Document 524
PRELIMINARY DESIGN REPORT

CHAPTER: Oregon State University
COUNTRY: Kenya
COMMUNITY: Lela
PROJECT: Lela Community Water Project

PREPARED BY

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Preliminary Design Report Part 1 – Administrative Information

1.0 Contact Information

Project Title	Name	Email	Phone	Chapter or Organization
Project Leads	Zachary Dunn	kenya@ewb-osu.org		EWB-OSU
President	Sean Gertz	president@ewb-osu.org		EWB-OSU
Mentor	Jeff Randall			CH2M Hill (retired)
Faculty Advisor	Lewis Semprini			EWB-OSU

2.0 Travel History

Dates of Travel	Assessment or Implementation	Description of Trip
December 14-29, 2009	Assessment	Initial Community and Health Assessment
June 8-26, 2011	Assessment	Technical Assessment for Water Source Development
July 9-August 3, 2012	Implementation	Implementation of drilled well and rainwater catchment

3.0 Monitoring

Project Type	Project Discipline	Date of Completion
Water supply	Source development	7/9/12

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4.0 Budget

4.1 Project Budget

Project ID: **5091**
Type of Trip: Implementation

Trip Expense Category	Estimated Expenses
Direct Costs	
Travel	
Airfare	$6,500
Taxis/Drivers	$700
Travel Sub-Total	$7,200
Travel Logistics	
Exit Fees/ Visas	$100
Inoculations	$300
Insurance	$215
Licenses & Fees	$0
Medical Exams	$0
Passport Issuance	$0
Misc.	$500
Travel Logistics Sub-Total	$1,115
Food & Lodging	
Lodging	$250
Food & Beverage (Non-alcoholic)	$625
Food & Lodging Sub-Total	$875
Labor	
In-Country logistical support	$340
Local Skilled labor	$0
Labor Sub-Total	$340
EWB-USA	
Program QA/QC	$3,675
EWB-USA Sub-Total	$3,675
Project Materials & Equipment (Major Category Summary*)*	
Well drilling and construction	$15,000
Water quality testing	$300
Project Materials & Equipment Sub-Total	$15,300

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TOTAL	$28,505

EWB-USA National office use:

Indirect Costs	
EWB-USA	
Program Infrastructure	$1,225
Sub-Total	$1,225
TRIP GRAND TOTAL (Does not include Non-Budget Items)	$29,730

Non-Budget Items:

Additional Contributions to Project Costs	
Community	
Labor	$100
Materials	$0
Logistics	$150
Cash	$0
Other	$0
Community Sub-Total	$250
EWB-USA Professional Service In-Kind	
Professional Service Hours	200
Hours converted to $ *(1 hour = $100)*	$20,000
Professional Service In-Kind Sub-Total	$20,000
TRIP GRAND TOTAL (Includes Non-Budget Items)	$49,980

Chapter Revenue

Funds Raised for Project by Source	**Actual Raised to Date**
Source and Amount	
Rotary	$7,000
Grants - EWB-USA program	$4,000
Individuals	$5,700

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Special Events	$2,700
EWB-USA Program QA/QC Subsidy	$3,900
Total	$23,300

Remaining Funds Needed	**$6,430**

4.2 Donors and Funding

Donor Name	Type (company, foundation, private, in-kind)	Account Kept at EWB-USA?	Amount
Lake Oswego Rotary	Private	No	$7,000
EWB-USA Grant Program	Company	Yes	$4,000
Individuals	Private	Yes	$5,700
Events	Private	No	$2,700
Total Amount Raised:			**$19,400**

5.0 Project Disciplines

Water Supply
__X__ Source Development
____ Water Storage
____ Water Distribution
____ Water Treatment
__X__ Water Pump

Sanitation
____ Latrine
____ Gray Water System
____ Black Water System

Structures
____ Bridge
____ Building

Civil Works
____ Roads
____ Drainage
____ Dams

Energy
____ Fuel
____ Electricity

Agriculture
____ Irrigation Pump
____ Irrigation Line
____ Water Storage
____ Soil Improvement
____ Fish Farm
____ Crop Processing Equipment

Information Systems
____ Computer Service

6.0 Project Location

Latitude: 34.398536
Longitude: -1.123123

7.0 Project Impact

Number of persons directly affected: 1,000
Number of persons indirectly affected: 1,000

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8.0 Professional Mentor Resume

Jeffery H. Randall
Principal Groundwater Hydrologist (retired October 2012)

Education
Ph.D., Hydrology, University of Arizona, 1983
M.S., Hydrology, University of Arizona, 1974
B.S., Geology, Indiana University, 1971

Professional Registrations
Registered/Certified/Licensed Geologist: Indiana (1980, #IN160), Oregon (1982, G855), Idaho (1984, #PGL-559), and Washington (2001, #101)
Licensed Hydrogeologist: Washington (2001, #101)

