Proposal for:

Clean Energy Water Disinfection System

Prepared for:

Waste-Management, Education, and Research Consortium

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Summary

This proposal details JAMM, Inc.'s work plan for the design of a drinking water disinfection system and demonstrates their understanding of the project and the tasks necessary for its completion. This system will be designed for the Waste-Management, Education, and Research Consortium's (WERC) environmental competition, as per Dr. Wilbert Odem's request, and a working bench-scale system will be judged at the competition based on its ability to meet the given criteria. The intent of the disinfection system is to help alleviate the demand for safe drinking water in rural, third-world areas by meeting the World Health Organization's standards for bacterial contamination, which state that there should be no coliform present in any sampled drinking water. In addition, the system should be capable of disinfecting 3,000 gallons of water per day, be cost effective based on initial capital cost and operating cost per gallon of water disinfected, be easily implemented, operated, and maintained by ordinary citizens in third-world environments, and it should be mobile.

JAMM, Inc. has developed a detailed Scope of Services for the project, which identifies all of the tasks necessary to complete the design of the disinfection system for the WERC competition. The project has been separated into two phases, feasibility and implementation, to differentiate between the design and construction portions of the project. Included in Phase I are tasks for project management, project analysis, evaluation of alternatives, selection of final design, and documentation of design. In Phase II the tasks for procurement of materials, construction, testing and analysis, and documentation will take place. JAMM, Inc. has also provided a Staffing Plan and Schedule, which shows the role of each staff member throughout the project and a schedule for the completion of the project including all relevant milestones and deliverables.

Many potential challenges associated with the project have been identified. For example, JAMM, Inc. anticipates it will be difficult to integrate the pretreatment, disinfection, and power systems necessary to successfully complete the design. In addition, it will likely be challenging to design a system capable of disinfecting 3,000 gallons of water per day while retaining its mobility. The project is further complicated by the lack of a specific location at which the final design will be implemented. Instead, the disinfection system must be designed to be as universally applicable as possible. The last challenge is the short amount of time allotted to deliver the design, as the disinfection system must be constructed and ready to use by April 3, 2011. In order to allow six weeks for construction, testing, and analysis, the design will have to be completed by January 29, 2011. However, JAMM, Inc. feels that with their expertise as environmental engineers they will be more than capable of overcoming these challenges, and have already identified potential solutions for the system. Among these solutions are rapid sand filtration for pretreatment, ozone, electrochemical, and magnetic fields for disinfection, and wind, solar, and manpower for energy sources.

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I. Work Plan

i. Introduction

JAMM Inc. offers a detailed work plan to successfully design and build a Clean Energy Water Disinfection System for the Waste-Management, Education, and Research Consortium (WERC). The work plan is based on discussions with WERC representatives and experience with similar projects.

The cost proposal is included in a separate, sealed envelope.

ii. Project Understanding

One of the most serious problems developing countries face is the lack of safe drinking water. Often, the water available to people in rural and third world areas is contaminated with microorganisms that cause diseases such as cholera, schistosomiasis, diarrhea, typhoid fever, dysentery, and intestinal worms. Water-borne diseases such as these account for 3.575 million deaths each year and cause one child to die every 20 seconds.[1] Even in developed areas, such as the United States, where safe drinking water is generally available, people die from disease after natural disasters when drinking sources become contaminated.

In an effort to provide clean drinking water to more people in developing countries, the Waste-Management, Education, and Research Consortium (WERC) is holding a competition for college students to design a water disinfection system for use in rural third-world areas and in emergency situations. Dr. Wilbert Odem, an Environmental Engineering professor at Northern Arizona University (NAU) has elected for JAMM, Inc. to participate in this competition. The design by JAMM, Inc. will be judged at the competition based upon its ability to meet WERC's design criteria, which dictate the system must:

- Harness clean energy to disinfect water to World Health Organization (WHO) drinking water standards for bacterial contamination
- Be a mobile unit
- Be cost effective based on initial capital cost and operating cost per gallon of water disinfected
- Be applicable to rural, third-world settings
- Be able to be scaled to meet a flow of 3,000 gallons per day
- Be easy for ordinary citizens in third-world environments to implement, operate, and maintain.

Although existing technologies capable of these goals are available, WERC wishes for students to design a system that couples these available technologies in a new way to meet the objectives of this design challenge.

