. This will be addressed by including an exclusion for that specific test within our project. However, if the test is essential for the success of the project RAVA Fontus Engineering Inc. will purchase the necessary equipment.

This project will require some professional help, assistance that the technical advisor may not be able to provide. Experts needed for this project include, a veterinarian, a nutritionist, a human physiology expert, and a marketing advisor. These experts will be contacted through multiple means of communication and will be given proper credit for any expertise they provide.

2.0 Scope of Services

RAVA Fontus Engineering Inc. has decided to break the project into five main tasks for the successful completion of this project. The five main tasks are background research, testing, design/build bench scale model, documentation, and WERC competition.

2.1 Background Research

There will be five subtasks within the background research main task. These subtasks include researching reverse osmosis, nutritional/health requirements, effects on the water distribution system, regulations, and standard analytical methods.

2.1.1 Reverse Osmosis

The project requires research of the process of RO and how RO water affects human health. Also, bottled water industries who use RO water will be identified. Any other type of water besides RO water will not be considered for this project.

2.1.2 Nutritional/ Health Requirements

This subtask includes researching the nutritional requirements and health effects of minerals for children, adults, the elderly, and livestock. These minerals need to be analyzed for the impact they may have on taste and odor once they are added to RO bottled water. Vitamins, sweeteners, and other additives will be excluded from the research. Only the nutritional mineral information for children, adults, and the elderly will be used to complete the mineral composition for this project. The nutritional/health requirements of livestock will not be considered for the end product, but will be discussed. Since the RAVA Fontus

Engineering Inc. team does not have professional expertise in nutrition, livestock, or human physiology, experts on these areas will need to be consulted. Gender will not be considered for the nutritional/health research.

2.1.3 Effects on Water Distribution System

The water distribution system subtask entails researching the minerals which cause corrosion or decrease scaling in water systems. These minerals will be identified and compared to those used in the project to assess the possible effects they may have on the water distribution system. The end product does not need to have a beneficial comparison for the water distribution system, therefore this is another exclusion for the Drinking Water Stabilization project.

2.1.4 Regulations

This subtask consists of identifying the regulations listed in the CFRs under title 21 (Food and Drugs), which are enforced by the FDA. CFR 165 (Beverages) and CFR 129 (Processing and Bottling of Bottled Drinking Water) need to be analyzed and used for this project. The end product will be in compliance with any standards underlined in the CFRs.

2.1.5 Standard Analytical Methods

The book titled "Standard Methods for the Examination of Water and Wastewater" will be used to complete this subtask[1]. The team will identify which standard methods will be used to test alkalinity, pH, color, odor, turbidity, total dissolved solids (TDS), and chemical quality (minerals). Any standard method needed to test pathogens, manganese, and phenols will be excluded because these components are already heavily regulated and will unlikely be present in bottled water (CFR 165.110(b)). The methods identified will be used either in the Environmental Engineering Lab at Northern Arizona University or the Colorado Plateau Analytical Lab. The additive will not be available for consumption, therefore no taste standard method is needed.

2.2 Testing

Task two of the project will be accomplished by testing different mixtures of water and minerals. This task consists of three subtasks which includes analyzing three RO water

bottles, testing three optimum mineral compositions, and selecting the additive mix. These subtasks are crucial to deliver the most optimum mineral composition for the end product.

2.2.1 Analyze Three RO Products

The team will be analyzing three water samples from popular RO water bottles. This analysis will be conducted in order to find the original mineral content of RO water. This subtask will require mineral testing for copper, calcium, magnesium, iodine, fluoride, potassium, chloride, sulfate, iron, sodium, and nitrate. Also tests for acidity, alkalinity, odor, color, TDS, conductivity, hardness, and turbidity will be conducted on the water products. This information is required as it will indicate any excess/lack of minerals[1].

