Alternative Analysis - Addendum Revised 3/23/2020
Kansas City Professional Chapter
Guatemala, Los Churuneles II

In response to reviewer comments received on the first submittal of the Alternatives Analysis Report (1/19/2020), additional storage tank and distribution network alternatives were considered. Analysis of these alternatives follows.

Storage Tank Alternative 4 - Ferrocement Tank

In this alternative, a ferrocement tank is constructed. The ferrocement tank would be round in shape, approximately 15' diameter, and have a roof that is a continuation of the walls. This design is typical of the region and the EWB-Guatemala office has familiarity with its construction. There are design guides available that will aid in the design process and allow EWB-KC to provide all the necessary information for the EWB-Guatemala office to acquire materials and the appropriate labor in a timely manner. The alternative solves the identified need by holding a capacity sufficient to meet the current demands in the community, along with the 2% increase in population size that must be accounted for. The community has requested one storage tank to provide for the whole community, and this alternative would satisfy that request.

Due to the round shape, ferrocement structures can typically get by with thinner walls, thus reducing the amount of concrete construction materials. An important feature to the construction of a ferrocement tank is that it does not require much, if any, formwork, while the construction costs associated with a cast concrete tank is driven by the amount of formwork required. Instead, the sand-cement mixture is plastered directly on to the steel cage and formwork is unnecessary.

The construction of a ferrocement tank will require approximately 80 ft^3 of cement, 46 ft^3 of gravel, 159 ft^3 of sand, 2010 linear feet of #4 rebar, 179 ft^2 of formwork, and 3593 ft^2 of chicken wire. The total estimated cost of this alternative is $865.

A rapidly developing factor that must now be addressed is the impact of COVID19 on the implementation of the project. With travel restrictions and complications with travel expected to remain in place for an unknown amount of time, it is best to assume that the implementation of this structure will have to take place without the physical presence of the EWB-KC project team. With this in mind, a ferrocement tank lends itself as the ideal alternative as the EWB-Guatemala office will be the one facilitating this construction and has experience with acquiring the materials, contacting a foreman, and assisting in the construction.

Selected Storage Tank Alternative: Alternative 4 - Ferrocement Tank

Table 3.1.1 Storage Tank Alternatives								
Criteria	**Alternative 1: Build New Concrete Storage Tank**		**Alternative 2: Use Existing Tank**		**Alternative 3: Concrete Pad with 3 HDPE Tanks**		**Alternative 4: Ferrocement Tank**	
Ability to solve identified need	5	We have the ability to design whatever they need	2	If we do a zoned system we have to build more infrastructure and it doesn't have the required capacity	4	Design life of system may not be long enough	5	We have the ability to design whatever capacity is required
% of community impacted	5	Everyone will get water	5	Everyone will get water	5	Everyone will get water	5	Everyone will get water
% of need met	5	Everyone will get water	5	Everyone will get water	5	Everyone will get water	5	Everyone will get water
Community Input	5	This is what they expect	1	They do not want this option	4	Not what they are expecting, but shouldn't be too foreign	4	Although not the exact structure they are expecting, it will fulfill all of their requirements
Construction Cost	1	Would require the most material and construction cost would be high	5	No construction	1	Tanks would be more expensive and would have to be transported to community	3	The lack of formwork keeps the cost low
Maintenance Cost	5	Minimal	5	Minimal	4	Might require some upkeep because it is plastic	5	Minimal

Operation and Maintenance Difficulty	5	Should be very accessible for any needed maintenance	1	The tank is difficult to get to, especially in poor weather, and the landowner doesn't want it there	3	Could require a change in the tank, which could require ordering a new one	5	Should be very accessible for any needed maintenance
Regional Experience with Technology	5	Similar systems have been constructed before	5	N/A	5	These systems exist throughout the community	5	EWB-Guatemala has constructed these tanks before and has the ability to help with the construction of this as well
Material Availability	5	Concrete is widely used in and around the community	5	N/A	3	HDPE tanks exist in the community, but not the size we need. We'll probably need one shipped in	5	All materials are readily available around the region
Expandability and Scalability	1	We would need to purchase more land, and expanding a concrete tank is very challenging	1	No land is available	3	Could purchase a larger tank(s), but would have to have it shipped in	1	Ferrocement tanks are unable to be expanded, but an additional tank could be constructed if required
Impact of Climate Change	5	Concrete should not be impacted by any changing climate	5	Concrete should not be impacted by any changing climate	5	HDPE should not be impacted by any changing climate	5	Cement, aggregate, and rebar should not be impacted by any changing climate
Totals	47		40		42		48	

Distribution Network Alternative 4 - Single Zone

In this alternative, no schedules or separate zones would be employed to divide the community. Instead, a single header will supply water to the community from the new storage tank, with isolatable branches serving clusters of households in close proximity. Previous analysis had assumed a daily demand of 80 L/person per day, however conversations with Steve Crowe and Tatiana Maldonado indicate that regional demand is closer to 55-60 L/person per day. Using this value allows for the supply to be more easily divided and the flow balanced without employing a zoned or scheduled approach. Once the community is accustomed to having a consistent water supply, hoarding practices will decrease, reducing the peak demand. Community members will no longer need to store water locally, and overnight demand will decrease giving the storage tank an opportunity to recharge.