Because the largest concern for drinking water in developing countries is contamination by pathogenic microorganisms, the effectiveness of disinfection is the only parameter that will be tested by judges at the WERC competition. Water disinfection is the method used to remove, deactivate, or kill these microorganisms, and it is accomplished by physical or chemical disinfectants.[2] For the purposes of this project, it is necessary to satisfy the WHO drinking water standards for bacterial contamination. These guidelines recommend there be no coliform, an indicator organism, present in any sampled drinking water.[3] Indicator organisms are microbes whose presence indicates fecal contamination and potentially pathogens such as bacteria.[4] The disinfection system designed by JAMM, Inc. for this project aims to produce effluent water with no bacterial contamination.

There are many technologies available to use to achieve disinfection, though the choices for this project are limited due to WERC design constraints. Among the possible solutions that will be investigated are activated carbon, ozone, ultraviolet light, chlorine, electrolysis, reverse osmosis, and the use of magnetic fields. In addition, solar technologies such as distillation and solar cookers to boil the water and filtration methods such as ultrafiltration and slow sand filtration will be evaluated. It has also been noted by JAMM, Inc. that a pretreatment stage will likely be necessary in the system to remove solids from the water prior to disinfection. Pretreatment will help to reduce the required maintenance and lengthen the overall lifetime of the system. Some pretreatment options include rapid sand filtration, membrane filtration, and coagulation and settling.

One challenge JAMM, Inc. will face in the design of this disinfection system will be the integration of clean, renewable energy for any power requirements in the case that electricity is not available in the area of intended use. Forms of renewable energy include any sources of power which can be replenished by natural processes at a rate comparable or faster than its rate of consumption, and include such sources as sunlight, wind, rain, tides, and geothermal heat.[5] Applying renewable energy to the final design will be difficult mainly due to the fact that the system must be mobile. However, some possible solutions have been identified including the use of wind or solar energy, biomass, and manpower.

The project is further complicated by the lack of a specific location at which the final design will be implemented. Instead, the disinfection system must be designed to be as universally applicable as possible. It will also be difficult to design a system capable of disinfecting 3,000 gallons of water per day while retaining the system's mobility. The last challenge is the short amount of time allotted to deliver the design as the disinfection system must be constructed and ready to use by April 3, 2011. In order to allow 6 weeks for construction, testing, and analysis, the design will have to be completed by January 29, 2011. However, JAMM, Inc. feels capable of overcoming these challenges and has created a project plan as detailed in the following sections of this document.

iii. Scope of Services

The following scope of services provides the necessary work structure describing the proposed work and deliverables for a disinfection system meeting the WERC criteria for off grid rural implementation. The scope also provides quality control methods. JAMM, Inc's scope includes the following tasks:

Phase 1: Feasibility
- **Task 1: Project Management**
- **Task 2: Project Analysis**
- **Task 3: Evaluation of Alternatives**
- **Task 4: Selection of Final Design**
- **Task 5: Documentation of Design**

Phase 2: Implementation
- **Task 1: Procurement of Materials**
- **Task 2: Construction**
- **Task 3: Testing and Analysis**
- **Task 4: Documentation**

Phase 1: Feasibility

Task 1: Project Management

1.1 PDT Meetings

The project development team (PDT) will consist of student engineers from JAMM, Inc. and technical advisors as needed. The PDT meetings will serve to assess the status of the project and determine and resolve project issues. The PDT will provide notice of each meeting, prepare an agenda, provide necessary meeting materials, and provide documentation of the meeting through the recording of minutes.

Deliverables: Meeting notice, agenda, and minutes

1.2 Coordination Meetings

The PDT will coordinate meetings with Dr. Wilbert Odem, the Northern Arizona University (NAU) faculty representative for the Waste-Management, Education, and Research Consortium (WERC) competition, as needed. These meetings will consist of discussions regarding specific project needs and issues, and will serve as a weekly progress check on the design project.