Distinguishing Qualifications

- Over 40 years of teaching, research, and consulting experience in groundwater hydrology
- Diverse breadth and depth of project work in the U.S. and overseas including hazardous waste, solid waste, water resources, and water supply
- Considerable regulatory expertise involving CERCLA, RCRA, and Washington State MTCA, MFS, and water rights
- Appointed member of the Washington Department of Ecology Well Drilling Technical Advisory Group charged with revising and maintaining regulations governing water and monitoring well construction and driller licensing (1995-2000)
- Appointed member of the Washington Geologist Technical Advisory Committee charged with developing regulations governing the licensing of geologists and geologist specialties (2000-2001)
- Twice appointed member of the Washington Geologist Licensing Board (total board term 2001-2009) and elected Chair (2001-2002 and 2007-2009)
- Executive Committee member of the Association of State Boards of Geology charged with developing and reviewing the national geologist licensing examination (2008 to 2011)

Relevant Experience
Since joining CH2M HILL in 1978, Dr. Randall has been responsible for numerous projects for federal, municipal, agricultural, industrial, and mining clients. Projects have included: hazardous and solid waste site characterizations, remedial action feasibility studies, and remedial designs; geochemical and flow modeling studies; groundwater monitoring system designs; groundwater resource evaluations; production and dewatering well and well field designs; wellhead protection studies; artificial recharge studies and designs; and environmental impact assessments.

Groundwater Resource Evaluation and Development
Dr. Randall has extensive experience in groundwater resource evaluation and development, including well and well screen design, specifications, testing and analysis, and rehabilitation. He has developed water supplies for municipal and industrial clients in glacial outwash, alluvial, and

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basalt aquifers using natural pack, gravel pack, and open rock hole well designs. Yields have ranged from 100 to 10,000 gallons per minute, diameters from 8 to 30 inches, and depths from 75 to 1,500 feet. Municipal experience includes well field developments for Rockwood and Parkrose Water Districts, the Springfield Utility Board, and the cities of Umatilla, Corvallis, and Lincoln City in Oregon; the cities of Quincy, Wenatchee, and Seattle, Washington; and Wasilla, Alaska. International municipal experience includes exploration, design and construction of a well field in Sri Lanka for USAID. Dr. Randall's industrial and hatchery experience includes well field developments for US Gypsum and Anadromous, Inc., in Oregon; Chelan County PUD, Crown Zellerbach, Greater Wenatchee Irrigation District, Tulalip Tribes, Grant County PUD, and BPA in Washington; and ADF&G Elmendorf and Ruth Burnett hatcheries in Alaska. He is also one of the leading experts in the field of artificial recharge in the northwest United States. He was the project manager for design and construction of a 10-mgd aquifer storage and recovery (ASR) system for the Seattle Water Department and senior consultant on ASR feasibility studies for the cities of Tacoma and Walla Walla.

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Preliminary Design Report Part 2 – Technical Information

1.0 EXECUTIVE SUMMARY

This report pertains to the Lela Community Water Project (EWB-USA Project #5091) conducted by the EWB-USA Oregon State University student chapter. The project's primary purpose is to secure a safe and dependable domestic water source for the residents of Lela.

The goal of the Lela Community Water Project (LCWP) is to meet World Health Organization (WHO) standards for water quality, quantity, and access for all 2,000 residents of Lela. The WHO recommends 40 liters per capita per day (lpcd) for the purposes of drinking, cooking, basic personal washing, and clothes washing, with ten liters per category. In the context of a school, the WHO recommends two liters per student per day. By comparison, the Migori Ministry of Water (MMW) design criteria call for 20 lpcd for members of rural households and 5 lpcd for students. EWB-OSU has chosen to defer to the WHO standards, on the basis that those guidelines are widely accepted and the water usage is not directly indicated in the local standards. Also, aiming for the greater of the two benchmarks in the general sense will ensure both are satisfied upon successful project completion. The WHO standards are the ultimate goal for the community, while the MMW criteria standards can be considered as a benchmark of progress. Note that quantity of water is not the only pertinent aspect of this project; adequate access should also incorporate time spent collecting water and water quality. Because of this, the WHO also provides recommendations to address these factors. Following is the stated goal of this project, based on WHO recommendations:

- Provide two lpcd for students at the Lela Primary School for the purposes of drinking & hygiene,
- Provide 40 lpcd for the purposes of drinking, cooking, hygiene, and laundry
    - During all seasons/months
    - Meeting or exceeding WHO recommendations
        - Access less than 500 meters away for all households
        - At least one water point for every 250 people
        - Flow rate of at least 7.5 lpm at each access point
        - Safe water quality for the intended purpose

For the 2,000 people in Lela, the total water required to meet the minimum value of 40 lpcd is 80,000 lpd. This includes the two lpcd that students require during school hours, but does not account for population growth. According to the CIA World Factbook, The current population growth in Kenya is 2.4%. Assuming that the average population growth in Kenya is representative of Lela, the projected population of Lela in 2020 is approximately 2,500 people, increasing the estimated daily water demand to 100,000 lpd, which EWB-OSU concludes is an appropriate goal.

