Cerro Gallina Water Distribution Systems

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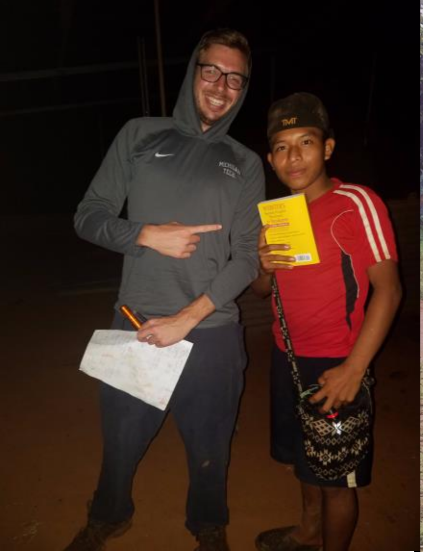
Matthew Adams * Sasha Drumm * Kira Koboski * Juli Mickle

Outline

- Background
- Problem Description
- Design Components
  - System 1
  - System 2
- Cost and Scheduling
- Operation & Maintenance
- Conclusion

Background

- Cerro Gallina
- South-western Panama within the state of Chiriquí
- Ngöbe indigenous group
- 5 neighborhoods
- 42 houses




HUSKIES
ECT

Problem Description

- Inadequate access
- Improperly assembled piping
- Lack of education
- Social disputes

Problem Description

- Inadequate access
  - Dry season
  - Spread out community
  - Houses on ridge

Problem Description

- Improperly assembled piping
  - Above ground
  - Crosses well-traveled paths
  - No sealant used for joining pipes
  - Requires constant maintenance

Problem Description

- Lack of education
  - No rainwater catchment
  - Uncovered spring sources
  - Infrequent cleaning of spring (toma)
  - Dirty gathering jugs
  - No treatment methods used
  - No knowledge of potential causes of bacterial contamination

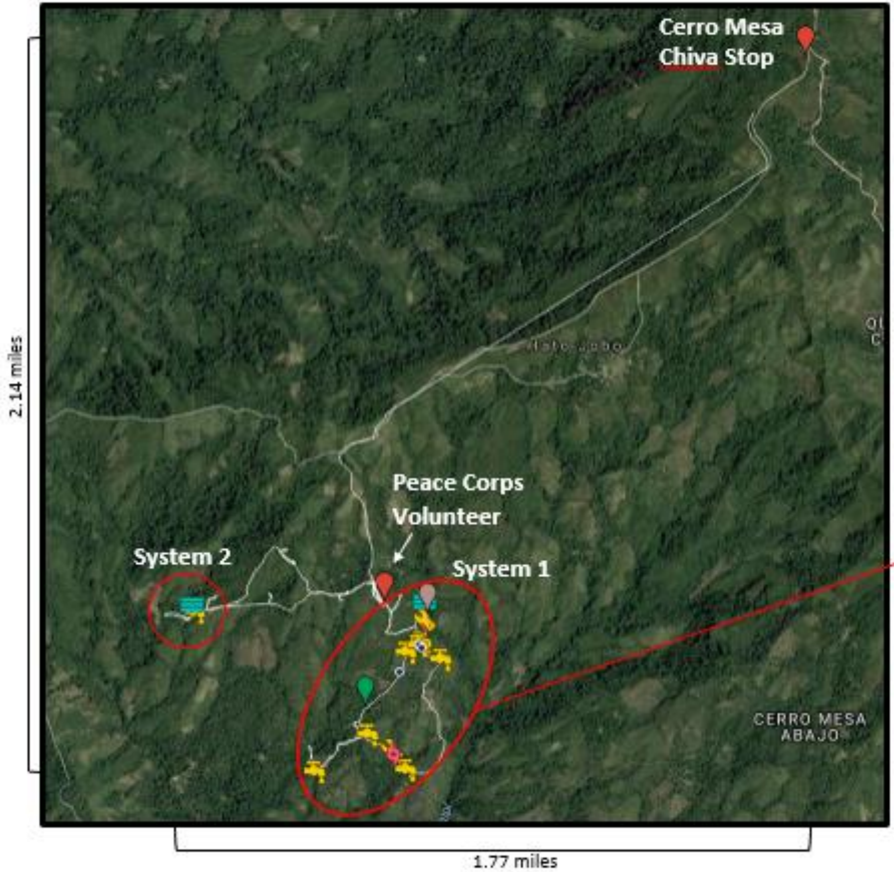
Problem Description

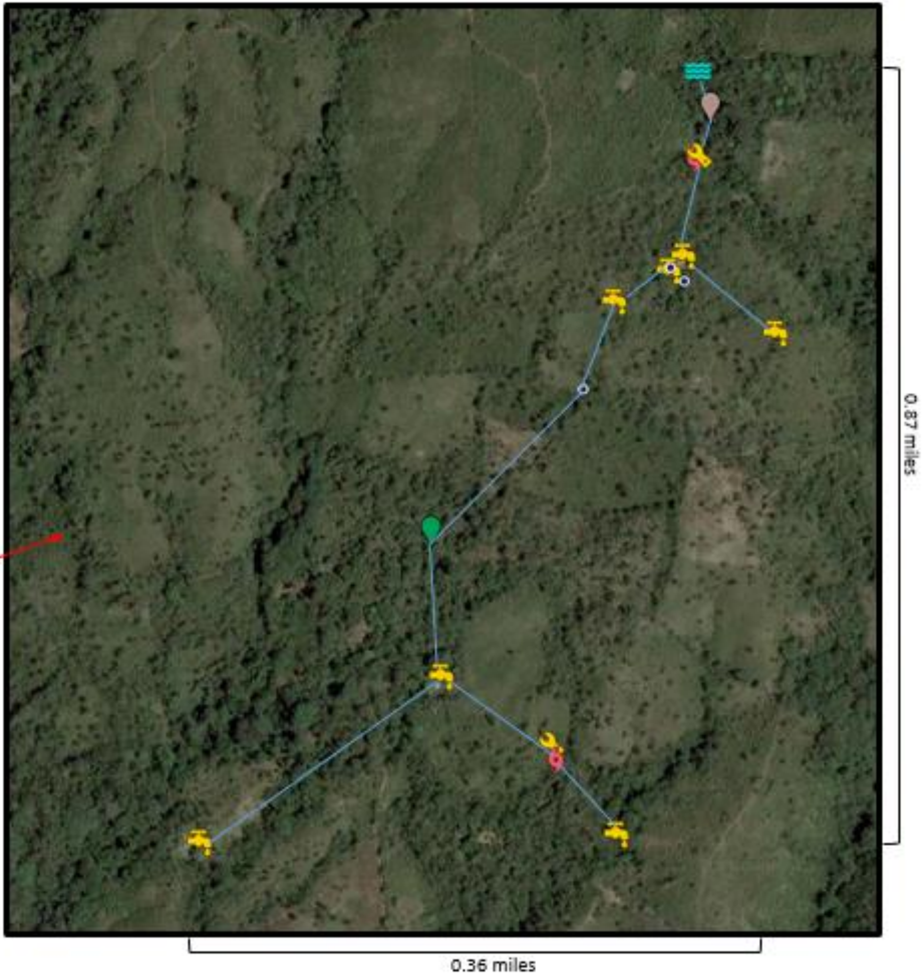
- Social disputes
  - Government project leaves out one home
  - Family feud
  - Unequal interest and engagement in development

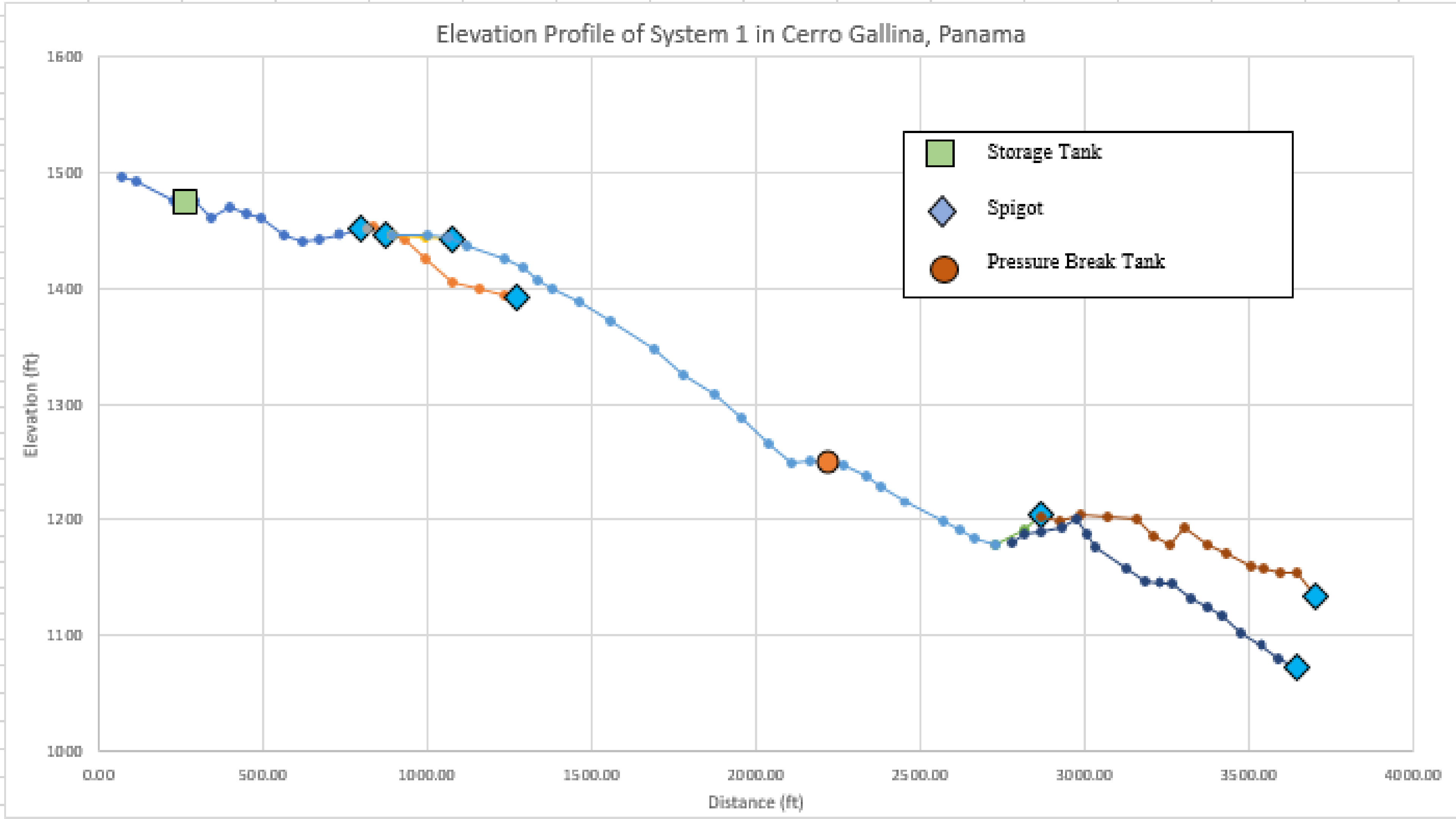
System 1: Gravity Fed Water Distribution

Problem Statement: Design a system to allow for clean drinking water to flow by gravity from a spring to 7 homes. It must be within the government's budget of $12,500.

- 7 homes
- 425 ft elevation change
- Spring box
- Storage tank
- Pressure break tank
- 2 Air-release valves
- 2 Clean-out valves


Cerro Mesa
Chiva Stop
Peace Corps
Volunteer
System 2
System 1
CERRO MESA
ABAJO
2.14 miles
1.77 miles


0.87 miles
0.36 miles



Elevation Profile of System 1 in Cerro Gallina, Panama
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Elevation (ft)
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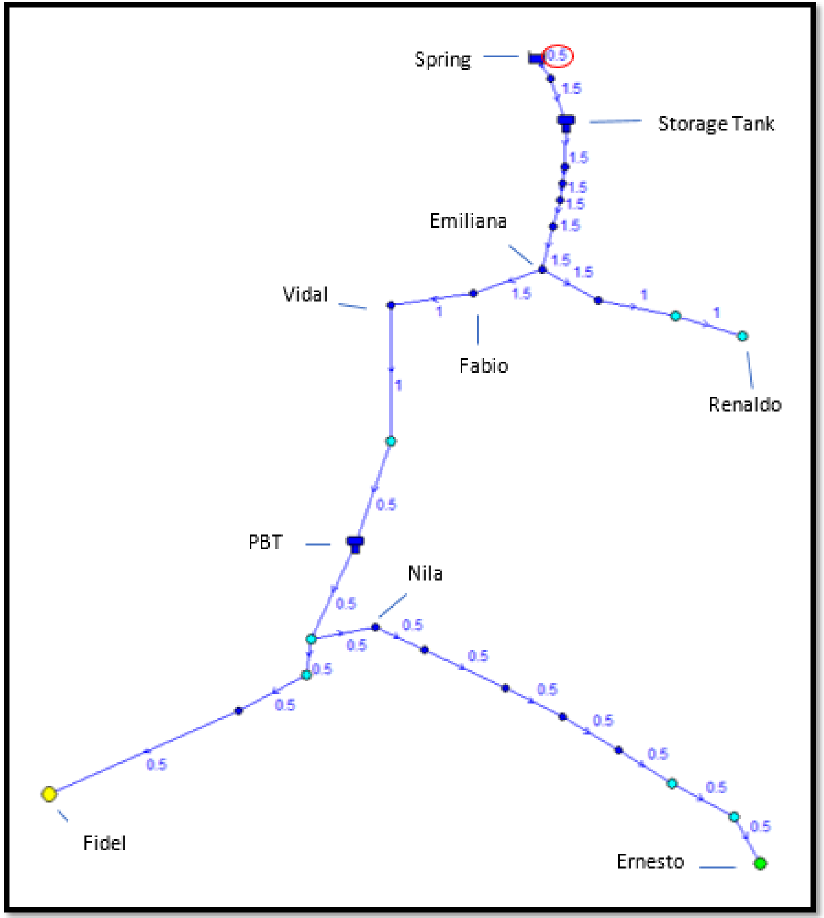
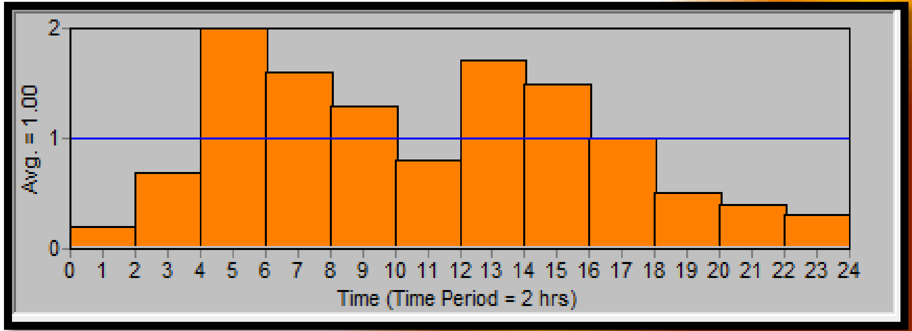
Distance (ft)
Storage Tank
Spigot
Pressure Break Tank