2.2.2 Test Three Optimum Mineral Compositions

This subtask requires the RAVA Fontus Engineering Inc. members to identify three different optimum mineral compositions for children, adults, and the elderly. Thus, the background research task and the analysis of the three RO products subtask needs to be completed before this subtask can begin. Some of the tests that the RAVA Fontus Engineering Inc. team will perform include: odor, taste, color, turbidity, acidity, conductivity, alkalinity, total dissolved solids, and hardness. The minerals that will be tested in the lab include: calcium, magnesium, copper, iodine, fluoride, iron, sodium, potassium, chloride, sulfate, and nitrate. The standard and mineral methods are subject to change. Again, an exclusion of this project is to not design an optimum mineral composition that takes into account livestock or the corrosion effect on the water distribution system.

2.3 Design/Build Bench Scale Model

The task of designing and building the bench scale model includes three subtasks such as the medium of product, selection of additive mix, and economic analysis. The bench scale model will be used to present the final product to the client. The bench scale model has both, a testing component and a visual component. The design/ build bench scale model task cannot begin until the testing of the three possible optimum mineral composition is completed.

2.3.1 Medium of Product

The medium the product will be delivered is an important component to test. The medium of the product will either be in liquid or powder form. This criteria will be tested by analyzing solubility and TDS of the different mediums. The medium of the end product must meet the standards outlined by the FDA. The packaging of the medium will not be determined.

2.3.2 Selection of Additive Mix

The selection of additive mix subtask will be a crucial tool in the selection of the optimum mineral content. The five factors of the decision matrix will be: taste, odor, cost, solubility, and nutritional benefits. After three different mineral optimum contents are created and tested by the RAVA Fontus Engineering Inc. team, the use of the decision matrix will determine which one of the options will be chosen. Each component will be weighted relative to its importance in the final product. The criteria of the decision matrix may be subject to change. This subtask will exclude the decision of the delivery method of the mineral additive, such as packaging.

2.3.3 Economic Analysis

The subtask of calculating the production cost will involve an analysis of the different elements of the bench scale model. The costs of the bench scale model will include costs associated with the station area, display poster, and mineral additive. A cost analysis will be calculated in an Excel spreadsheet for data collection purposes. This subtask will not include any travel costs, the cost of the machinery used during testing, or the cost of the chemicals used during testing.

2.4 Documentation

The documentation task is a collective of all the documented parts of the project which include: the written report, the oral presentation, and the website

2.4.1 Written Report

The written report will have two main stages of completion, the 50% report will be finished by March 13, 2014, and the 100% report will be finished by May 1, 2014. The written report will consist of:

- Introduction and literature review
    - Research includes the RO process and its impacts; bottled water industries; nutritional requirements and health effects of children, adults, the elderly, and livestock; analysis of the water distribution system; regulations; and standard analytical methods.
- Problem statement
    - The description of the Drinking Water Stabilization project.
- Design process
    - This section will describe the different designs that have been taken into consideration as well as the final chosen design for the optimum mineral content. A decision matrix will be used to determine the final optimum mineral composition.
- Results
    - Discusses the results of the tests conducted that led to the bench scale model.
- Marketing plan
    - The marketing plan is aimed to entice the public to purchase the end product of this project. The plan will include considerations for cost, energy requirements, and environmental impacts. Furthermore, this subtask will include a strategy to implement the addition of the end product to existing RO bottle waters, and another tactic to add the mineral additive into the bottling process for future bottled waters. The cost to the consumer and to the producer will also be incorporated in the marketing plan. This marketing plan is in theoretical terms only and will not be used to sell the product. There will be no use of product trade names in the project.
- Impacts
    - This section describes how the project will specifically impact the social, political, cultural, and environmental realms.
- Conclusion
    - Summarizes the main highlights of the design.

2.4.2 Oral Presentation

This oral presentation will consist of presenting the end product and how it was obtained. The 50% design report oral presentation will be due March 11, 2014 and the final design oral presentation will be on April 25, 2014.

2.4.3 Website

The website subtask will provide a central location for all the information on the project. The website has two deliverables: the 50% completion/submission and the 100% completion/submission.