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Located in southwest Kenya, Lela is an agrarian community of approximately 2,000 people. EWB-OSU is currently working with Operation H2O, an NGO that focuses on well drilling and community capacity building in Kenya, to help meet Lela's need for clean water. During the July 2012 trip, the Lela Women's Water Committee (LWWC) signed a Memorandum of Understanding (MOU) with EWB-OSU and Operation H2O, affirming their commitment to managing Lela's new water sources. However, a $200 community contribution towards the first implementation agreed to in the MOU has not yet been met. EWB-OSU has made clear it is expected that this contribution will be made as a precursor to continued water source development in Lela. Whether or not an additional $200 contribution will be required is a topic of ongoing discussion.

The Lela Community Water Project started in 2009, and is currently the only project within the program. This trip will be the fourth made to Lela by EWB-OSU, and the second implementation trip. The first two trips (in 2009 and 2011) were assessment trips, while the third (2012) was an implementation trip. A detailed description of previous trips can be found in section 3.0 (program background).

The implementation described in this report pertains to a single drilled well fitted with a hand pump, similar to the previous well implemented in July 2012. A technical design of this facility can be found in section 4.0 (facility design). The design is driven by locally available drilling equipment and materials (such as the Afridev hand pump). No calculations are required. Figure 4.3.1 depicts the proposed well design for Lela's second well.

EWB-OSU will be providing technical expertise while overseeing the construction of a well. Members of EWB-OSU and the LWWC will act as project leaders during the construction process. The drilling company is expected to provide construction expertise, local hydrogeologic knowledge, and the materials necessary for the implementation phase. The trip will be approximately three weeks in length. If the previous implementation trip is any indication, drilling will proceed quickly (1-2 days), followed by a relatively slow process of developing the well and completing installation of the casing, well pad, and hand pump. The time required to reach the water table will dictate how quickly construction can be completed.

The sustainability of the project is driven by the economic, social, and environmental circumstances of the Lela community. EWB-OSU has worked with the LWWC especially to convey the importance of their commitment to the long-term viability of the project. The most important consideration is maintenance of the hand pump. The LWWC has been collecting fees from users of the well drilled in Lela in 2012. These fees have reportedly been deposited in the committee's account in Migori to be used in the event that maintenance of the hand pump is required. A similar plan will be put in place for Lela's second well.

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2.0 INTRODUCTION

The purpose of this document is to present the preliminary design for the second implementation trip of the Lela Community Water Project. Lela is home to an estimated 2,000 people and their top priority is securing a clean and local source of water that is available year-round for domestic use. Based on recommendations from WHO, the ultimate goal of this project is a water provision of 40 lpcd. Accounting for population growth, this equates to 100,000 lpd for the entire community. This is a significant endeavor that will require a phased approach over time with the utilization of multiple water sources to ensure success. The Kenyan Government standard for water supply per person is 20 lpcd, translating to 50,000 lpd for the entire community. This value provides a baseline for the eventual meeting of WHO water provision requirements. While water quality is critical to the ultimate success of the project, the first priority of the community is quantity; therefore this implementation will focus on water source development. The implementation trip in the summer of 2012 did meet the minimum flow rate goal for a single water point, but does not provide for the total water needs of the community. Thus, the goal for this trip is to add to existing water sources within the community. Additionally, EWB-OSU will monitor the quality and the performance of previously implemented projects in Lela, including the first drilled well and the expanded rainwater catchment system at the Lela Primary School.

3.0 PROGRAM BACKGROUND

EWB-OSU took on the Lela Community Water Project in 2009. Two assessment trips were completed (2009, 2011) which focused on assessing community needs, surveying public health, completing a technical water source assessment, and mapping the community using GPS. An alternatives analysis was carried out in 2011 and considered several options for implementation including a drilled well in combination with a diesel or solar powered electric pump, rainwater collection, or surface water treatment and distribution. The high cost of diesel was considered prohibitive for Lela, while the potential for theft of solar panels ruled out a solar-electric system. Water quality testing has shown that surface water sources are highly contaminated with bacteria and would require substantial operating costs for treatment.

Ultimately, EWB-OSU determined the best option for implementation was to drill a community water-well fitted with a hand pump and build a rainwater catchment system at the Lela Primary School. These systems were successfully implemented in July of 2012. Following these implementations, EWB-OSU determined the additional implementation of a well would further increase the supply of potable water in Lela.

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4.0 FACILITY DESIGN

4.1 Description of the Facilities

EWB-OSU will implement a well in Lela in cooperation with Operation H2O, a third party NGO which has drilled over 100 wells in Kenya and has agreed to complete all steps of well construction. Operation H2O acted as general contractor for the first well drilled in Lela in July 2012, which was completed successfully. The well will be equipped with an Afridev hand pump, parts for which are locally available for any required maintenance and repair. The final well design is flexible due to uncertainty in geologic conditions encountered during the drilling process. Due to the complex hydrogeology in southwest Kenya, the prospect of successfully tapping sufficient water is uncertain.