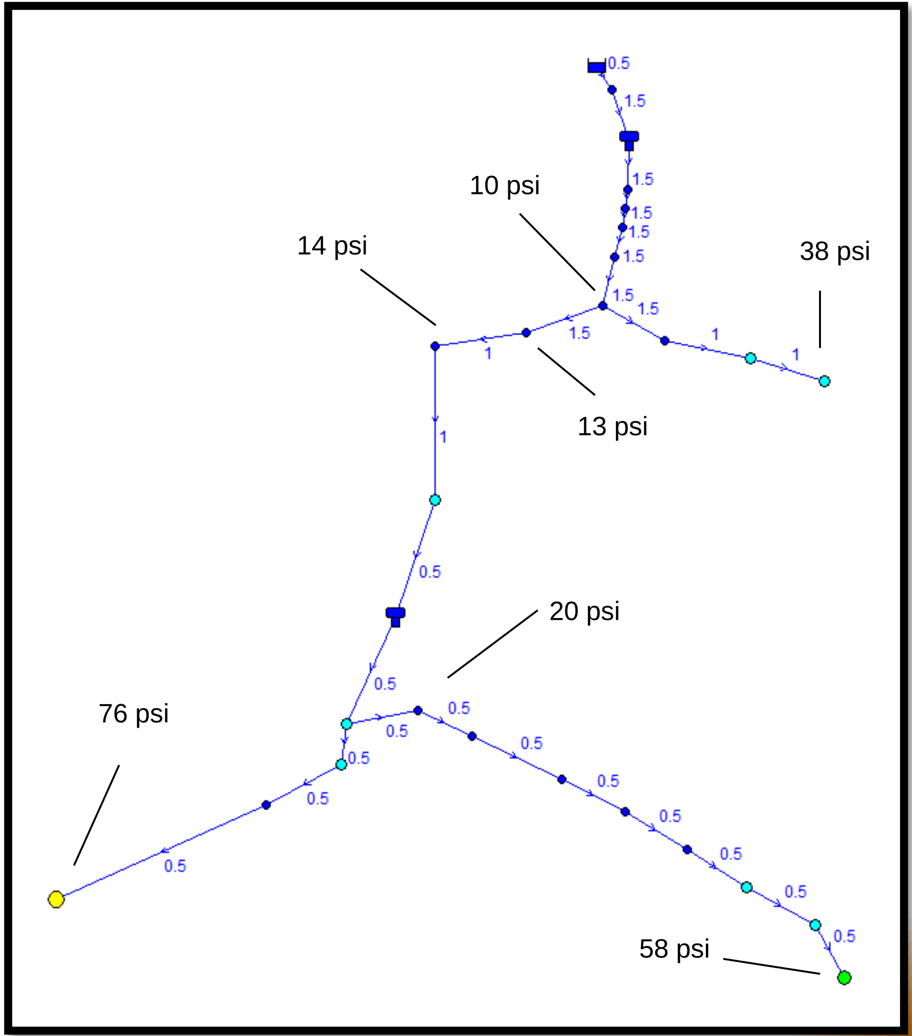
Pipes and Water Demand



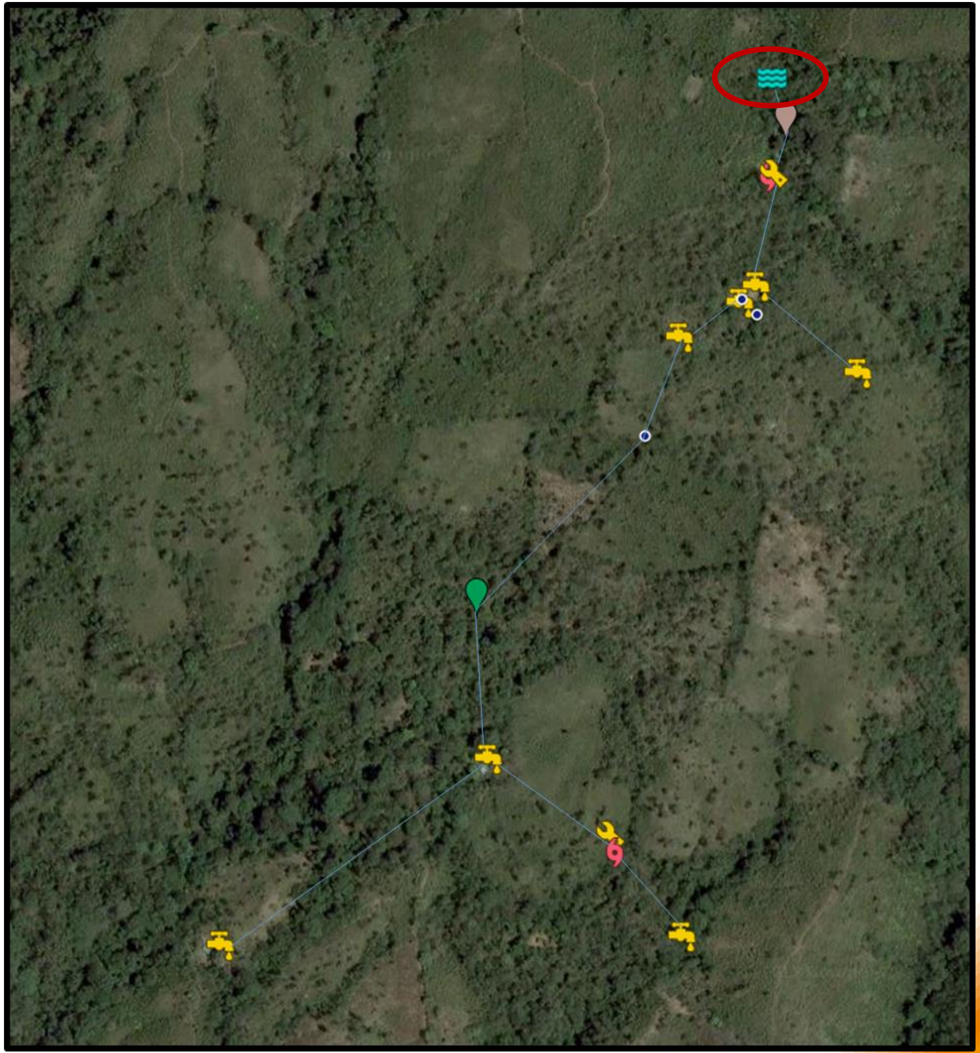
- Distribution of Pipe Diameters
  - Pressure increases with larger
  - Smaller is cheaper
- Model Includes:
  - Spring
  - Storage tank
  - Pressure break tank
  - 7 homes
- One family uses 180 gpd = 0.125 gpm
- Demand varies with meals

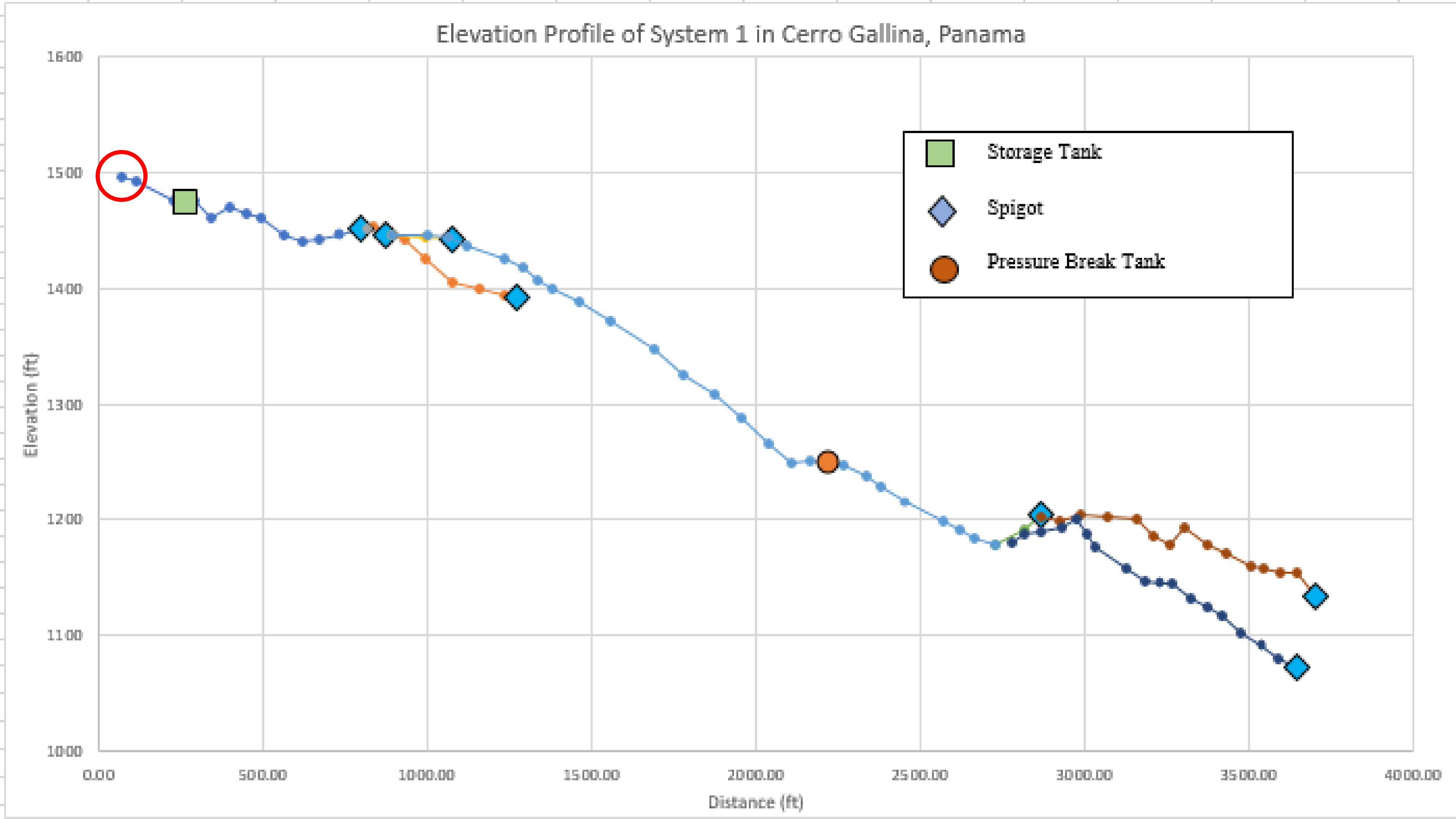


Model Results



Spring Box: Low Profile





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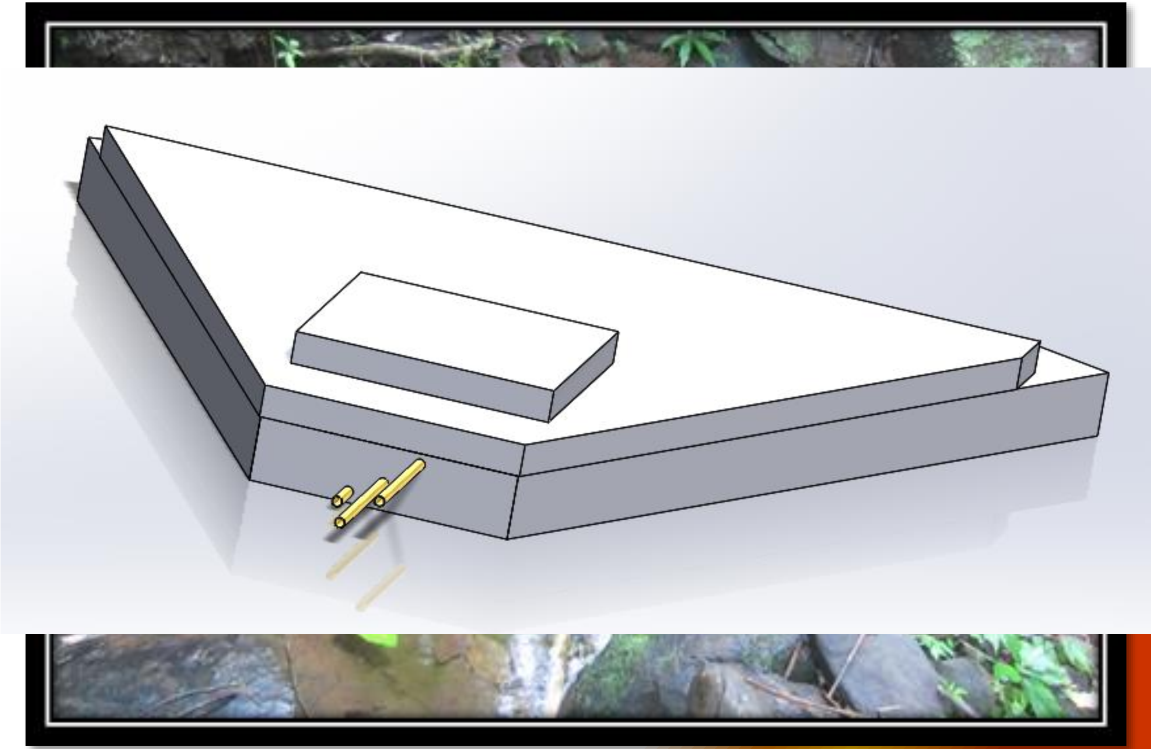
Storage Tank
Spigot
Pressure Break Tank