Deliverables: Meeting minutes and presentation materials

1.3 Quality Control

The PDT will prepare a quality control plan and provide the technical resources necessary to ensure the deliverables meet the requirements of the WERC competition. Reviews will be conducted by JAMM Inc.'s technical advisors, Dr. Terry Baxter and Dr. Marti Blad, and by members of the PDT. This task includes providing quality control reviews for the following deliverables:

- Design Blueprints on AutoCAD 2D
- Cost Estimates
- Proof of Concept
- Decision Matrices
- Final Written Report
- Safety-Summary and Flow Sheet Diagramming the Unit Operation Plans

Deliverables: Quality control plan and quality control review documents

Task 2: Project Analysis

2.1 Research Pretreatment and Disinfection Systems

The PDT will research and analyze current technologies used to pretreat and disinfect water on a community scale of 3,000 gallons per day including various forms of filtration, chemicals, and UV disinfection. The advantages, limitations, processes, necessary equipment, power requirements, and any chemicals used will be identified for each alternative. As offered by the WERC competition for consideration, the PDT may also use existing commercial technologies for disinfection to meet the objectives of the design challenge. An informal evaluation process will take place during this task to eliminate disinfection systems clearly not suitable for the project. Preliminary research of disinfection systems will be considered during the selection of design as discussed in Tasks 3 and 4.

Deliverable: Disinfection system research summary

2.2 Research Types of Alternative Energy

Research will be conducted to familiarize the PDT with various sources of alternative energy available to power the disinfection system, as the WERC competition requires the use of non-fossil fuel energy sources. The research will need to be conducted on a wide variety of power options ranging from wind and solar power to manpower. An informal evaluation process will take place during this task to eliminate power systems clearly not suited to the project. Preliminary research of viable types of alternative energy will be considered during the selection of design as discussed in Tasks 3 and 4.

Deliverable: Energy research summary

Task 3: Evaluation of Alternatives

3.1 Comparison of Alternatives

The PDT will compare the pretreatment and disinfection methods researched during the project analysis task in order to determine which of the methods will work best to clean and disinfect drinking water. In addition, the PDT will determine which methods are most viable using the criteria given by WERC. The design considerations by WERC for the proposed method of disinfection dictate the system must:

- Harness clean energy to disinfect water to WHO drinking water standards for bacterial contamination
- Be a mobile unit
- Be cost effective based on initial cost and cost per gallon
- Be applicable to rural third-world settings
- Be able to be scaled to meet a flow of 3,000 gallons per day
- Be easy for ordinary citizens in third-world environments to implement, operate, and maintain

During this stage of the design process, the PDT aims to select two to four design options for further consideration which best meet the criteria.

Deliverable: Laboratory results for each alternative

3.2 Cost Estimates

The system is required to be cost effective. An evaluation of this criterion will be based on the initial cost of the system as well as the cost per gallon of disinfected water. The PDT will evaluate the overall value of each of the design alternatives by its cost in relation to its effectiveness. Therefore, the cost of procurement of materials, operation, and maintenance will be taken into account when evaluating design alternatives.

Deliverable: Estimated cost comparison of alternatives

3.3 Pretreatment and Disinfection Decision Matrices

Each of the design considerations presented in section 3.1 will be assigned a weight based on their order of importance, which will be determined through input provided by the WERC representative, Dr. Odem. Based on Dr. Odem's input, two decision matrices will be created to determine the best forms of pretreatment and disinfection.

Deliverable: Decision matrices comparing different forms of pretreatment and disinfection

3.4 Power System Decision Matrix

In order to ensure that the system is applicable to rural third world settings, as stated in section 3.1, the power supply must be implemented through a non-fossil based power source. A decision matrix will determine which power system will be the most viable in terms of WERC competition criteria. Specific criteria used in the decision matrix will dictate that the power system must:

- Be a renewable and non-fossil fuel based power system such as solar, wind, or manpower
- Be easily integrated to work with the chosen disinfection system
- Be reliable
- Be a mobile unit
- Be cost effective based on initial cost and cost of operation
- Be applicable to rural third-world settings
- Be easy for ordinary citizens of third-world environments to implement, operate, and maintain

Each of these design considerations will be assigned a weight based on their order of importance and used in a decision matrix to compare the power supply options.

Deliverable: Decision matrix comparing power systems

Task 4: Selection of Final Design

The PDT will consider the WERC competition criteria specifically stated in section 3.1 and the decision matrices developed in sections 3.3 and 3.4 to determine the best methods of pretreatment, disinfection, and power supply. During this task, the PDT will integrate design considerations for all systems and ensure compatibility between them. Compatibility of criteria will ensure the chosen power system sufficiently meets the needs of the chosen pretreatment and disinfection systems.