4.2 Description of Design and Design Calculations

The components of a well system include a drilled borehole, casing, gravel pack, screen, sanitary seal, concrete apron, and pump. The minimum depth of the borehole is determined by the depth at which sufficient water is present and the maximum depth is limited by the capabilities of the drilling equipment (in this case approximately 100 meters). The final depth of the borehole will not be known until drilling commences but based on experience is less than 100 meters. Below are the design specifications for the remaining components of the well.

Table 4.2.1 – Well specifications

Design component	Specification
Drilling equipment	Air rotary
Borehole diameter	7 inches
Casing	5 inch PVC
Screen	1 mm (40 slot)
Sanitary seal	20 ft cement
Gravel pack	2-4 mm rounded (non-crushed)
Hand pump	Afridev

The concrete well pad is an important component of the overall system. Figure 4.2.1 shows an example concrete pad that is well constructed and conveys water away from the pump area. The LWWC will be responsible for developing and maintaining a wellhead protection plan with technical assistance provided by EWB-OSU. EWB-OSU will oversee construction of the well pad according to the following design criteria:

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- The pad should be made as wide as possible out of properly reinforced concrete
- The well casing should be placed in the center of the slab to collect spill water
- All surfaces should be sloped towards the drainage channel, away (and downslope) from the pump to limit cross contamination
- Proper reinforcement (steel wire) should be used to prevent cracking, which can lead to well contamination
- The drainage channel should be sufficiently long to convey excess water away from the well head to limit cross contamination
- The construction of the slab should not take place until the soil surrounding the well head, which was disturbed during construction, has consolidated.

Figure 4.2.1 – Photo of the well pad constructed in Lela in July 2012

Prior to installing the Afridev hand pump, a pumping test will be conducted with a generator powered submersible pump to determine well yield, sustainable flow rate, and water quality (see section 6.0). The pumping test will also help facilitate well development by helping remove fines generated during drilling and improve flow into the well screen. The actual yield from the well is dependent upon groundwater aquifer properties. Research has indicated that Lela lies within an area with a relatively high groundwater potential (Mwango et al, 2004), although the actual yield will not be known until the well has been drilled. Based on the results of the first drilled well,

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potential well yield could be as high as 50 lpm however, based on EWB-OSU's experience with the first well where the total lift is moderate, the practical yield with the Afridev hand pump was in the range of 20 lpm.