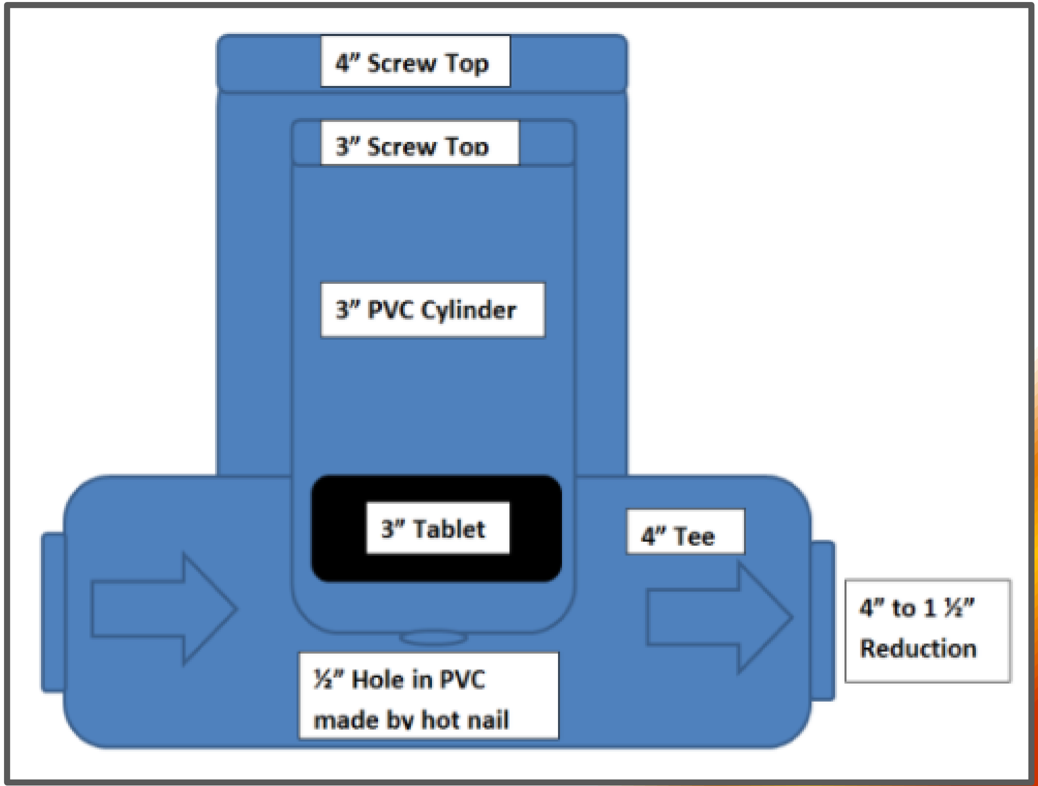
Design Components

- Spring dimensions:
  - 6ft x 5.5ft
  - 4.72 gpm
- Wing Walls:
  - Thickness = 0.5 ft
  - Width = 7.11 ft
  - Height = 1 ft
- Materials:
  - Existing rocks near the spring
  - Mortar

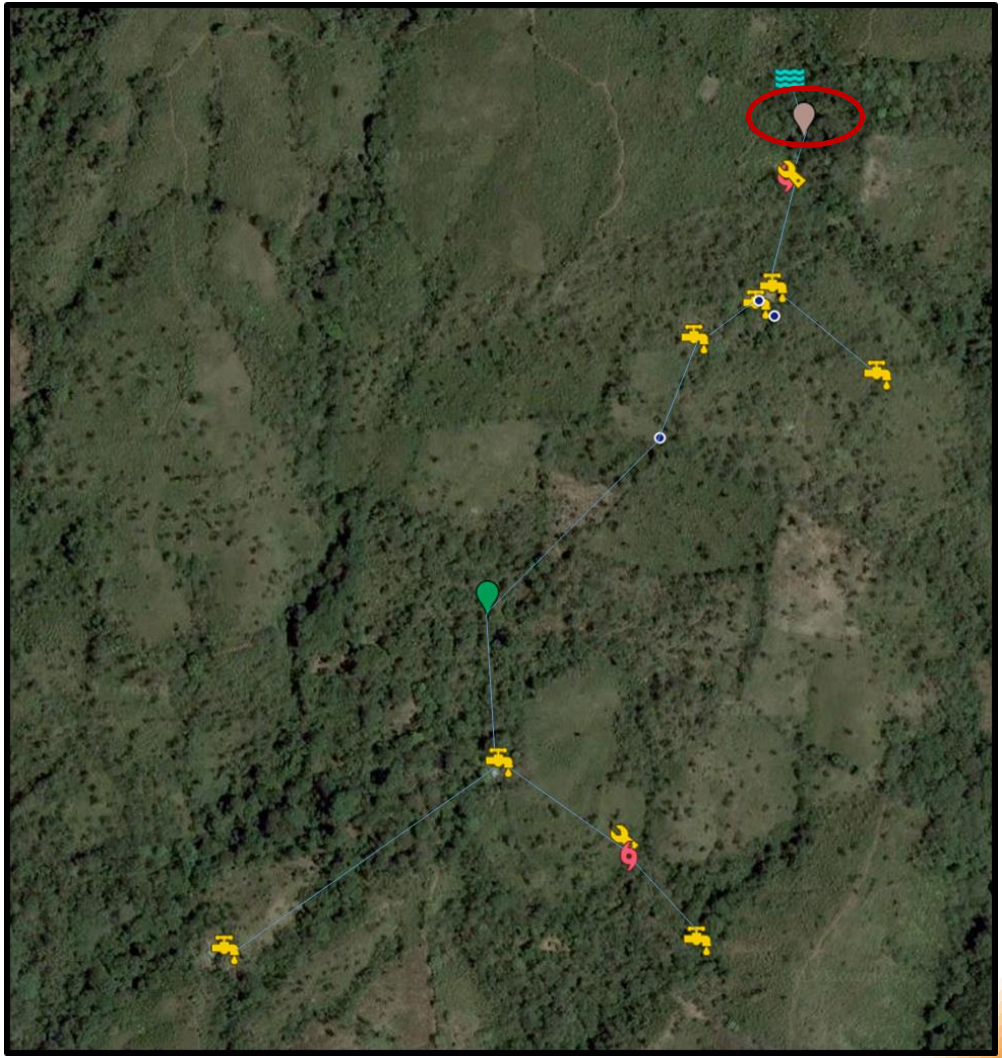


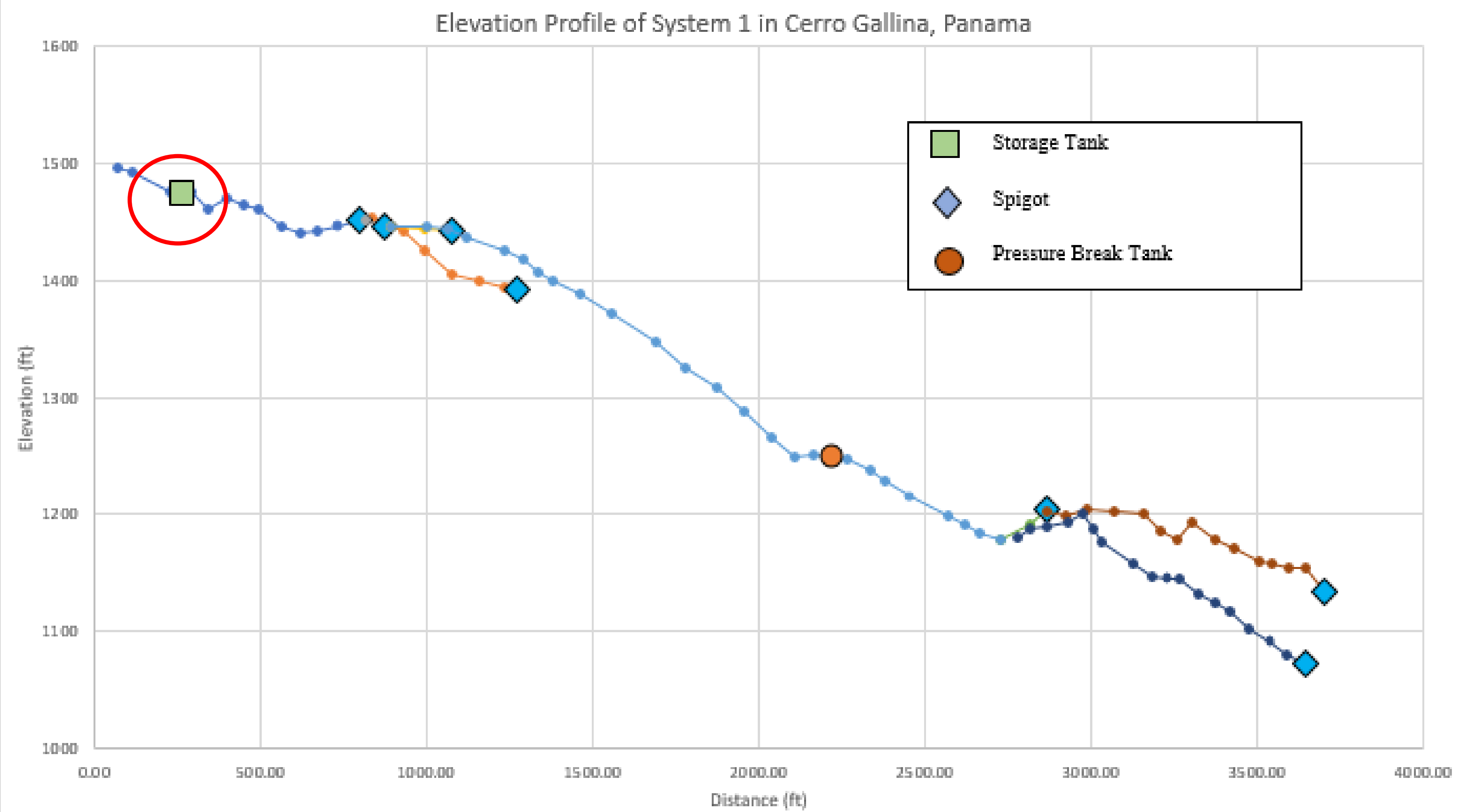
Chlorination

- High coliform counts were found at the spring source
- Chlorination applicator will be placed directly prior to the storage tank
- 1 chlorine tablet bi-weekly
  - Contact time of 36 hours at full tank volume
  - Tablet concentration of 60-70% calcium hypochlorite



Storage Tank





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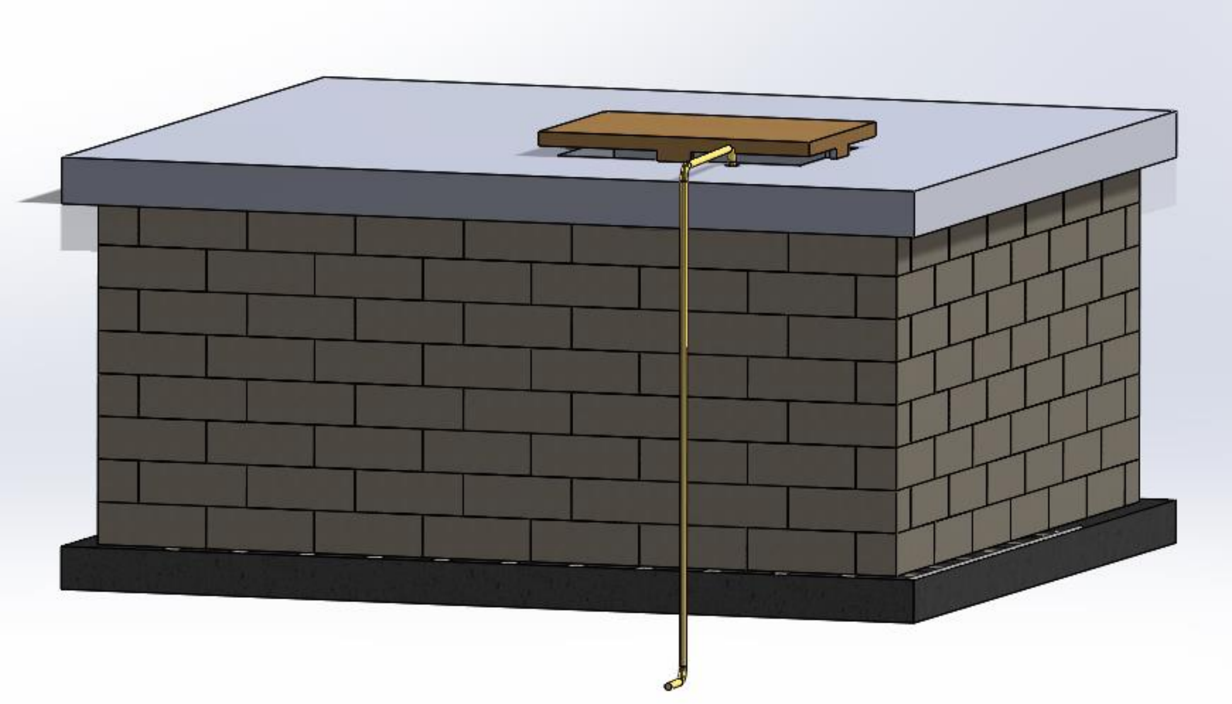
3000.00
3500.00
4000.00
Distance (ft)
Storage Tank
Spigot
Pressure Break Tank