2.4.3.1 50% completion

The 50% completion of the website must include the following:

- Home page
  - Including RAVA Fontus Engineering Inc. information, client information, and a brief overview of the project
- Project information page
- Documents page
- Other pages as needed to clearly communicate the final design/end product

The 50% submission should be completed by December 6, 2013.

2.4.3.2 100% completion

The 100% completion will be the finished website and it will be submitted by April 14, 2014.

2.5 WERC Competition

The Las Cruces, NM WERC Competition will happen over a three day period starting on April 6, 2014 and ending on April 9, 2014. For the competition there are four mandatory requirements. These are the safety summary, the WERC competition report, the oral presentation, and the bench scale demonstration.

2.5.1 Safety Summary

The safety summary subtask is one of the major deliverables of this project. This document entails writing a report to identify what, when, where, and how chemicals are used during

the bench scale test. The safety summary includes written plans for accident response, the Material Safety Data Sheet (MSDS) for each chemical, and a flow diagram of the bench scale test. The deadline for of all these deliverables is March 19, 2014.

2.5.2 WERC Competition Report

The deadline for the WERC written submittal is March 21, 2014. Furthermore, the written report has a set of guidelines that must be followed for the WERC competition. These guidelines can be found in Appendix B. Once the report is submitted, the document will be property of WERC. Thereafter, RAVA Fontus Engineering Inc. and experts will have no affiliation with any use of the document.

2.5.3 Oral Presentation

The oral presentation is where the project information will be orally and visually presented to a panel of judges. The RAVA Fontus Engineering Inc. members will present a 15 minute oral presentation. The oral presentation excludes the bench scale demonstration, and it will occur on April 7, 2014.

2.5.4 Bench Scale Demonstration

The demonstration will cover the composition and methods that were incorporated in the project. The purpose of the demonstration is to convey the bench scale model verbally and physically. Details of the end product created by RAVA Fontus Engineering Inc. will be on a poster. All the crucial elements of the project will be on the poster in a concise display. The poster needs to be succinct, so the vast majority of the information outlined in the written report will be excluded. The bench scale demonstration will be done on April 8, 2014.

3.0 Schedule

The Gantt chart of the schedule can be seen in Figure 1. The critical path is highlighted by the yellow line and it begins with the background research. It is necessary to have the background research completed in order to begin the testing. After the testing is concluded, the design and build of the bench scale model can begin. It is critical to have the testing completed before the engineering design process for without it, the project cannot be completed. The data from testing provides the parameters for the bench scale model design. Also, it is critical to have the design

and build bench scale model task completed before the written report can be started. The results of the bench scale model and its impacts need to be included the written report. This critical path is important in order for the project to be successfully completed. The project will begin in October 1, 2013 and end in May 1, 2014.