4.3 Drawings

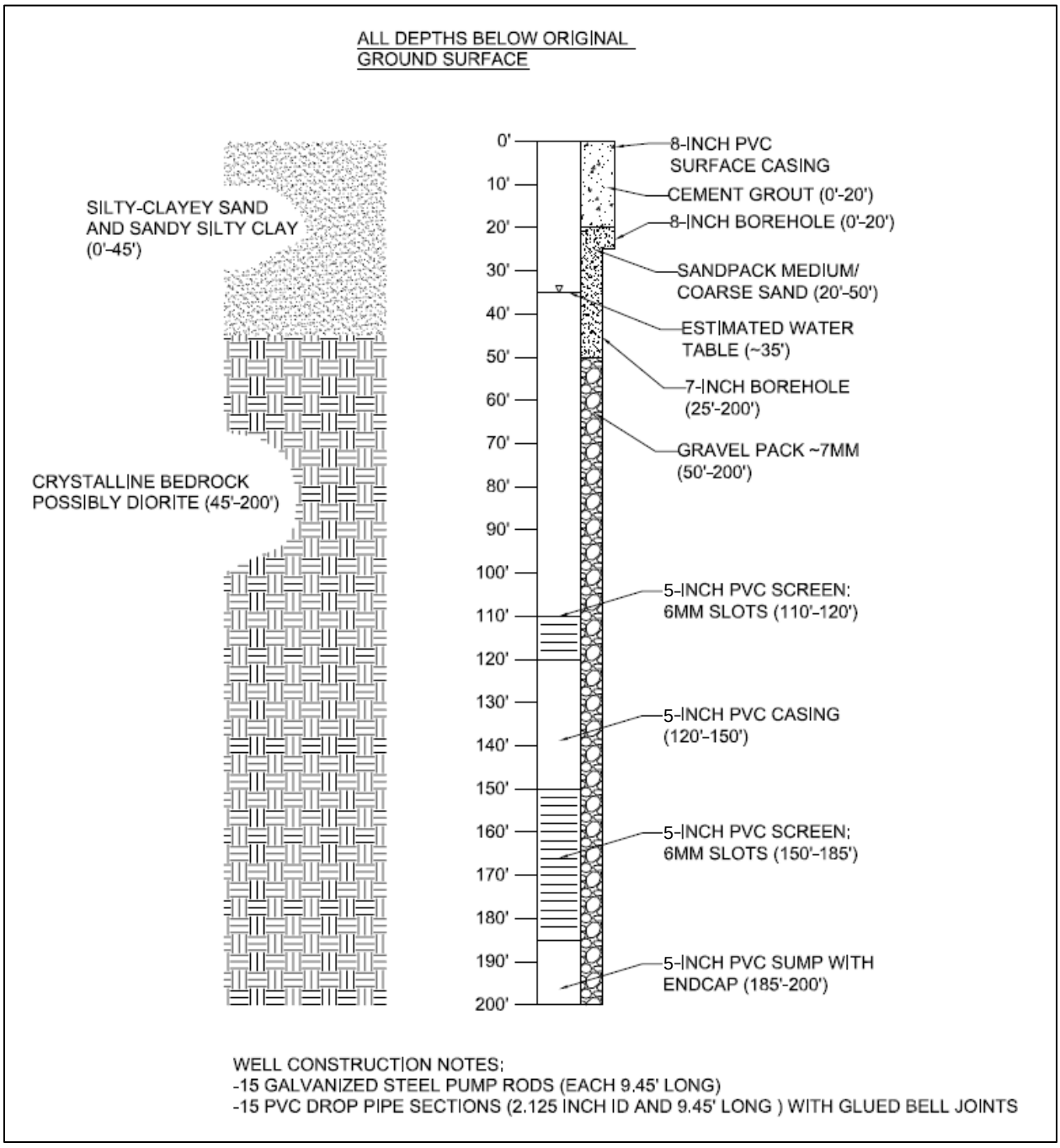

Figure 4.3.1 – Proposed well design (based on as-built drawing of first well)

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4.4 Names and Qualifications of Designers

Name	Student or Professional	Qualifications	Work Done
Zachary Dunn	Student	Groundwater hydraulics course, prior drilling experience	Well design
Jeff Randall	Professional	40+ years of experience in groundwater hydrology	Design review
Craig Harter	Student	CAD background	CAD

5.0 PROJECT OWNERSHIP

5.1 Well Ownership

The well constructed in July 2012 is publicly owned and is on public property. The LWWC manages ownership aspects of the well including fee collection, financial planning, skills training, and commissioning all necessary maintenance and repairs. The proposed second well will also be publically owned and managed by the LWWC. Community contributions for the well (such as building a fence around the well pad) will be confirmed through the MOU discussed in section 10.0.

5.2 Overall Community Ownership

The Lela community will be required to contribute significantly to the implementation phase of the project in order to foster a sense of ownership by the community thereby ensuring long-term sustainability. Participation in the implementation not only promotes the community's vested interest in the project, but is also an opportunity for community members to understand functional aspects of the facilities. Knowledge of how the well and pump operate is fundamental to maintenance and sustainable operation of the facilities.

Prior to the first implementation trip in 2012, community members of Lela stated their intention to do everything within their means to contribute to the project. Over the years this has included hosting all travel teams, preparing three meals a day for all travelers, translating, accompanying all travel teams during travel periods to and from Lela, participating in construction activities, and providing security and management of infrastructure. Through such contributions the Lela community has demonstrated their commitment. EWB-OSU is confident in the Lela community's ability to maintain their commitment into the future, which will be expected during the proposed implementation trip in June 2013.

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6.0 CONSTRUCTABILITY

EWB-OSU will be providing technical expertise while overseeing the construction of the proposed well. Members of EWB-OSU and the LWWC will act as project leaders during the construction process. Operation H2O will be contracted for the drilling and construction of the well to ensure the development meets the requirements of EWB-USA, the Kenyan government, and the needs of the community. The Kenyan Water Resources Management Authority (WRMA) requires that a hydrogeological survey be conducted before drilling a well. This survey is scheduled to be completed by Operation H2O on February 18. A permit to drill will be submitted to WRMA following completion of the survey.

Operation H2O is expected to provide construction expertise, local hydrogeologic knowledge, and the materials necessary for the implementation phase including the hand pump, well casing, screen, gravel pack, wellhead, and concrete well pad. The driller is also responsible for the provision of water used for drilling. Drilling will begin in June (the exact schedule is still to be determined). Once the regional groundwater table has been penetrated and drawdown tests can be used to indicate how productive the well will be. During the July 2012 implementation trip, water was first encountered at a depth of 82 feet (25 m) and the approximate static water level was at a depth of 35 feet (10.6 m). The amount of time it takes to drill to this depth is dependent on the types of rock formations encountered.