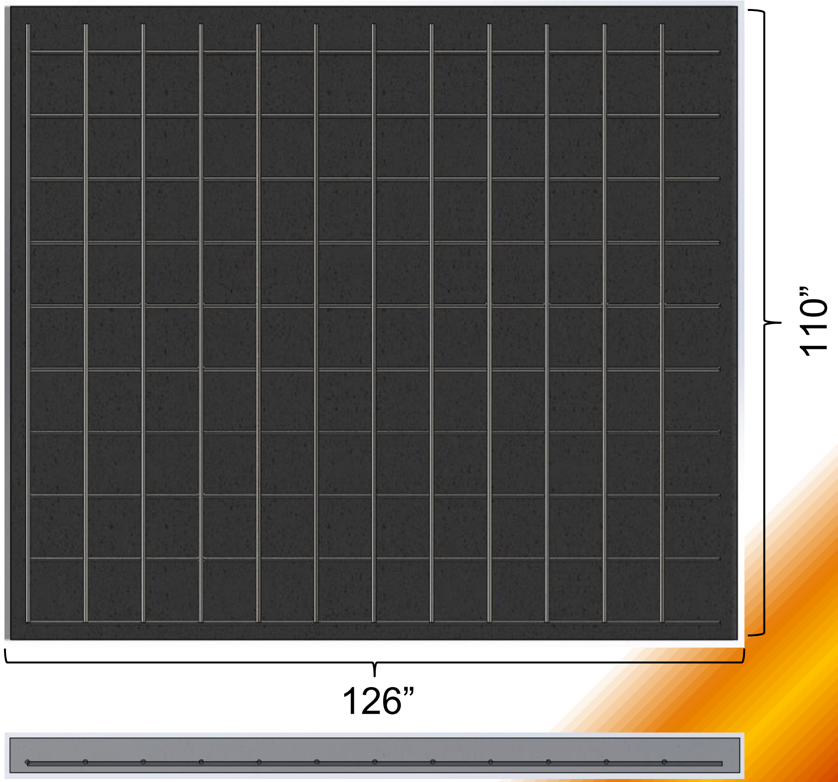
Design Components

- Sized based on the demand for 7 homes
  - 180 gpd per family
  - Total of 265 cubic feet
  - 1982 gallons



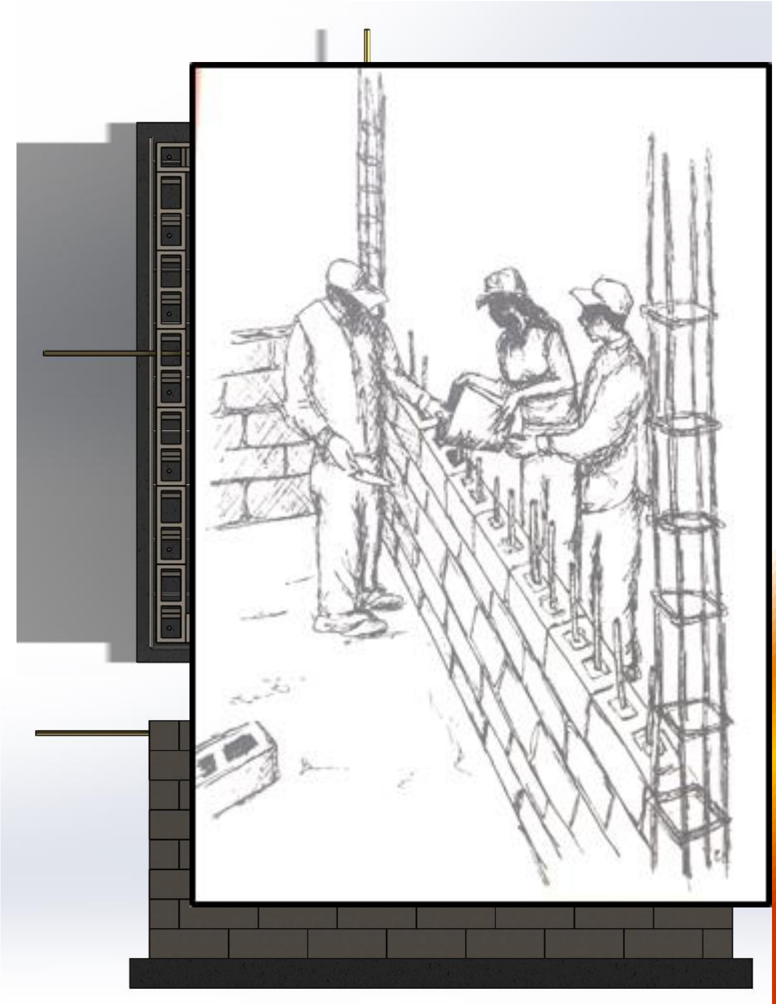
Base

- Base dimensions:
  - 126 inch x 110 inch
  - 6 inch thick with ⅜ inch rebar
  - 10 inches spacing on long side
  - 11 inches spacing on short side
- Concrete (1:2:3 mixing ratio)



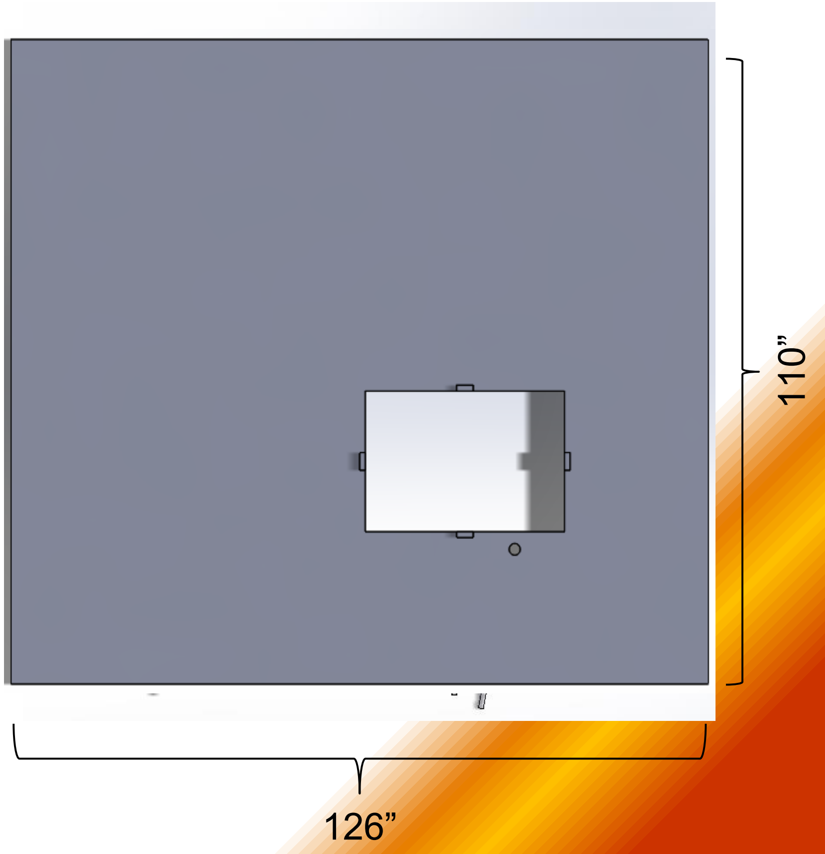
Walls

- Walls dimensions:
  - External-118 inches x 102 inches
  - Internal- 106 inch x 90 inches
- Materials:
  - 6 inch hollow CMU blocks
  - ⅜ inch thickness of mortar (1:3 mixing ratio)
  - ⅜ inch rebar with 16 inch spacing

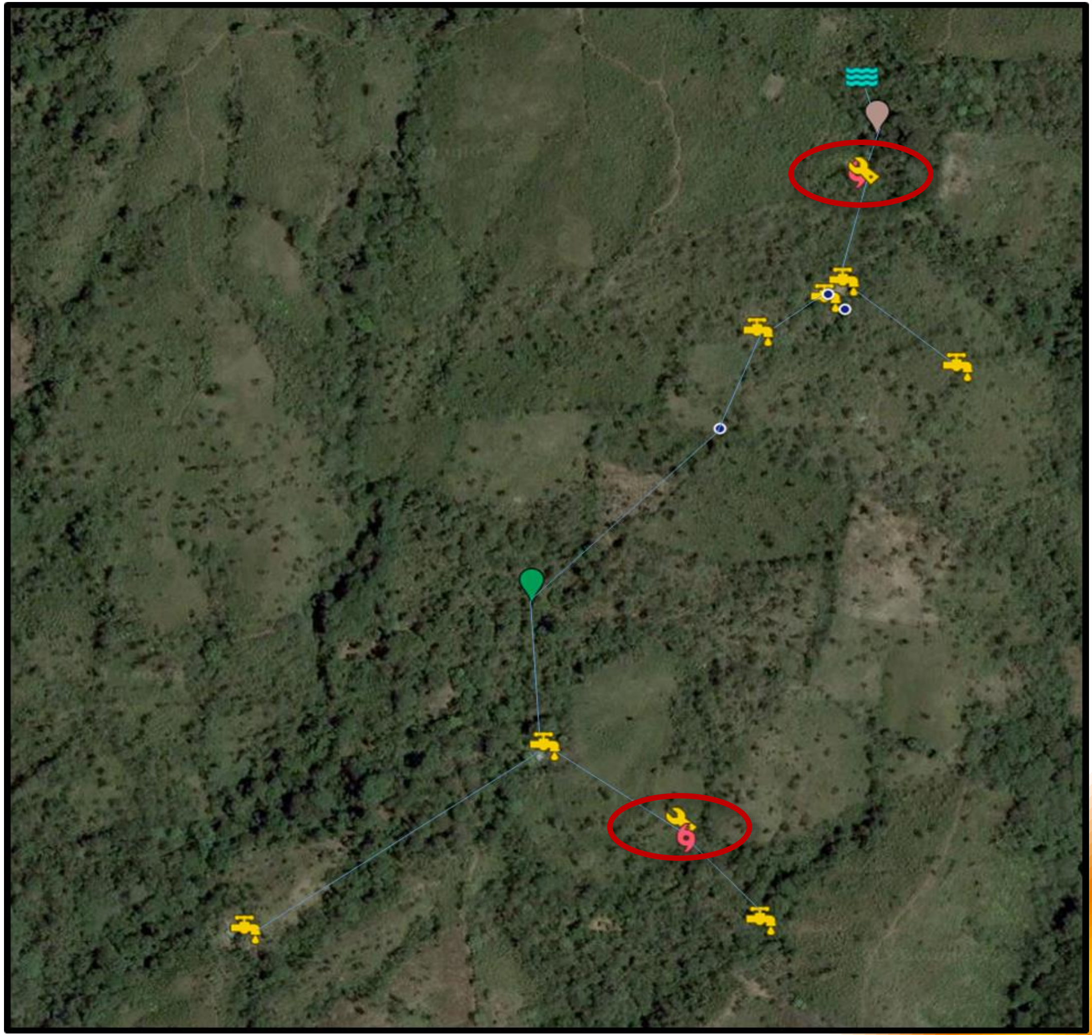


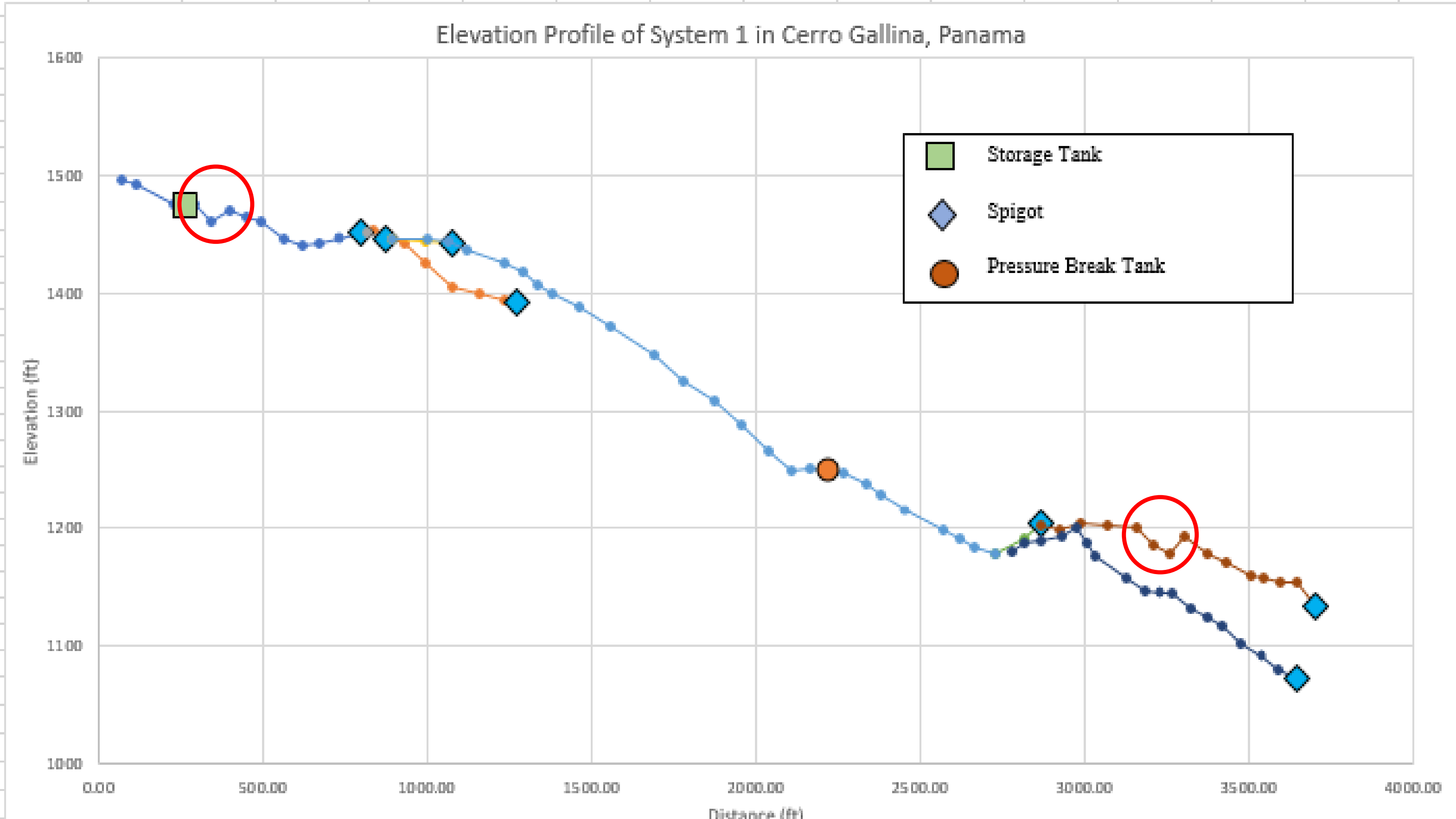
Cover

- Cover dimensions:
  - 126 x 110 inches
  - 6.5 inches thick
  - Materials
- Concrete (1:2:3 mixing ratio)
- ⅜ inch rebar
  - 14 inches spacing on the long side
  - 14.5 inches spacing on the short side
- 3ft x 2ft timber hatch