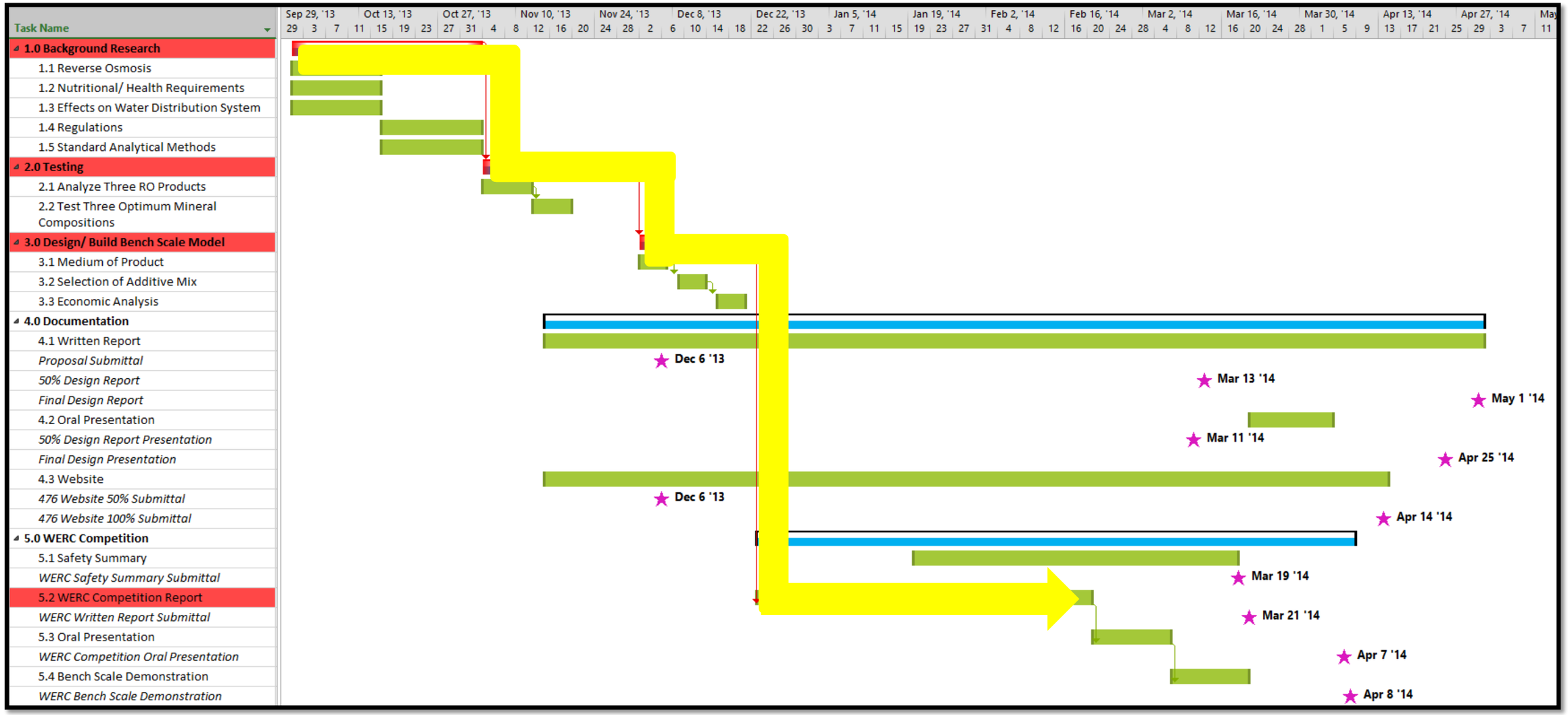

Figure 1: Project Schedule from October 1, 2013 to May 1, 2014.

4.0 Cost of Engineering Services

The cost of engineering services are needed for the client to understand the breakdown costs for this project. Table 3: Cost of Engineering Services is shown below.

Table 3: Cost of Engineering Services

1.0 Personnel	Person	Hours	Rate, $/hr	Cost, $
	SENG	170	172	29172
	ENG	600	70	41818
	LAB	20	45	905
	INT	380	20	7571
	Total Personnel			*$ 79,466*
2.0 Travel	*Local Meetings*	0		*$ 0*
3.0 Subcontractor	*Lab*	6	11	*$ 66*
4.0 TOTAL				**$ 79,532**

As shown in Table 3: Cost of Engineering Services the total estimated cost of the engineering services for this project will be $79,532. This total was found by adding the cost per person, cost of travel, and cost of the subcontracting. The personnel costs totaled at $79,466 and where the bulk of the costs for the project. Personnel costs were broken down by rate of pay per level of employee and the number of hours worked. The overhead costs were accounted in each person's billing rate. The overhead for each person is different depending on the level of that employee. The different levels are: the senior engineer, the engineer, the lab technician and the intern. The senior engineer will have the highest overhead followed by the engineer. Both the intern and lab technician have little to no overhead. There is no expense for local meetings that happen in the office because there is no long distance travel involved. Thus the price is shown as zero for local meetings in Table 3: Cost of Engineering Services. The subcontractor used was the Colorado Plateau Analytical Laboratory for cation and anion testing, which came to a total of $66.