During drilling, a field decision will be made to stop drilling when there is the consensus that when completed, the well will produce at least 7.5 lpm with the Afridev hand pump. A short duration pumping test of 1 to 2 hours will then be conducted using an electric submersible pump in the open borehole [before or after casing and screen installation TBD] prior to completing the well to initially confirm the consensus. Once the well has been fully constructed (gravel pack and seals installed), the next step is to develop the well and test its production rate. This is carried out by pumping water using an electric pump at controlled rates and assessing the amount of water level drawdown in the well. A 24-hour drawdown test will be performed. Based on the performance of the well, it will either be capped (if the long-term yield is not high enough), or the well head and pad will be constructed and the Afridev hand pump installed. A minimum flow rate of 7.5 liters per minute will be necessary to deem the well productive enough for a hand pump. Afridev pumps are capable of a maximum flow rate of well over 20 liters per minute.

The final steps for completion of the well after the hand pump has been installed are chlorination/disinfection of the borehole and the construction of a fence surrounding the well pad. Operation H2O is responsible for disinfection, while the LWWC will be responsible for constructing the fence and maintaining the perimeter. The purpose of the fence is to prevent cattle from contaminating the area surrounding the well, which is more vulnerable to groundwater contamination. The Kenya WRMA requires that all newly constructed wells must be assessed for water quality prior to human consumption. Therefore following well completion, water quality testing will be completed as described in section 9.1.2 to determine if the water produced is safe. Precautions will be taken to notify the community that the water is not yet confirmed safe until testing is completed, including discussion with the LWWC and placing a lock on the pump.

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7.0 OPERATION AND MAINTENANCE

As EWB-OSU plans to complete one distinct system during the second implementation trip, there is one operation and maintenance plan detailed in this report. Of primary concern is the ability of the Lela community to successfully maintain the system once EWB-OSU is no longer involved in the community. To ensure that this goal is met, EWB-OSU has developed a plan for operation and maintenance of the well.

Operation and maintenance training will be addressed in multiple ways. The travel team's direct influence will be primarily during meetings held with the community, the LWWC, and with Melchizedeck Okello, Operation H2O's lead hydrogeologist who will serve as general contractor for the proposed well. Further management techniques (such as how to collect monthly fees from users and what to charge) will be developed in partnership with the Migori Ministry of Gender and Social Development. Families have been paying 50 KSH per month since July 2012 to use Lela's existing well, and names and payment records have been kept by the committee. It will be recommended that the same structure should be used for the next well.

With regards to maintenance training, EWB-OSU will work with the local ministries of water and public health (who have already held workshops in the Lela) to conduct technical trainings which include correct operation and maintenance procedures to ensure the longevity and sustainability of the well. Following installation of the new well, Mr. Okello will return to Lela to follow up with the community and check on their management progress.

The primary long-term maintenance concern of the well to be installed is the proper maintenance of the hand pump. To support the aforementioned hiring of a pump technician to maintain the hand pump, EWB-OSU required an upfront cash contribution from the LWWC in the previous implementation. This contribution was to be equal to the amount typically required to perform routine maintenance on the hand pump for one year. The general guideline for annual maintenance costs is 10% of installation costs, which is $2,000 for an Afridev pump. Thus it was expected that the LWWC would contribute $200. However, such contribution has not been made to this date. It is expected that the LWWC will follow through with this cash contribution during the upcoming trip. In addition, a bank statement will be requested for the LWWC's account in Migori, which will shed light on fundraising activities which have taken place since EWB-OSU's July 2012 trip.

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8.0 SUSTAINABILITY

8.1 Background

The impacts of the Lela Community Water Project will be fully realized only if the project initiatives are successful and sustainable, that is to say long-lasting and considerate of economic, social, and environmental factors. For this trip, sustainability will be promoted using a multifaceted approach, as detailed in the following subsections. The main concerns at this point are (1) extracting too much groundwater, (2) introducing potential contaminants to drinking water and/or to the environment during the construction phase or through extended use, and (3) community ownership and commitment to maintenance.

8.2 Well Sustainability

This project aims to utilize groundwater for human consumption in a manner that is environmentally sustainable. The main concern is extracting too much water, resulting in a lower water table. In Lela, the surface water and groundwater are likely hydraulically connected, in which case over-pumping could lead to degradation of other resources. To avoid this situation, Kenya drilling permits limit the allowable withdrawal to 23,000 lpd. It is virtually impossible to reach this limit with a hand pump. The Lela Community Water Project will abide by these regulations and confer with the drilling company to ensure sustainable practice in well drilling. The implementation of a second well should still be sustainable, as well as within regulations.

Despite the fact that Afridev hand pumps are well-built, constant usage will eventually wear them out or cause them to break if not properly maintained. It is important for the community to know exactly how to maintain the system, have written instructions for the hand pumps as reference, and own the tools required for maintenance. EWB-OSU will provide a copy of an Afridev maintenance/repair manual (available online at http://waterwellsforafrica.org/wp-content/uploads/2012/01/AFRIDEV_MANUAL.pdf), verbal training on how to do weekly maintenance and monthly tests, and an extra seal for the hand pump (the most common source of failure). Further repairs and maintenance will need to be funded by the community.