Clean-Out and Air-Release Valves

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Elevation (ft)
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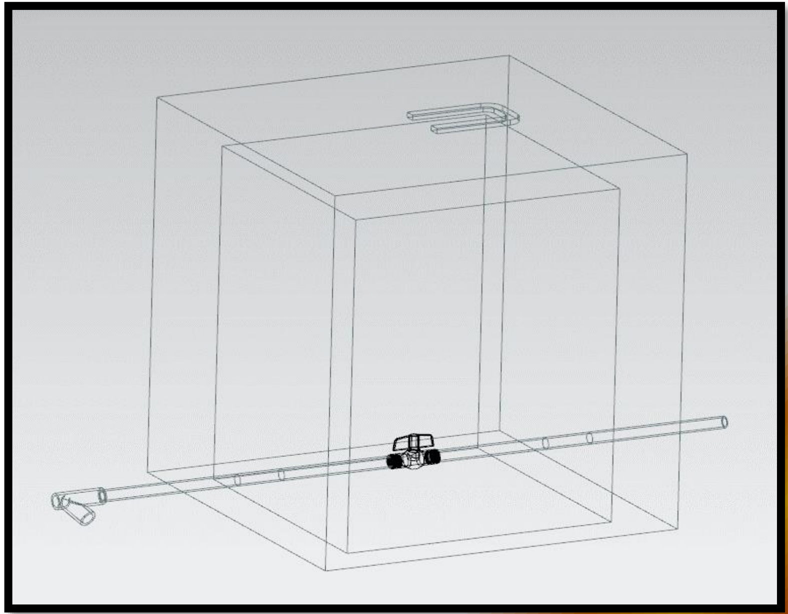
4000.00
Distance (ft)
Storage Tank
Spigot
Pressure Break Tank

Design Components

- Clean-out valves flush out sediment
  - At each spigot
  - Spring box
  - Low spots

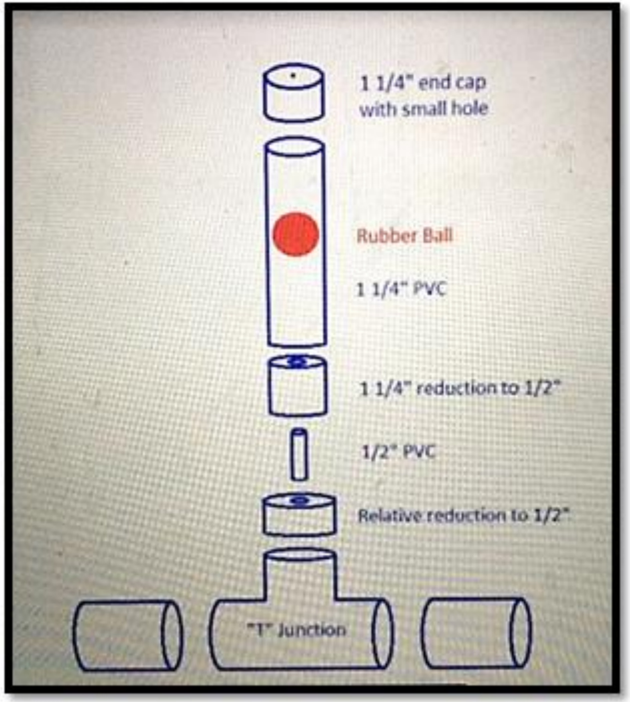
Clean-Out Valve



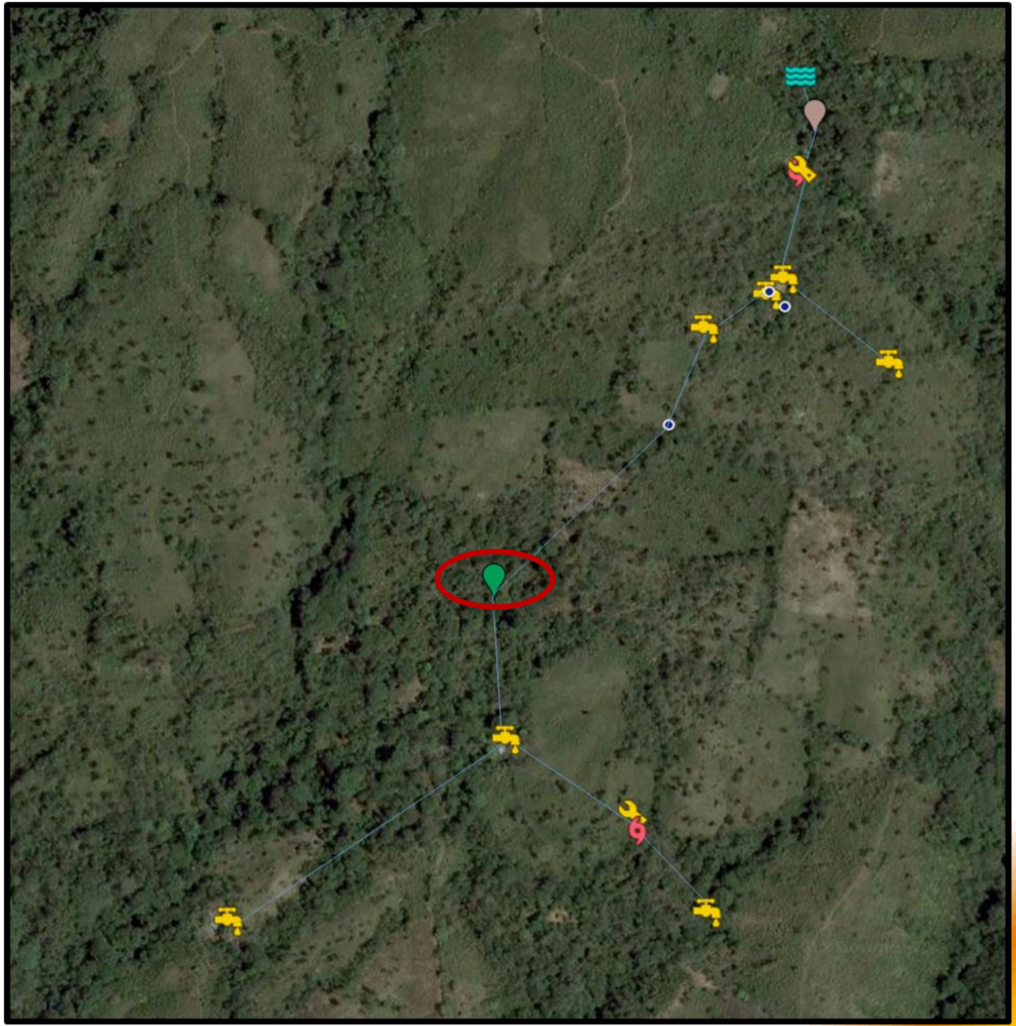
Design Components

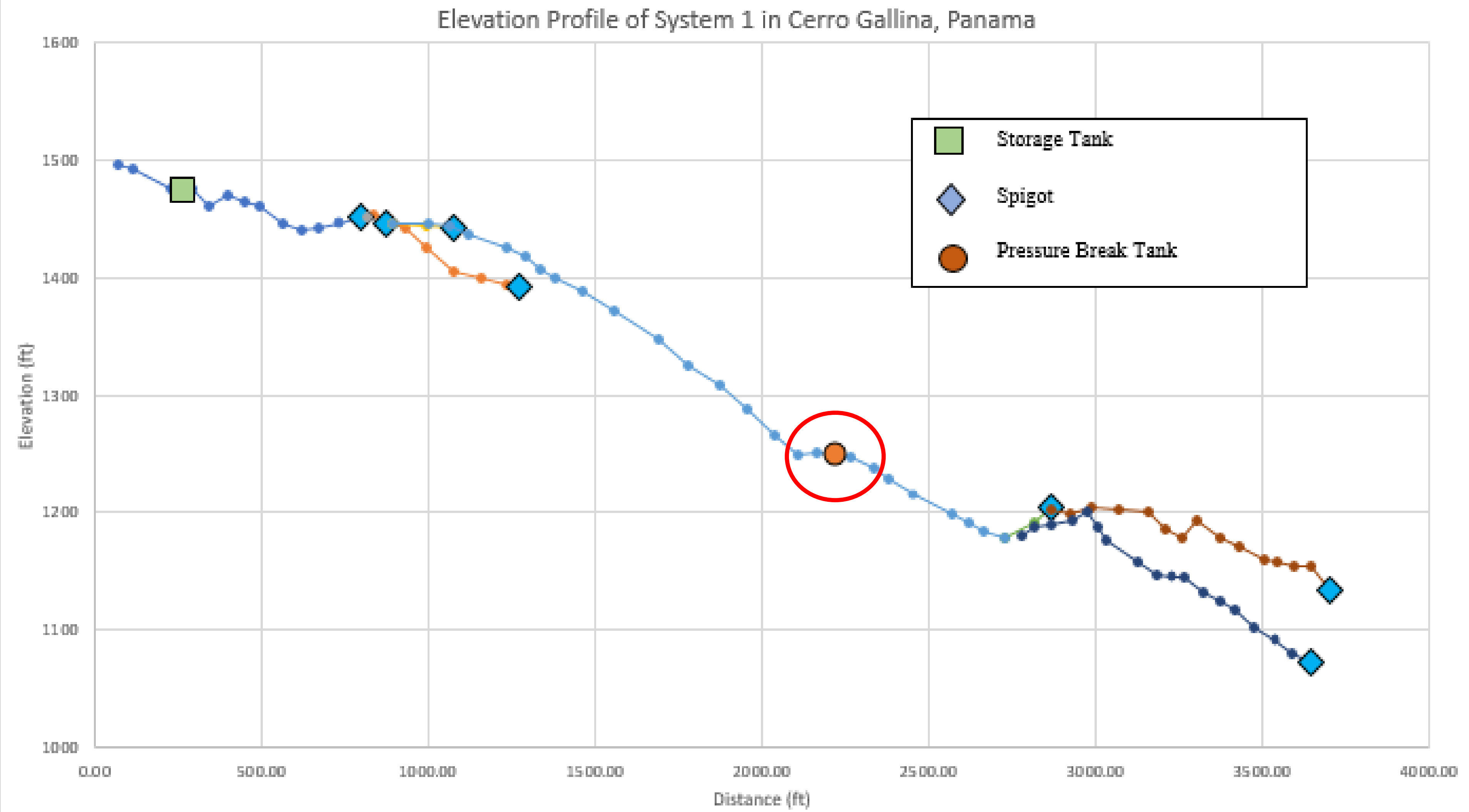
- Air-release valves reduces flow impeding air pockets
    - High spots