5.0 References

[1]Clesceri, L., Greenberg, A., & Eaton, A. (1998). *Standard methods for the examination of water and wastewater*. (20th ed., pp. 2-1 to 4-180). Washington, DC: American Public Health Association.

[2]Environmental Design Contest. (2013, August 22). Retrieved from http://www.ieenmsu.com/werc-2/design-contest-2014/.

[3]Kozisek, F. (2004). Health risks from drinking demineralized water. *World Health Organization*, 1-22. Retrieved from http://www.aqualiv.com/images/WHO_RO_Warning.pdf

[4]Task 2: Drinking Water Stabilization. (2013, August 22). Retrieved from http://www.ieenmsu.com/werc-2/design-contest-2014/tasks/task-2-drinking-water-stabilization/.

[5]Water distribution system definition. In (2012). Retrieved from http://www.muellerwaterproducts.com/about/glossary.php

[6]WomansDay.com. 2013. Retrieved from http://www.womansday.com/food-recipes/8-bottled-water-brandsunscrewed-72193.

6.0 Appendices

6.1 Appendix A- WERC Task Description

Environmental Design Contest – 2014

Join us on Facebook – search for NMSU IEE or click here: Facebook

WERC's Environmental Design Contest is a unique event that brings together industry, government and academia in the search for improved environmental solutions. Held annually since 1991 at New Mexico State University in Las Cruces, New Mexico, the contest draws hundreds of college students from throughout the United States and around the world.

The student teams design solutions for real-world problems while developing fully operational bench-scale solutions that are presented to panels of judges comprised of environmental professionals. The teams prepare four different presentations: written, oral, poster and bench-scale model. You may enter as many teams as your university would like in any of the tasks.

Many universities use the contest as part of their capstone design courses. After the contest, WERC provides the judges' feedback to the participants. Feedback to the students has become an important part of ABET accreditation.

Our current plan is to hold the contest at the New Mexico Farm and Ranch Museum in Las Cruces (Directions). Please be aware that this may change based on the number of teams that register.

Background

Water treated through reverse osmosis (RO) is depleted of minerals. Minerals are essential for health as well as for stabilizing water to prevent corrosion of distribution systems. Post treatment involves adding back hardness to achieve a positive Langlier Saturation Index (LSI).

Bottled water is sometimes obtained from springs or wells but often it is tap water that may or may not have been treated with reverse osmosis. There are no regulations for the mineral content of bottled water. Nevertheless bottled water is often marketed as a healthy alternative to other beverages or tap water. Some companies add "Vitamins" to their bottled water with or without flavoring and artificial or natural sweeteners.

Problem Statement

The objective of this task is to find the best fortification for desalted water most commonly obtained from Reverse Osmosis processes.

Specifically your task is to:

- identify minerals that would improve taste and prevent the water from leaching minerals from the skeletal system and review nutritional requirements for people and livestock
- address the additionally beneficial use for protection of water distribution system from corrosion

Additionally your team must address the existing types of bottled water and bottled beverages in North America; their source of origin, added minerals content and specifics on the type of mineral and its beneficial use. This should include determining the composition of the most popular and local bottled water products – by analysis or by questioning the bottling company specific to the southwestern United States. Your research must also address how close the actual products are to the optimum mineral composition determined by your team and what impact it may have on taste and odor.

Design Considerations

The following outcomes are required:

- identification of detailed mineral content required for healthy skeletal life cycle existence including childhood development and geriatric impacts
- identification of mineral content in existing bottle waters obtained from Reverse Osmosis processes and springs
- identification of corrosion potential or improvement to water systems resulting from the addition or lack of minerals

Once your team identifies the available bottle waters or beverages from reverse osmosis systems based processes and determines the ideal mineral content, your team must provide specific details on:

- how to implement the addition of supplementary minerals to existing bottle waters on the grocery store shelves, the cost to the consumer and the producer, the "enticement" to the public to use the supplementary minerals with their bottled water
- how to implement adding the supplementary minerals into the bottling process for future bottled waters, and the cost of the added minerals to production
- beneficial and adverse impacts to the water treatment and delivery systems by the added/removed minerals

Your team should demonstrate your process, analyze several bottled waters for mineral content, present mineral addition or removal approach, identify steps required to protect the drinking water standard include water stabilization process if needed, discuss energy impacts, environmental constraints, taste and odor and other pertinent regulatory driven issues. Innovative approaches to the issue including demonstration of the process will be given extra credit.