Assuming a daily demand of 60 L/person per day and a current community size of 500 yields a daily demand of 30,000 L. The daily supply of water is approximately 44,000 L per day (0.51 L/s x 3,600 s/hr x 24 h/day), which should be more than sufficient to supply the needs of the community. Assuming a design life of 20 years and a 2% yearly population growth, this supply should be nearly sufficient to meet the projected community future demand (44,600 L projected future demand vs 44,000 L supply).

Averaging out the daily demand of 30,000 L/day yields an average outflow from the storage tank of 0.35 L/s. Assuming a Peak Demand Factor of 10 and a Seasonal Peak Factor of 1.2 yields a peak design flow rate of 4.17 L/s. The existing pipeline from the storage tank to the community has a diameter of 1.5”, which results in a peak flow velocity of 3.6 m/s. This is well above the maximum velocity of 2 m/s per the EWB-USA Guatemala standards. These preliminary calculations indicate that the pipeline will need to be replaced with a larger size of approximately 3” in order to meet the water velocity design requirements. Where the existing pipe network is sufficiently sized and undamaged, it will be retained to reduce cost of materials. It is expected that individual supply lines to households will not need to be replaced, and that the main pipeline header at the end of the community will also not need to be replaced. A detailed hydraulic model will be completed in the design phase to calculate and confirm the necessary pipe sizes, as well as which aspects of the existing piping network can be retained. The precise routing of the main supply header will also be examined in the hydraulic model, but it is expected to mirror the existing supply header as much as is feasible to reduce constructional complexity.

The materials necessary for this alternative are the same as the materials necessary to construct a zoned solution, as the main supply header will need to be replaced. Materials needed for this alternative include piping (most likely PVC) and elbows, isolation valves (ensuring no more than 20 households are on a single segment), PVC cement, and water meters. Small concrete boxes to protect the isolation valves and water meters are also expected to be necessary. The necessary maintenance activities will be similar to that of the other alternatives considered. The only necessary maintenance will be minimal and involve periodic repairs to the pipeline and valves should they become damaged. The cost of this alternative is less than the cost of a zoned solution, as only a single header is used instead of multiple.

From the community's perspective, this solution would be the most accepted. Community members would always have access to water, and no schedules would have to be implemented. Operationally it is also simpler, as it does not require daily actions of opening or closing valves to serve different zones.

This alternative was compared to the other 3 alternatives considered for the distribution network, and scored using the matrix below. A single zone alternative scored the highest, and is thus selected as the preferred alternative for the distribution system.

Selected Distribution Network Alternative: Alternative 4 - Single Zone

Table 3.1.2 Distribution System Alternatives

Criteria	**Alternative 1:Schedule**		**Alternative 2: 2 Zones**		**Alternative 3: 3 Zones**		**Alternative 4: Single Zone**	
Ability to solve identified need	3-5	Depending how increased storage impacts distribution, everyone may or may not be able to receive water	5	Rerouting new zone to houses that don't currently receive water will provide water to all households	5	Rerouting new zone to houses that don't currently receive water will provide water to all households	5	All community members will have access to water at all times
% of community impacted	3-5	Depending how increased storage impacts distribution, everyone may	5	Everyone should get water	5	Everyone should get water	5	Everyone will have access to water

		or may not be able to receive water						
% of need met	3-5	Depending how increased storage impacts distribution, everyone may or may not be able to receive water	5	Everyone should get water	5	Everyone should get water	5	Everyone will have access to Water
Community Input	3	The community is expecting an engineered solution	4	Community is accepting and familiar with zoned solution	4	Community is accepting and familiar with zoned solution	5	This is the community's preferred alternative
Construction Cost	5	Limited or no construction	3	Lower construction cost	1	Highest construction cost	3	Lower construction cost
Maintenance Cost	5	Shortest total pipeline length, lowest maintenance cost	4	Longer total pipeline length, larger maintenance cost	3	Longest total pipeline length, largest maintenance cost	5	Shortest total pipeline length, lowest maintenance cost
Operation and Maintenance Difficulty	3	Difficult to enforce schedule necessary for proper operation, but least maintenance	3	Operation requires 3 valve actions daily	2	Operation requires 4 valve actions daily	5	No daily operation actions required
Regional Experience with	3	The community essentially	1	No known experience with zones	1	No known experience with zones	5	A single zone solution is the most common in the

Technology		operates on a schedule now, with some community members only getting water overnight						region
Material Availability	5	Materials available in Sololá	5	Materials available in Sololá	5	Materials available in Sololá	5	Materials available in Sololá
Expandability and Scalability	1	Flow rate limited to single pipe's maximum flow rate	3	Higher maximum flow rate if both zones open simultaneously	5	Highest maximum flow rate if 3 zones open simultaneously	5	Replacing the main supply header allows for future demand to be considered
Impact of Climate Change	5	Negligible impact	5	Negligible impact	5	Negligible impact	5	Negligible impact
Total	39-45		43		41		53	