Air-Release Valve



Pressure Break Tank





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Storage Tank
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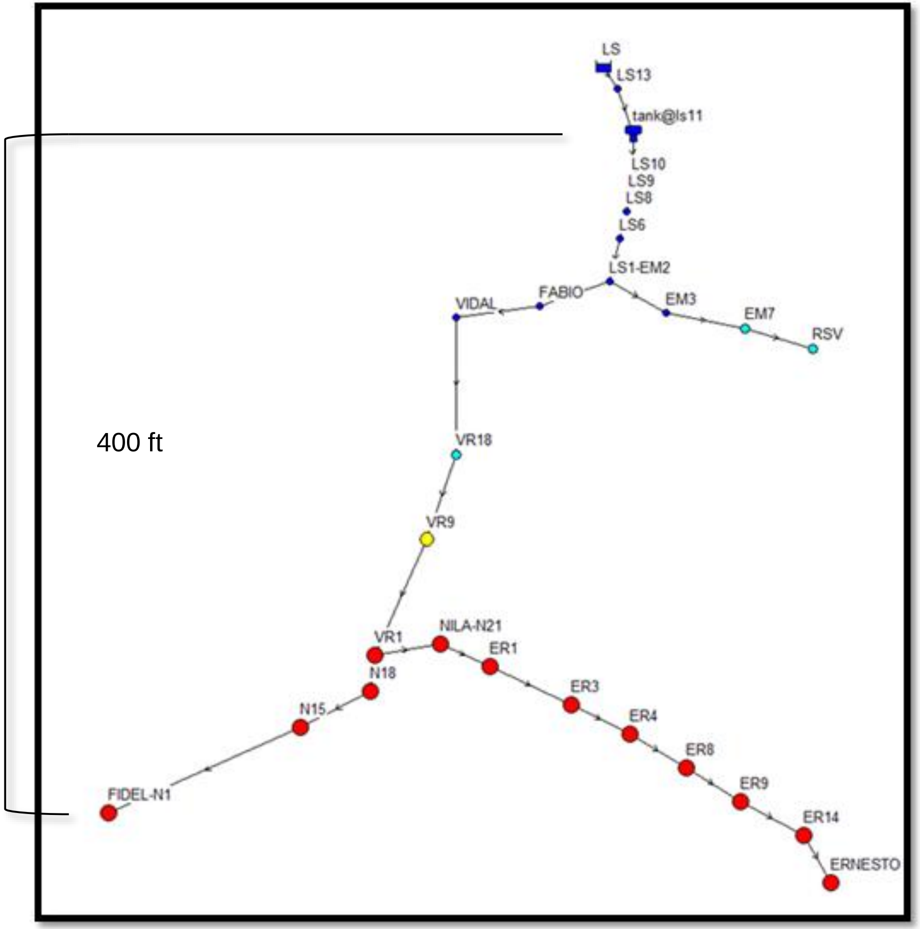
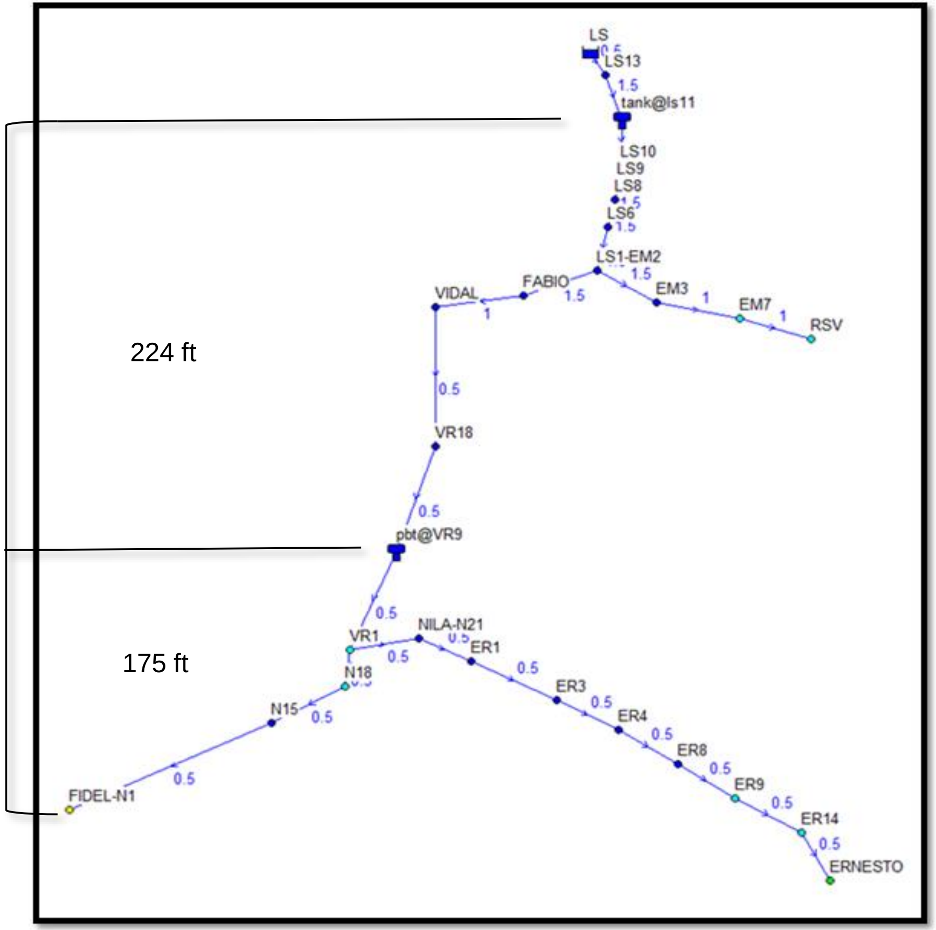
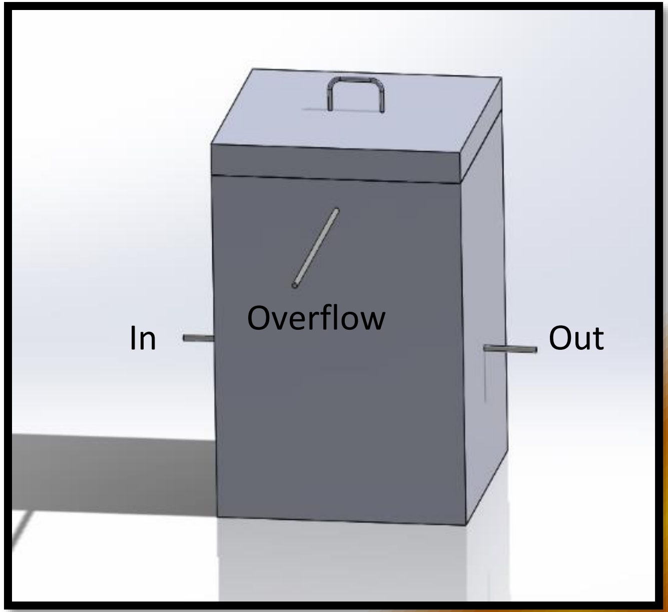
Pressure Break Tank



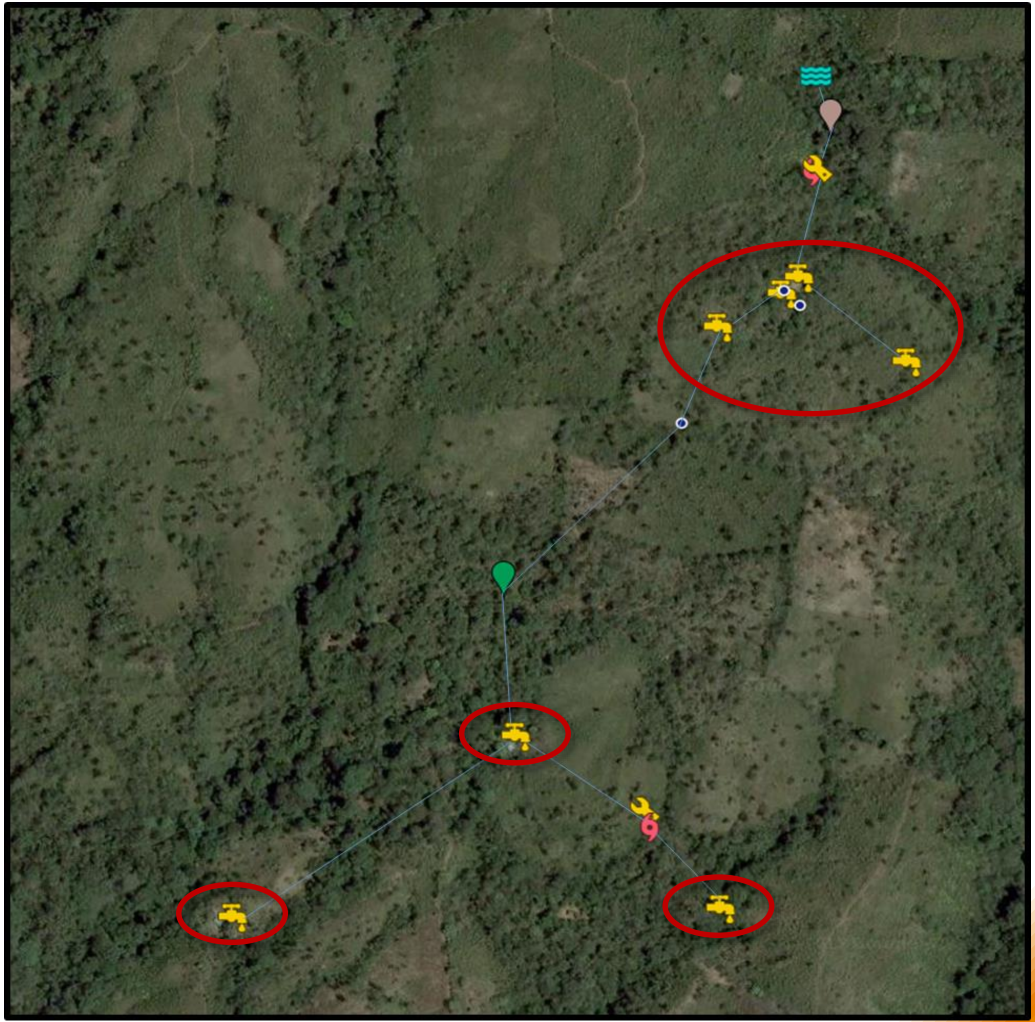


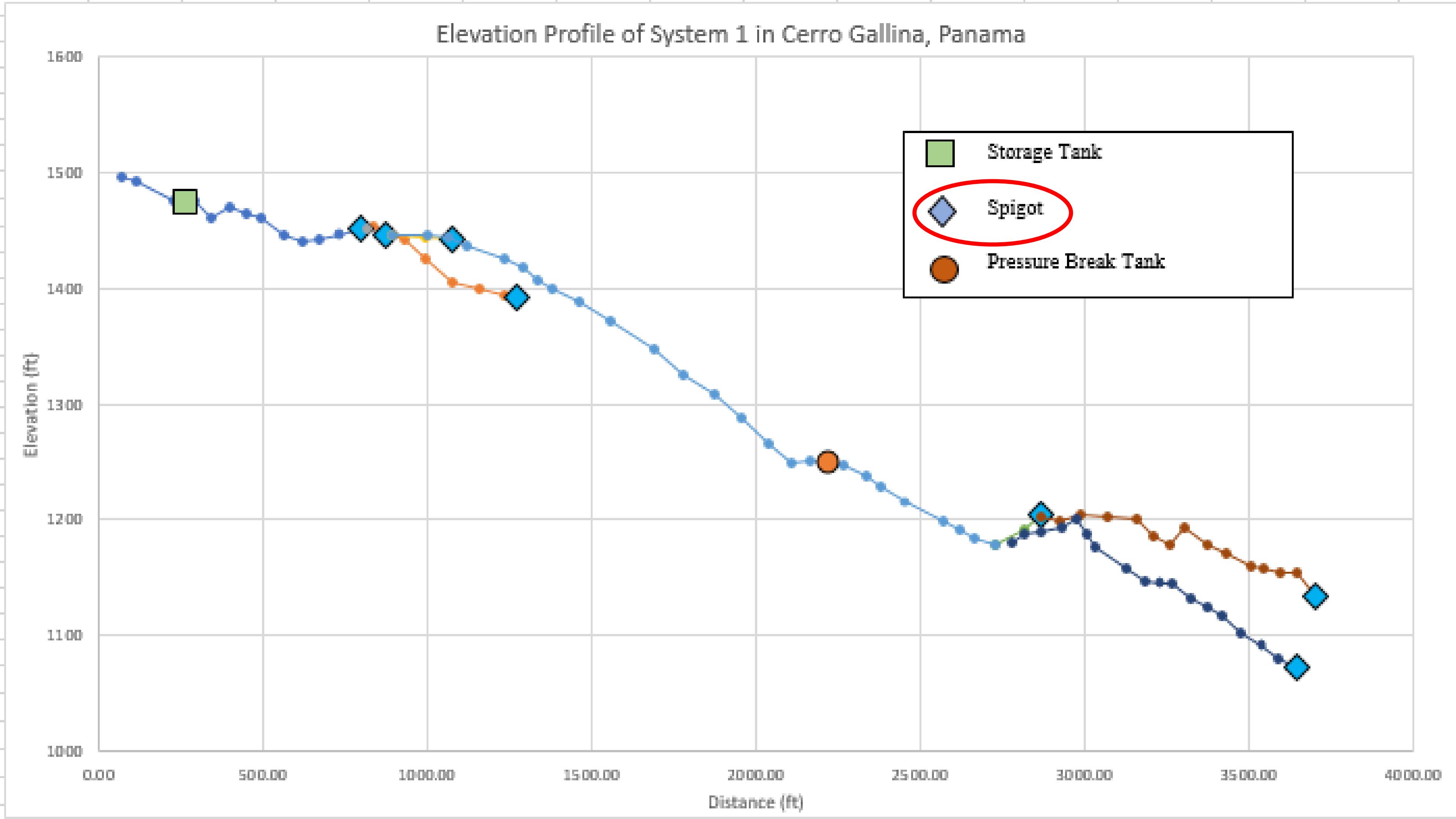
Design Components

- 0.5” pipes
- 1.5 ft square base, 2 ft tall
- 1:2:3 concrete mix
- Lid includes 3/8th inch rebar



Spigots





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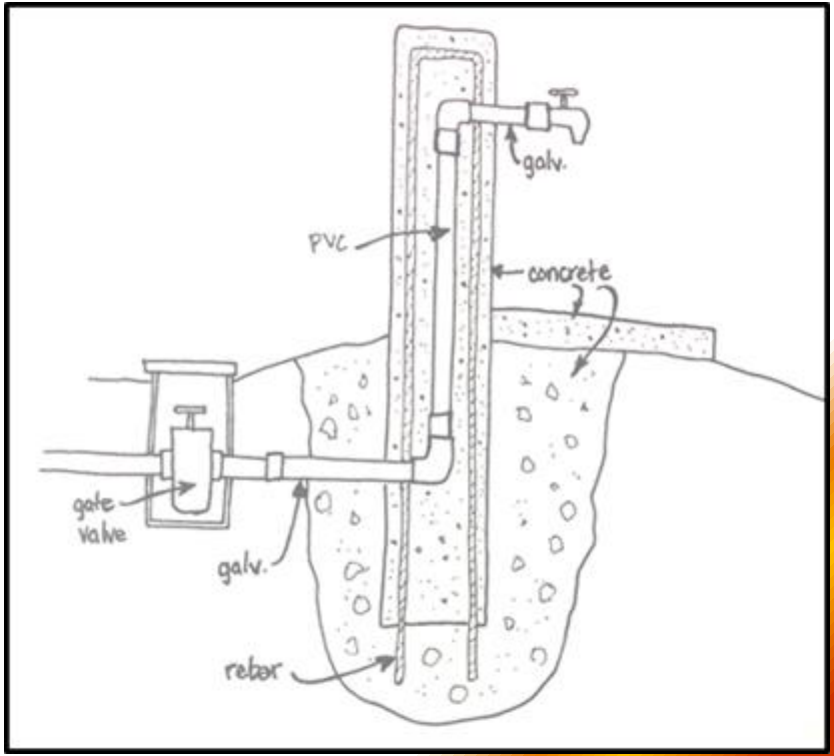
Distance (ft)
Storage Tank
Spigot
Pressure Break Tank