For socio-economic sustainability, the well must serve the community efficiently and equitably. This requires the community to have a plan to share the resource and its associated costs, including maintenance-related organization and funding. This is addressed in the MOU (section 10.0).

8.3 Overall Project Sustainability

The project goal is to improve the Lela community's access to safe water (quantity, quality, and distance to source) in a manner acceptable to local practices and considerate of the context and growth of the community as a whole. This process will be addressed on a continual basis throughout the project by means of constant discussion with the community. The extent of the project's socioeconomic sustainability will be demonstrated depending on the level in which the community takes ownership of the project.

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Long-term community involvement is a significant factor when considering sustainability of the well. EWB-OSU will continually work with the Lela community to convey the significance of their commitment, and will strive to ensure clear communication of responsibilities for both the community and EWB-OSU. Additionally, EWB-OSU and the LWWC will remain open and flexible to any concerns or issues that arise and any agreements will be amended as necessary.

8.4 Education

The main components for this trip's educational plan are technical training and health education. Such training is offered as a service by local government ministries in Migori. During the first days of the trip, the travel team will meet with the Migori Ministry of Water, Migori Health Ministry, and Gender and Development Ministry to schedule education workshops in Lela. These workshops will cover a variety of topics including operation and maintenance of the well, public health, and women's empowerment. The trainings will be in the local Dholuo language and available for participation to the whole community. The team will explain to the LWWC the importance of community participation in these trainings and share ideas about the best way to inform the community about these sessions. In addition, the team plans to hold visioning workshops during which community members can express their goals and roles for the future of their community. The travel team will also ensure that any questions or uncertainties are addressed regarding operation and maintenance of the rainwater catchment system installed at the Lela Primary School during the previous implementation trip to ensure its longevity.

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9.0 MONITORING

Table 9.0.1 provides an overview of the project's monitoring plan. Note that this table considers only engineering project aspects. Program monitoring does include public health assessment, which is not included in this report.

Table 9.0.1 – Project monitoring plan

Goal	Objective	Metric	Data Type	Data Collection
Water Supply meeting requirements determined by the LWWC to improve public health and meet societal objectives	Year-Round Access	Number of days per year with access to a water supply meeting all other objectives	quantitative	Tracked and reported by the LWWC
	Aesthetically Acceptable	Acceptable taste, color, etc.	qualitative	User interviews
	Water Supply meeting or exceeding WHO standards for the Lela Primary School (i.e., Rainwater Catchment System)	2 liters per student per day	quantitative & qualitative	Inherent in design, actual performance monitored using reported tank levels from LWWC and sustainability metrics
		Sustainability	qualitative	Physical examination of components, discussion with LWWC regarding how operation, maintenance, and repairs are being managed, survey Lela Primary School board members and a random selection of students for user satisfaction
	Water Supply meeting or exceeding WHO standards for the Lela Community (e.g., drilled and hand dug wells, pipelines, treatment systems)	40 liters per capita per day	quantitative & qualitative	Inherent in design, actual performance monitored using reported tank levels from LWWC and sustainability metrics
		Percentage of households with access less than 500 meters away	quantitative	Count number of households with access to an improved water source less than 500 meters away and reference total number of households count provided by LWWC
		Number of people per water point, less than 250 each	quantitative	Survey households at varying distances about use of the water supply to determine approximate radius of usage, and ultimately number of users within that radius
		Flow rate of at least 7.5 lpm at each access point	quantitative	Measure discharge rate pump
		Safe quality for intended purpose	quantitative & qualitative	Measure distance to possible contamination sources, water quality analysis, and survey users regarding purpose of water collected
		Sustainability	qualitative	Physical examination of components, discussion with LWWC regarding how operation, maintenance, and repairs are being managed.

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9.1 Monitoring plan for current project

9.1.1 Quantity of water

One of the goals of the Lela Community Water Project is to meet the standards set by the WHO for sustainable water provisions for all people in Lela. Based on recommendations from the WHO, the ultimate goal of this project is water provisions of 40 lpcd. Accounting for population growth, this means a supply of 100,000 lpd for the entire community. The WHO also recommends a flow rate of at least 7.5 lpm at each access point. The implementation trip in the summer of 2012 did meet the minimum flow rate goal but does not provide for the total water needs of the community. Thus, the goal for this trip is to add to existing water sources within the community.

Once the well system is constructed there are multiple avenues that can be used to test the water quantity. Drawdown tests (step-rate and constant rate) may be used to help determine the maximum sustainable yield of the well by recording the depth to pumping water level under various discharge rates. Using these values, the team will be able to roughly estimate how much water the well could possibly produce over certain intervals of time. The instantaneous and long term yield of the well is highly uncertain at this time, so it is essential that the travel team obtain an accurate baseline during and after construction to be used for future analysis and planning. Once the well is complete, the performance of the pump and well will be regularly monitored until the end of the trip. To determine the success of the well, it will also be necessary to monitor it for a period of time after the travel team leaves Lela. After the end of the trip, EWB-OSU will continue to monitor well performance through continuous contact with the LWWC and other contacts in the community until the next trip.