Deliverable: Determination of final design for power supply and disinfection system

Task 5: Documentation of Design

The PDT will produce blueprints for the construction phase of the final design will be created in AutoCAD 2D. The AutoCAD blueprints will document the details of the chosen final design. In addition, the final documentation for the project will be at 66% completion.

Deliverable: Printed copy of AutoCAD final design, and 66% completion of final documentation

Phase 2: Implementation

Task 1: Procurement of Materials

The first step to begin construction of the chosen system is to procure all of the materials to be used. This will primarily involve comparing the prices from different retailers to find the most cost effective resource. Once this is complete, the material will be purchased from the selected retailer.

Deliverable: Retailers, final cost of system, and procurement of materials

Task 2: Construction

During this stage, a bench scale disinfection system and power system will be constructed based on the selected design from Phase 1. As stated in the Project Understanding, the disinfection system designed to treat 3,000 gallons of water per day will not actually be constructed. Instead, a bench-scale system will be constructed for the purpose of the demonstration required for the WERC competition. The final disinfection system will be scaled and constructed based on a five gallon water limit.

Deliverable: Constructed disinfection system and power system

Task 3: Testing and Analysis

Once the disinfection system has been built, it will be tested to ensure it is working properly. If the system fails to meet the requirements, it will be re-evaluated under the criteria set forth in section 3.1 and changes will be made as needed. Once it is operating as anticipated, a final analysis of its performance will be conducted by running a sample of infected water through the system and testing the effluent to ensure it is free of bacteria.

Deliverable: Final analysis of disinfection system's performance

Task 4: Documentation

Once the design has been finalized, a final electronic representation of the disinfection and power systems will be developed using AutoCAD 2D including size specifications for both the bench-scale demonstration and the real-world applicable disinfection system.

A final written report will be created which will include the design description for the full-scale disinfection design along with the bench-scale system lab results, waste generation considerations, and a technical evaluation as per the WERC competition guidelines. Also, recommendations for suitable locations for the disinfection system to be used will be given. However, additional analyses of water chemistry in the area of intended use are often required before implementation is possible, but JAMM, Inc. will not be responsible for the completion of these tests.

As required by WERC for the competition, the PDT will also create a safety summary and flow sheet including information related to the bench-scale operation, process safety, chemicals used, and waste stream emissions.

Deliverables: Final drawing of system (As-Built), drawing of system for real-life application, proof of concept, final written report, safety summary, flow sheet, and poster

II. Staffing Plan & Schedule

This section discusses the project schedule and the role of each staff member throughout the project. The project began on November 15, 2010 and will end on April 28, 2011 for a total of 119 working days as illustrated in the Gantt Chart seen in Figure 1. The project will be performed in two phases. Phase 1 will consist of the feasibility study and design of the project and phase 2 will include the implementation of the project.