Spigots

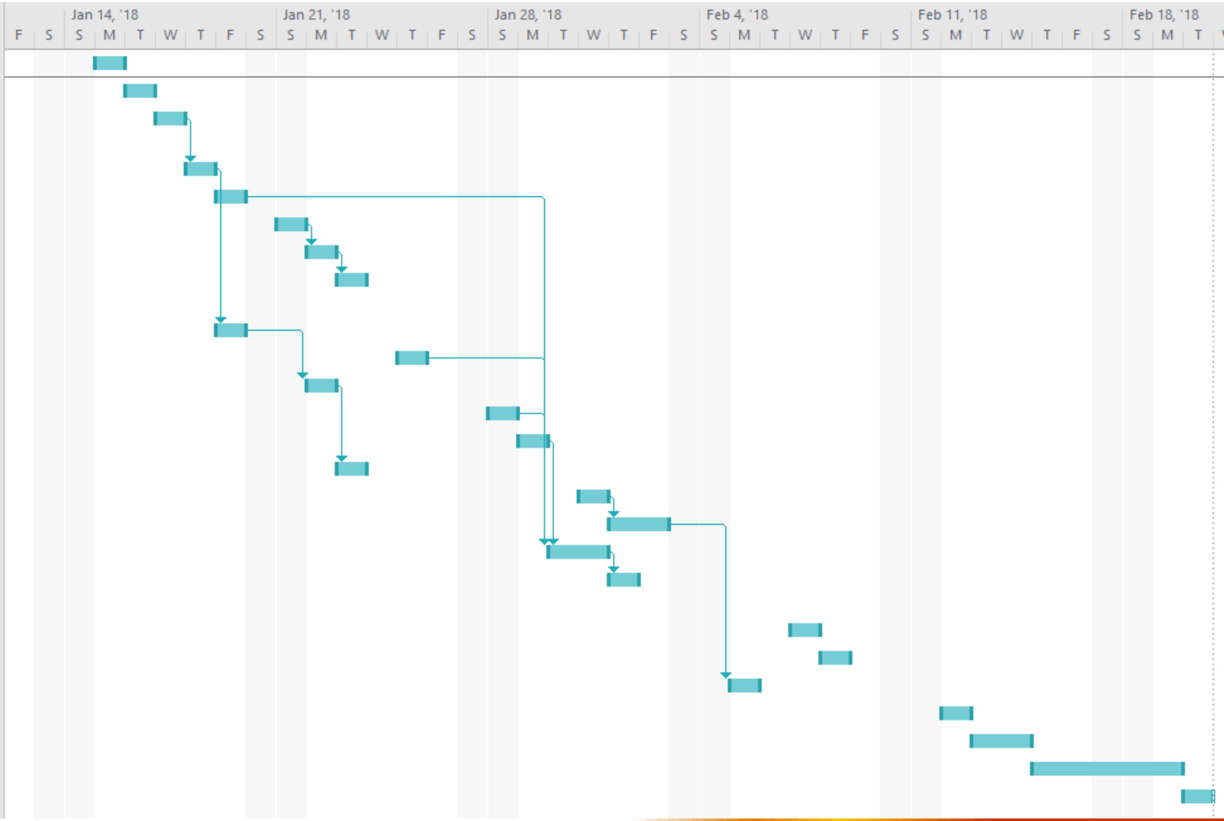
- 1 ft^3 of concrete per spigot
- PVC: valve, elbow joint, couplets, and ½ inch pipe.
- Galvanized pipe: elbow joint, brass valve, two couplets, and ½ inch pipe.
- Rebar for support



Construction Scheduling

GANTT CHART

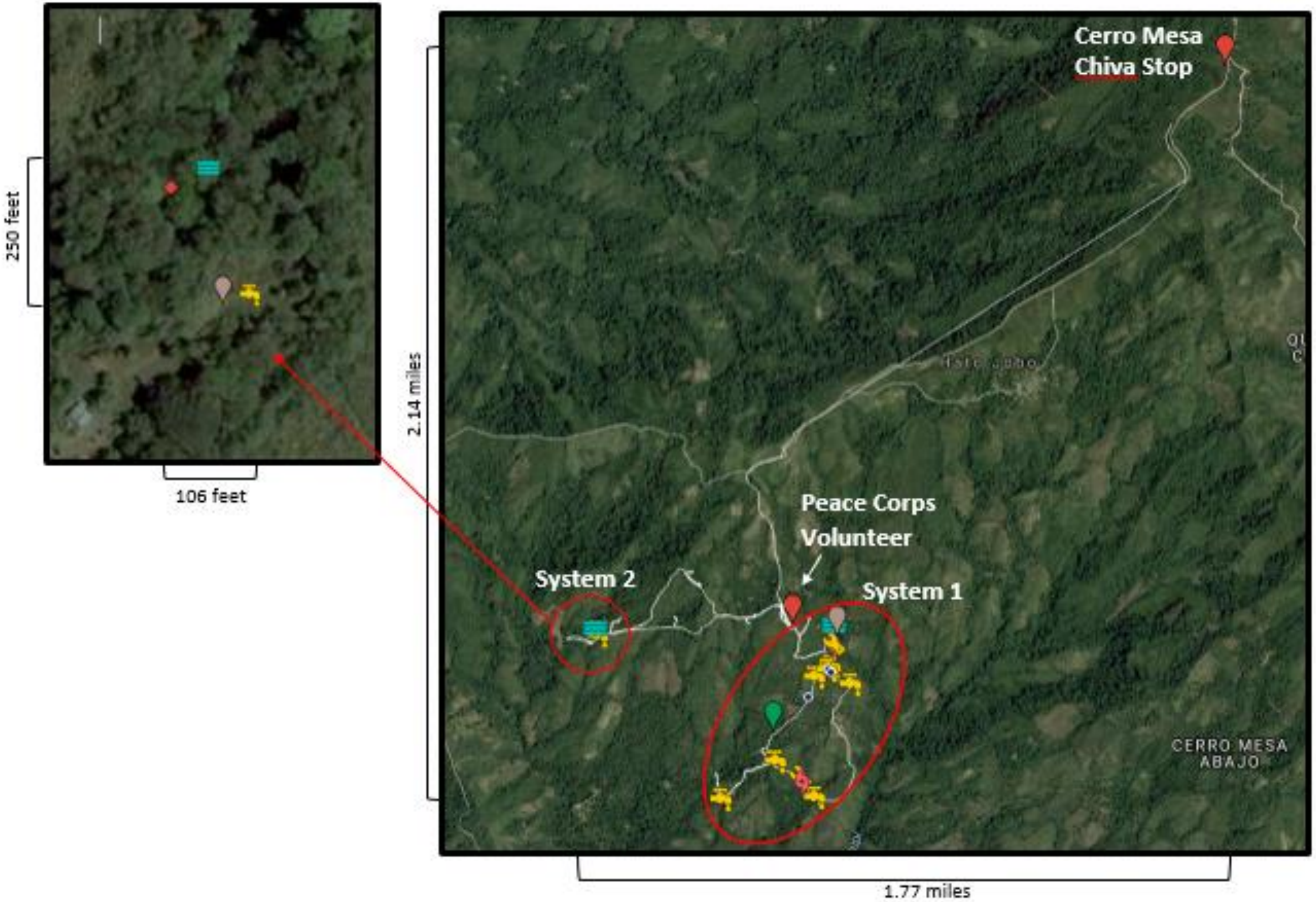
	Task Mode	Task Name
1		Transporting Materials
2		Safety Training
3		Level & Compact Ground for Storage Tank
4		Place Forms & Pour Base Slab for Storage Tank
5		Dig Trench from Tank to Vidals
6		Prepare spring location for spring box
7		Build spring box walls
8		Check to ensure walls have no leaks, pour spring box cover & hatch
9		Lay first four layers of tank walls
10		Dig trench from Vidal's to PBT
11		Lay last four layers of tank walls
12		Dig trench from PBT to Fedal's
13		Dig Trench from Nila to Ernesto's
14		Fill tank walls with mortar & rebar
15		Build Pressure Break Tank, set forms for tank cover
16		Pour Storage Tank Cover, Pour Forms For Valve Boxes
17		Lay System Pipes
18		Check System Pipe Connections, install chlorinator, Build first 2 spigots
19		Build Remaining Spigots
20		Build and Place Tank Hatch
21		Assemble and install all valve boxes
22		Test System
23		Make adjustments if needed and fill in the trenches
24		Contingency Days
25		Clean Construction Site



System 2: Ram Pump Distribution

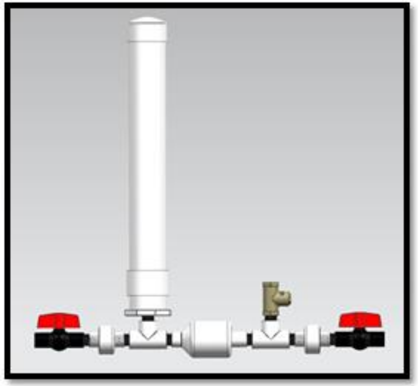
Problem Statement: Design a pump system for families that are high above the spring source.

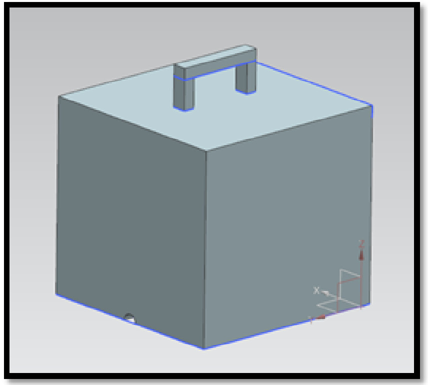
- Pump fed water distribution system
- Servicing one home
- Home located on the top of a hill
- Will be funded by the family

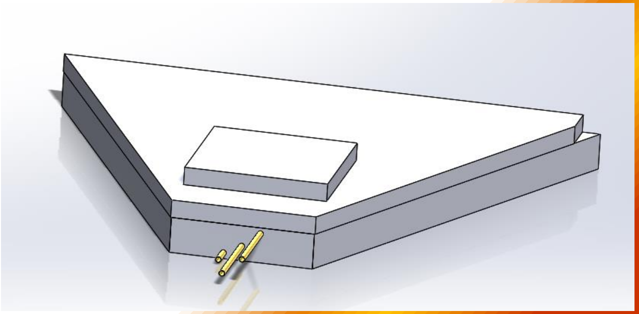

250 feet
106 feet
2.14 miles
Cerro Mesa
Chiva Stop
Peace Corps
Volunteer
System 2
System 1
CERRO MESA
ABAJO
1.77 miles

Project Components : System 2

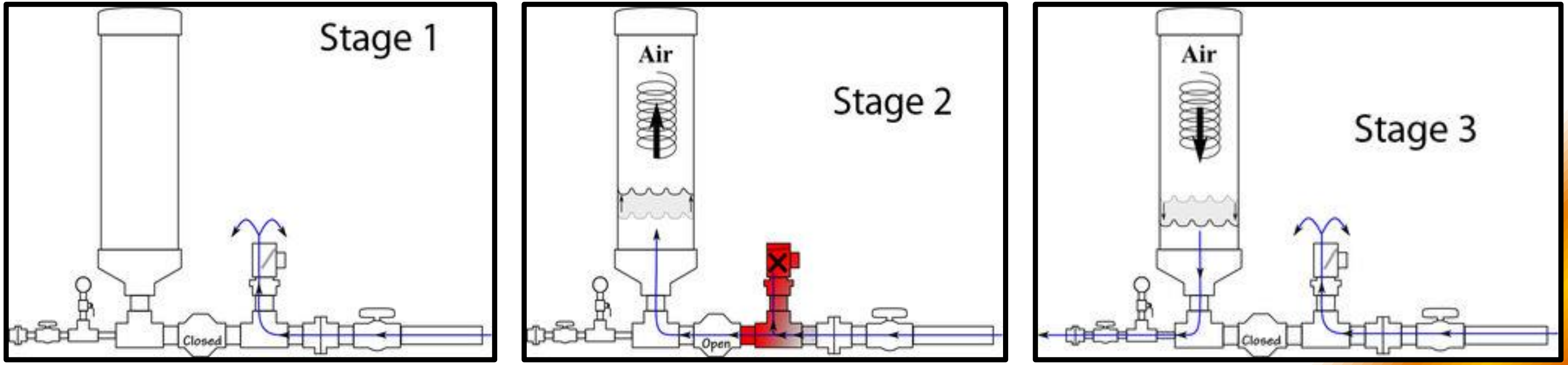
- Homemade ram pump
- Low profile spring box
- Piping system
- 55 gallon storage tank
- Ram pump cover box





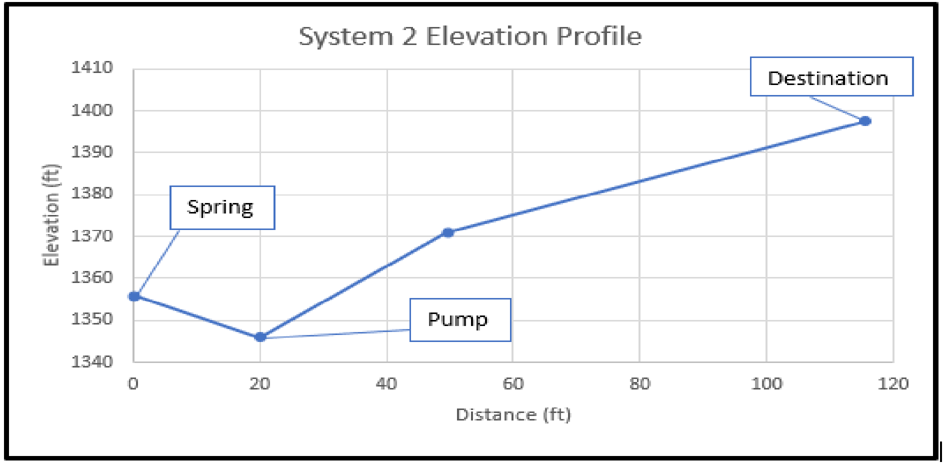


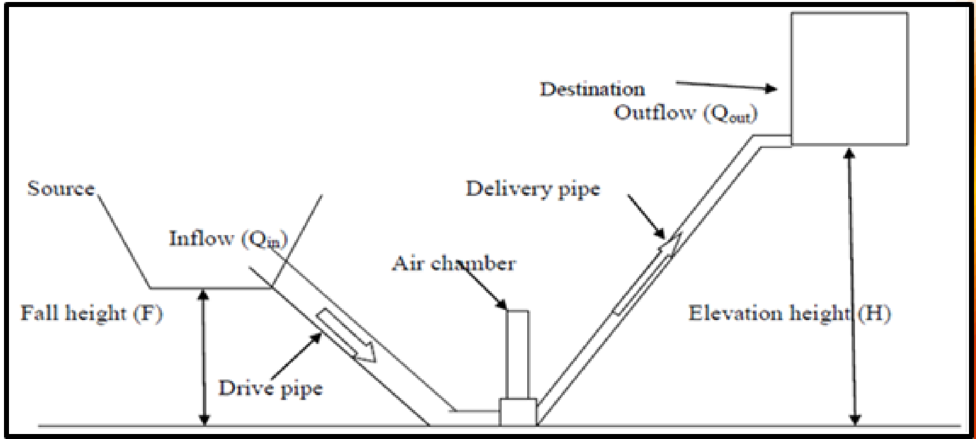
Ram Pump



Elevation Profile

- 10 feet drop from the spring source to the ram pump
- 52 feet of lift required to carry water from the pump up to the storage tank