Bench-Scale Demonstration

During the contest, your team will be provided with several (anticipated to be up to 5 different labels and 4 bottles of each of the labels) types of bottle water available in Las Cruces. These will be used for demonstrating your proposed process and details identified in the Design Consideration section above.

Written Report Requirements

The written report should demonstrate your team's insight into the full scope of the issue that you have chosen and include all aspects of the problem and your proposed solution. The report will be evaluated for quality of writing, organization, clarity, reason, and coherence. Standards for publications in technical journals apply. In addition to the listed requirements, your report must address in detail the items highlighted in the Problem Statement, Design Considerations, and Evaluation Criteria sections.

Evaluation Criteria

Each team is advised to read the Participation Guide for a comprehensive understanding of the contest evaluation criteria. Upon registration, WERC will provide you with a copy of the Public Involvement Plan and Participation Guide. Additionally, your proposed design will be evaluated on issues stated in the problem statement as well as the following:

- Degree of innovativeness
- Ease of implementation including cost
- Effectiveness of public enticement plan
- Manufacturing modification requirements including cost, energy requirement, environmental impacts and other relevant issues
- Overall degree to which design considerations are met including taste, odor and impact to a water system
- Final report clarity, logic, well supported conclusions
- Presentation skills
- Team involvement

6.2 Appendix B- Guidelines and Details for WERC Written Report

- Guidelines for Written Report
  - Task identification
  - Full-scale design description
  - Bench-scale/prototype lab results
  - Waste generation considerations
  - Technical evaluation
  - Length of 26 pages
  - Report cover identifying the school and task (not included in the page limit)
  - Title page (counted as the first page)
  - Table of contents
  - Executive summary (maximum of two pages) highlighting the proposed solution
  - The report body
  - Photographs, line drawings and graphs are permitted for illustrative purposes (included in the page limit)
  - References pages (included in the page limit)
  - Audits are not included in the page limit

- Details for Written Report
  - Manuscript Preparation
    - The paper length should not exceed 26 pages.
    - Use of laser or ink jet printers is recommended.
    - Font:
      Times, Times New Roman, or TMS Roman (If unavailable, a similar type with serifs is preferred over sans serif).
      Size: 12 point
      Major Headings: 12 point, Bold
      Title: 14 point, Bold
    - Margin settings:
    - Cover page (Title page)
      Title: 2″ top margin
      Centered (school name, team name, task number, advisor name and team member names)
      Body
      Top and bottom margins – 1″
      Right and left margins – 1″
    - Each page of the written report must have a footer that includes the task number and the name of the participating school.
    - Use 1.5 line spacing
    - Paper:
      White, 8 ½” X 11″
  - Headings
    - Title: Center, upper case, bold; 14 point type
    - Major Headings: Left justify, upper case, bold; 12 point type
    - Subheadings: 1 tab (5 spaces); bold, 12 point type

- Sub-subheadings: 2 tabs (10 spaces); underline, 12 point type

- References
  - List and number all bibliographical references at the end of the paper.
  - When referring to references in the text, type the corresponding reference number in superscript form.
  - Equation Numbers
  - Enclose equation numbers in parentheses
  - Page Numbers
  - Center bottom of the page
  - Symbols and Abbreviations
  - Use only standard symbols and abbreviations in text and illustrations.
- Illustrations, Drawings and Photographs
  - Line drawings and photographs should be reduced to proper size and placed as close to where they are referenced as possible.
  - All lines should be black on white paper and heavy enough to be legible.
  - All lettering should be large enough to be legible.
  - Original illustrations should not exceed 8.5″ X 11″.
  - Omit all unessential illustrations.