9.1.2 Quality of water

An objective of the Lela Community Water Project is to meet the standards set by the WHO for water based on the intended purpose. Baseline water quality characterization was completed for various available sources during past trips. This baseline will be used for comparison to newly developed sources throughout the project.

Pathogens are one of the most pressing human health concerns. Water sources will be analyzed for total and fecal coliform (E. coli) in the field using the Coliscan Easygel technique. It is important to complete this analysis soon after collecting the sample in order to obtain accurate results. Other characteristics to be evaluated include pH, turbidity, alkalinity, hardness, and levels of nitrate, nitrite, fluoride, and arsenic. Additional cations, anions, and metals will be assessed as needed.

Water characterization will be completed using a combination of field techniques and laboratory analysis. Samples that require laboratory analysis will be sent to the Catholic Diocese of Nakuru (CDN) Water Quality Programme laboratory. The team will take care when collecting samples to ensure they are representative of the source and detailed reference notes will be taken for each sample. More than one sample will be taken for each source of interest in order to produce a

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thorough data set and to insure against possible contamination or loss of any given sample, particularly for samples being sent to CDN for analysis.

Some areas of Kenya are known to have fluoride concentrations which greatly exceed the WHO recommendation of 1.5 ppm or less, which can cause fluorosis from prolonged consumption. The overall geology of the Migori District (including Lela) makes it unlikely that problematic fluoride concentrations will be found, but testing the water is the only way to be certain. Baseline assessment of the surface waters in Lela and the nearest well in Bondo (2.5 km away from Lela) indicated safe levels of fluoride. Arsenic is another constituent of concern. The WHO recommendation is less than 10 ppb. The Bondo well was measured at 10 ppb, and surface water sources in Lela measured in the range of 3-8 ppb. This is a cause for concern regarding the water quality of any new well in Lela.

Research on levels of potentially hazardous naturally occurring in-situ arsenic and fluoride was done by Amini et al. for Statistical Modeling of Global Geogenic Arsenic and Fluoride Contamination in Groundwater in 2007. Their research indicates that Lela falls within a probability of 0.6-0.8 of having concentrations greater than or equal to 1.5 ppm Fluoride and a probability of 0.75-1.00 for greater than 10 ppb Arsenic in reducing conditions and a probability of 0.50-0.75 for greater than 10 ppb Arsenic in oxidizing conditions. While samples from the well drilled in July 2012 demonstrate that the water is safe for human consumption, it is important to continue water quality testing moving forward.

10.0 COMMUNITY AGREEMENT/CONTRACT

An MOU will be used for the upcoming implementation trip and will be based on the MOU signed in agreement with the LWWC and Operation H2O in July 2012. Previously stated verbal commitments will be incorporated into the MOU and both parties will verbally agree to the conditions in the MOU prior to submission of the 525 Pre-Implementation Report. Sufficient time at the beginning of the implementation trip will be dedicated to reviewing the MOU with the LWWC and Operation H2O. These interactions will serve to finalize the MOU before it is signed, a condition to be met before drilling or major construction occurs.

One complication for finalizing the MOU will be incorporating any changes deemed necessary before signing. The nearest printers are in Migori and the electricity is often out for extended periods of time, so while this could be attempted it cannot be relied on. Therefore, the document will be written and printed with enough spacing to make official changes and/or additions. Translation is another consideration; the MOU will be written in English and translated to Swahili. The MOU will also be read aloud before signing occurs so that illiterate people can understand what is being agreed to.

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11.0 PROFESSIONAL MENTOR ASSESSMENT

11.1 Professional Mentor Name

Jeff Randall

11.2 Professional Mentor Assessment

The design of the proposed water supply well is suitable for installation of an Afridev hand pump (or equivalent nominal 2-inch diameter pump) and is consistent with the EWB-OSU/Operation H2O well installed in Lela during 2012. The design is also consistent with the design proposed by Mr. Isaiah O. Mawinda, RGEOL the author of the Hydrogeological Survey Report and is consistent with generally accepted international design standards.

Because of the complex and variable geology in the area and the uncertainties inherent in the interpretation of the geophysical survey results (vertical electrical sounding results), the well yield is unknown and the design may need to be adapted as necessary. However, I am in agreement with the team that it is still the best prospect for large volumes of clean water and should be attempted.

The travel schedule for the team will be coordinated with Operation H2O's and the drilling subcontractor's stated availability and assuming minimal downtime during construction due to equipment breakdown or difficult drilling conditions. Therefore, the return travel schedule should remain flexible if the team is to witness the full construction, development and testing of the water supply well.

11.3 Professional Mentor Affirmation

I endorse the water well construction work as presented in this preliminary design report.

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