Flowrate and Design validation

- Flowrate from spring = **1.43 gpm**
- Flowrate at destination = **0.23 gpm**

$$Qp = \frac{2 * Hd * Qd}{3 * Hp}$$

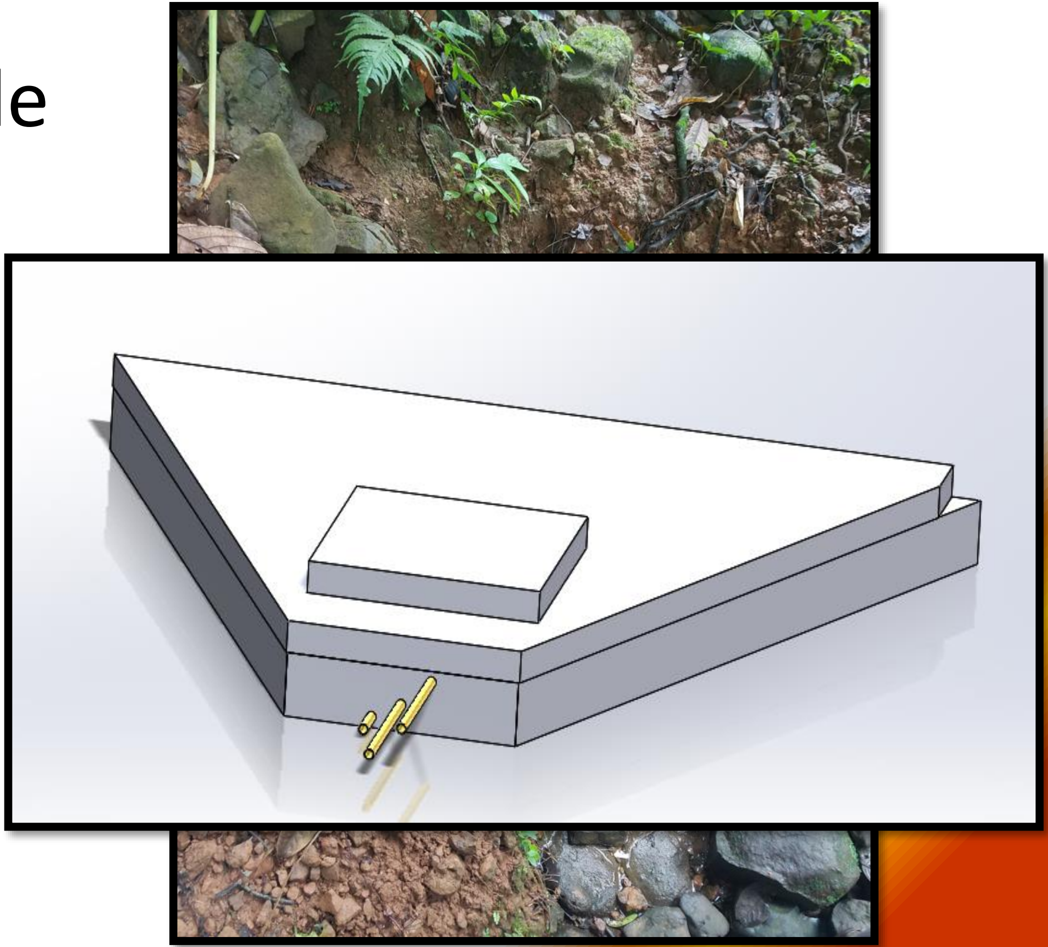
Qp= Flow Rate at Top of Hill
Hd= Falling Head
Qd= Falling Flow From Spring
Hp= Lifting Head

- Validated by tests ran at Clemson University

Drive Pipe Diameter (inches)	Delivery Pipe Diameter (inches)	At Minimum Inflow		At Maximum Inflow	
		Pump Inflow (gallons per minute)	Expected Output (gallons per minute)	Pump Inflow (gallons per minute)	Expected Output (gallons per minute)
3/4	1/2	3/4	1/10	2	1/4
1	1/2	1-1/2	1/5	6	3/4
1-1/4	1/2	2	1/4	10	1-1/5
1-1/2	3/4	2-1/2	3/10	15	1-3/4
2	1	3	3/8	33	4
2-1/2	1-1/4	12	1-1/2	45	5-2/5
3	1-1/2	20	2-1/2	75	9
4	2	30	3-5/8	150	18
6	3	75	9	400	48
8	4	400	48	800	96

Spring box – Low Profile

- Spring dimensions
  - 6.5 x 2.5 feet
- Wing walls
  - Thickness = 0.5 ft
  - Width = 7.11 ft
  - Height = 1 ft
- Concrete lid with a hatch for access
- Three pipes
  - Overflow
  - Transmission
  - Cleanout



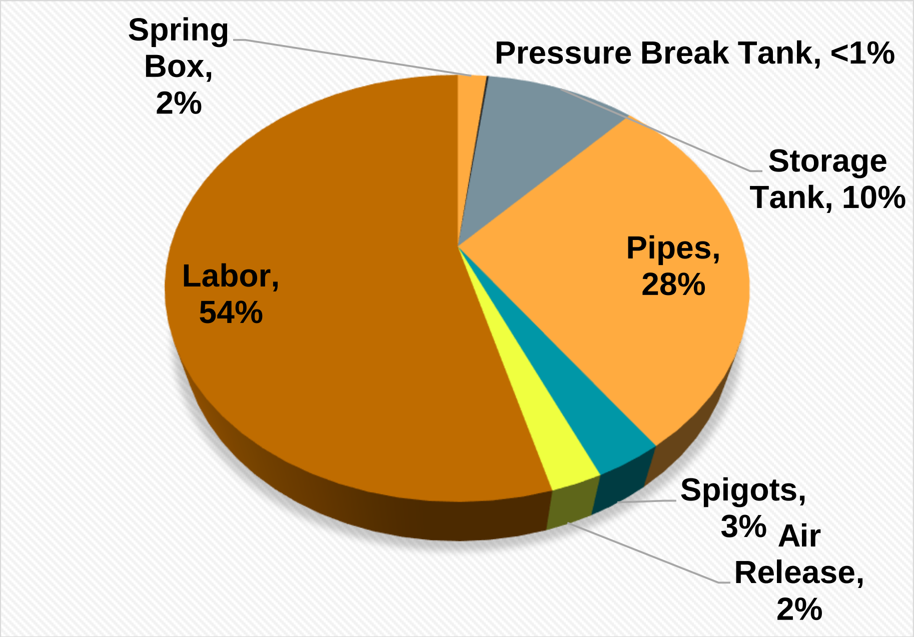
Construction Scheduling

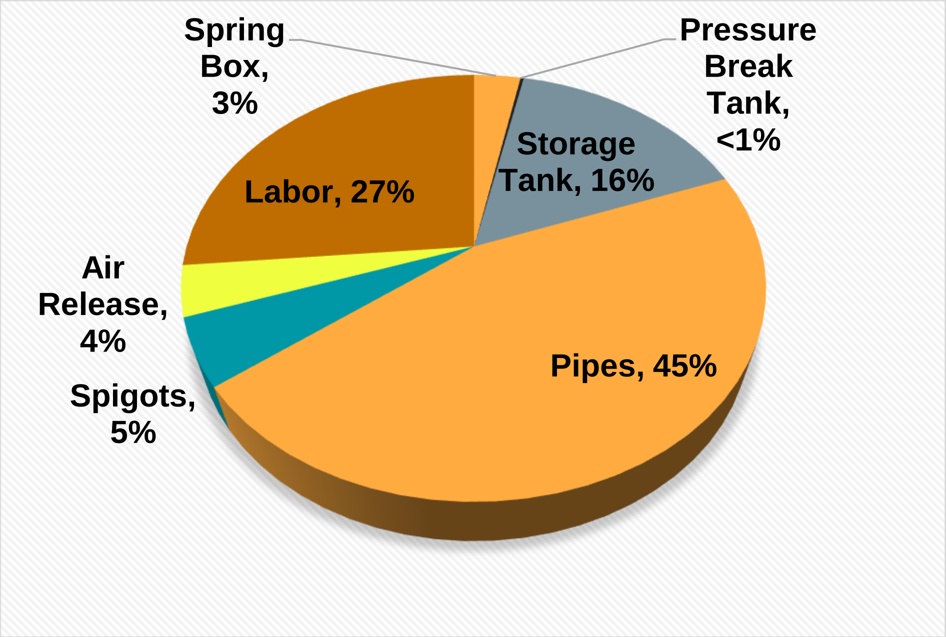
- Project Duration: **48 days (7 weeks)**
- Estimated time may seem long due to the fact that there will be no skilled labors and this will all be done by the family

System 2 Schedule

Task #	Task Description	Task Duration
Task 1	Travel into town and gather parts for pump	1 day
Task 2	Assemble Pump	3 days
Task 3	Excavate and Level ground for Spring Box	3 days
Task 4	Gather Material to Build Molds With	2 days
Task 5	Build Molds for Spring Box	2 days
Task 6	Put Molds in Place	1 day
Task 7	Travel into Town and get Material for Concrete	1 day
Task 8	Mix and Pour Concrete for Spring Box	1 day
Task 9	Travel into town and get PVC for system	1 day
Task 10	Have a 55 Gallon Drum Delivered	1 day
Task 11	Gather Material for Protection the Pump	1 day
Task 12	Build a Holding and Protection Box for Pump	2 days
Task 13	Connect System: Spring Box, Ram Pump, and Drum	3 days
Task 14	Test the System	1 day
Task 15	Inspect System	5 days
Task 16	Make ajustments to System	1 day
Task 17	Clean up from Project	1 day
	Total Duration Without any Days off	**48 Days**

Cost System 1

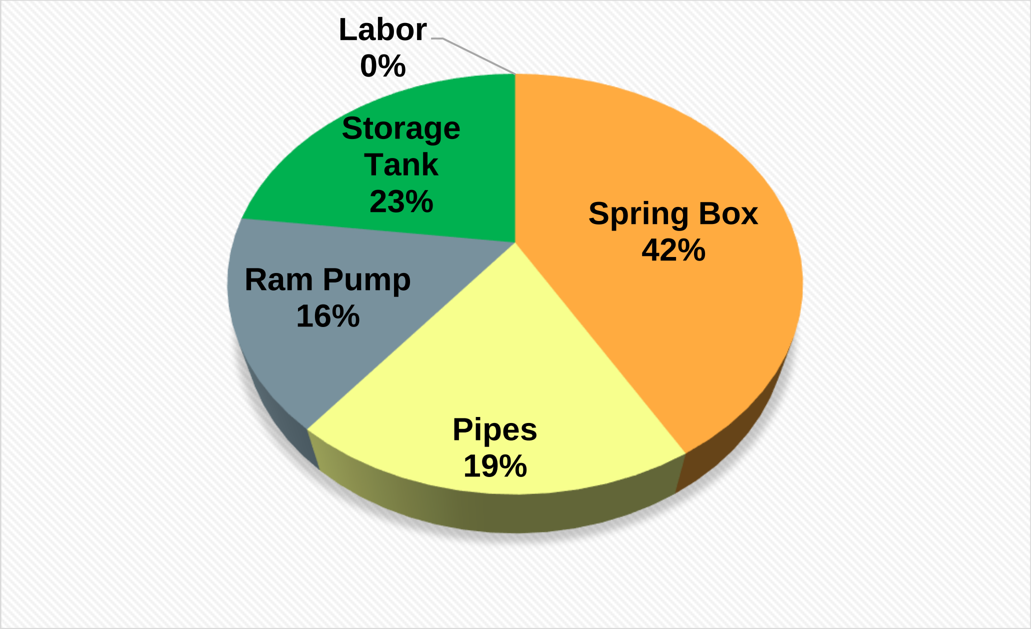




Using government labor: $8,000

Using community labor: $5,000

Cost System 2



Total cost: $240

Operation and Maintenance

System 1

- Operated by Water Committee
- Peace Corps volunteer support
- Monitor for leaks or breakage bi-annually
- Minimally used valves should be turned monthly
- Test for coliform using 3M petri-films or request MINSA support if poor water quality is noticed
- Maintenance costs are to be divided between families

System 2

- Constructed and operated by the owner
- Ram pump requires priming prior to running
- Maintenance actions and costs are the responsibility of the family
    - Clean the spring
    - Replace damaged fittings or pipes

Conclusion

System 1

- Design
  - The spring provides 4.72 gpm
  - 1982 gallon storage tank
  - Pressure Break Tank
  - 7 spigots, about 45 people
- Cost = $5000 to $8000
- 5 week implementation schedule
  - January-March 2018
- Owned by the water committee
- Regular maintenance may require a monthly fee

System 2

- Design
  - Spring box
  - Ram pump and cover
  - Serving 6-7 people
- Cost = $240
- 3 month implementation schedule
- Owned by the individual family

Acknowledgements

Advisors:

- Dr. Mike Drewyor
- Dr. David Watkins

Peace Crops-Panama:

- Sierra Schatz-University of Michigan

Questions?

References

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