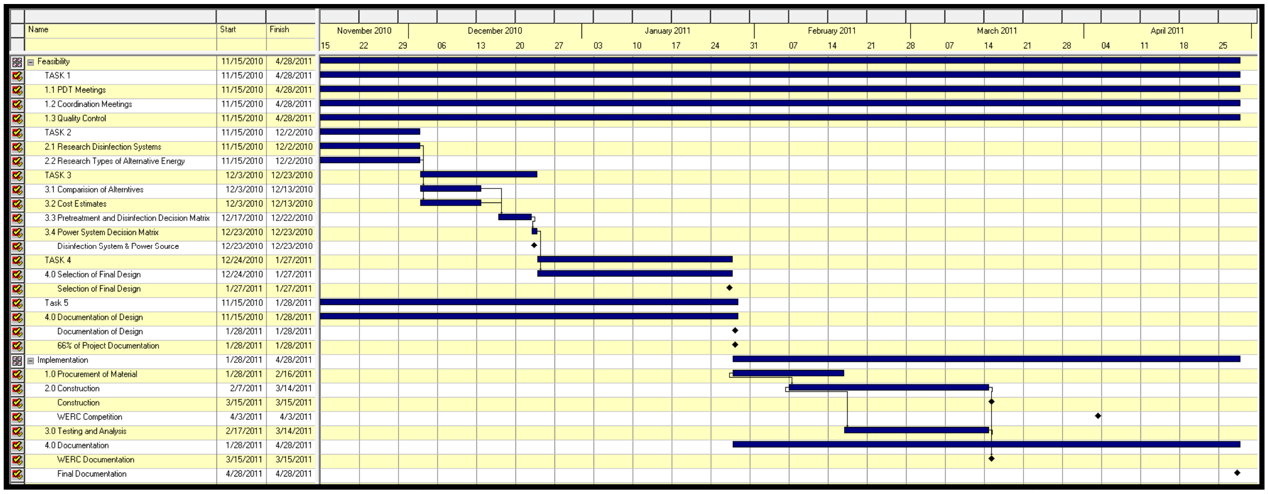

Figure 1 Project Gantt Chart

Phase 1 of the project has 11 tasks and subtasks with 4 deliverable milestones. Phase 1 of the project is estimated to cover the whole duration of 119 days, since the PDT meetings, coordination meetings, and quality control subtasks run from the start of phase 1 to the end of phase 2. Phase 2, which consists of 4 tasks with 4 deliverable milestones, will begin on January 28, 2011. A summary of the key project milestones can be seen in Table 1.

Table 1 Key Project Milestones

Milestone		Date
PHASE 1	Disinfection system and power source	12/23/2010
	Selection of Final Design	1/27/2011
	Documentation of Design	1/28/2011
	66% of Project Documentation	1/28/2011
PHASE 2	WERC Documentation	3/15/2011
	Construction Complete	3/15/2011
	WERC Competition	4/3/2011
	Final Documentation	4/28/2011

This project will have 4 staff members: Ashley Ullstrom, Jo-Anne Barcellano, Marilla Lamb, and Meshal Hussain. Project tasks will be divided between staff members as seen in Table 2. Project task hours are distributed evenly between members, where each member is expected to perform all task related activities.

Table 2 – Time Commitments Table

	Task	Ashley Ullstrom	Jo-Anne Barcellano	Marilla Lamb	Meshal Hussain	Total
PHASE 1	1.1 PDT Meetings	16	16	16	16	**64**
	1.2 Coordination Meetings	10	10	10	10	**40**
	1.3 Quality Control	7	7	7	7	**28**
	2.1 Research Disinfection Systems	16	-	16	16	**48**
	2.2 Research Types of Alternative Energy	-	16	-	-	**16**
	3.1 Comparison of Alternatives	8	8	4	4	**24**
	3.2 Cost Estimates	-	-	4	4	**8**
	3.3 Pretreatment Disinfection Decision Matrix	8	4	8	4	**24**
	3.4 Power System Decision Matrix	-	4	-	4	**8**
	4.0 Selection of Final Design	10	16	16	16	**58**
	5.0 Documentation of Design	6	6	6	20	**38**
PHASE 2	1.0 Procurement of Materials	10	-	6	-	**16**
	2.0 Construction	16	16	14	16	**62**
	3.0 Testing and Analysis	14	14	14	4	**46**
	4.0 Documentation	12	16	12	12	**52**
	TOTAL HOURS	**133**	**133**	**133**	**133**	**532**

JAMM, Inc. will monitor and update the schedule throughout the duration of the project and prioritize their work effort to ensure all milestones are met on time.

III. Conclusion

The staff members at JAMM, Inc. feel confident in their ability to design and build a successful Clean Energy Water Disinfection System for the Waste-Management, Education, and Research Consortium. The Project Development Team understands the time and commitment required to complete this project and is willing to put forth the effort in order to develop a successful high quality water disinfection system. The team understands the importance of considering all possible disinfection techniques and power sources before beginning the design process to ensure the best possible options are chosen. JAMM, Inc has already begun researching available disinfection techniques and power sources and will consider the use of rapid sand filtration for a pretreatment option, ozone, electrochemical disinfection, and magnetic fields for the disinfection of the drinking water, and wind, solar, and man-powered energy as a power supply. The project development team is highly motivated and eager to design a drinking water disinfection system that is able to serve those in rural, third-world settings as well as in emergency situations. The high level of interest and motivation found in JAMM, Inc. staff members will ensure the successful completion of the clean water disinfection system.

IV. References

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4. "Indicator Organisms." http://techalive.mtu.edu/meec/module02/IndicatorOrganisms.htm (accessed December 3, 2010).
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