



Operación de Agua Potable

Quebrada Caracol, Panama

Clean Water Consulting

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Outline

- △ Introduction
- △ Data Collection
- △ Final Design
- △ Cost Estimate
- △ Schedule
- △ Questions

Community Background

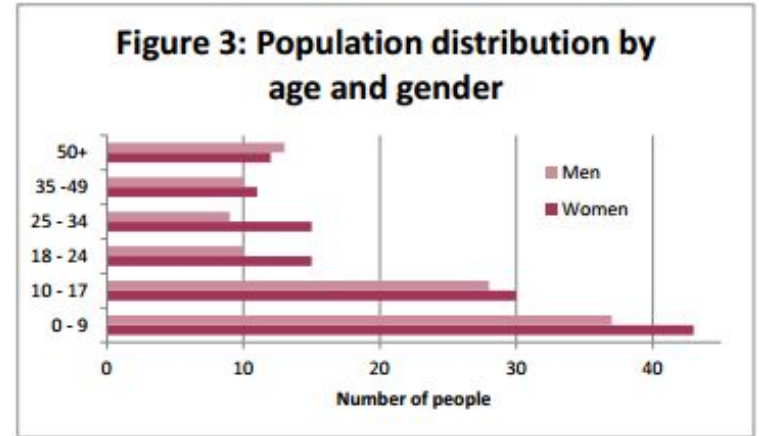
Geographic Location

Δ Quebrada Caracol, Ngöbe-Buglé Comarca, Panama

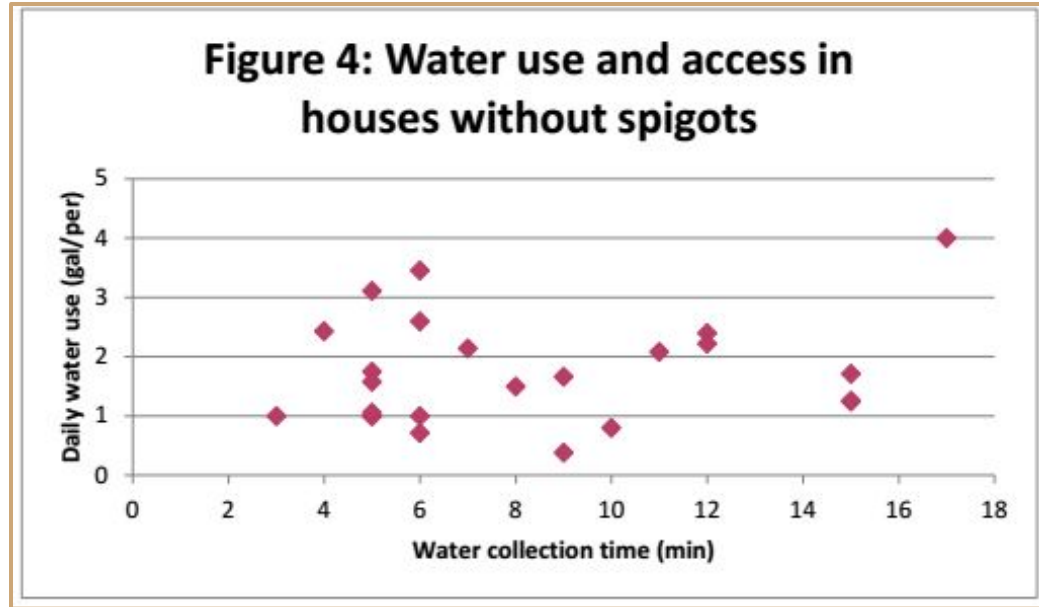


Community Population

- △ 233 residents living in the community
- △ 103 residents living outside of the community
- △ Education until elementary or middle school
- △ Seventh Day Adventists



Water Access



Water Collection Sites



Sanitation and Health

Community Goal	Environmental Health Project Objective
Aqueduct Repair	<ol style="list-style-type: none">1. Water committees will adopt water system management methods2. Potable water systems will be rehabilitated
Latrines	<ol style="list-style-type: none">1. Community access to sanitation

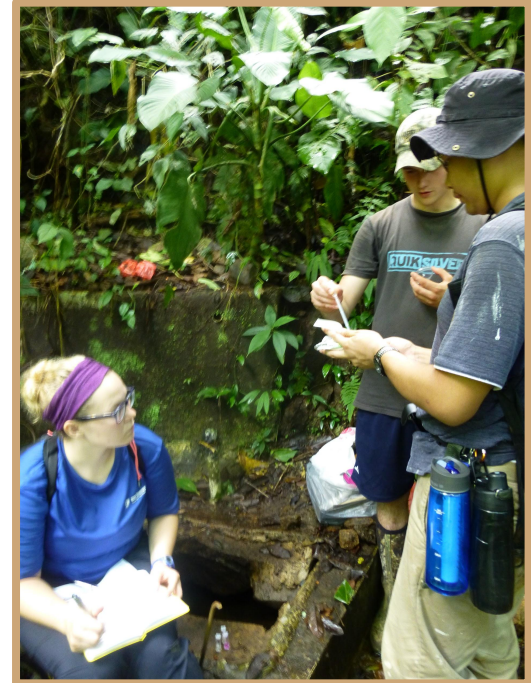
Project Objectives

- △ Protect watershed to enhance quality of spring water
 - Spring supplies drinking water to the system
- △ Rehabilitate water distribution system
 - Update and fix current system
 - Service additional homes

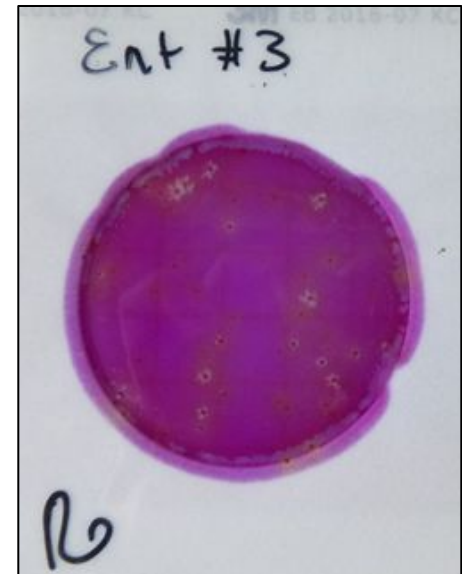
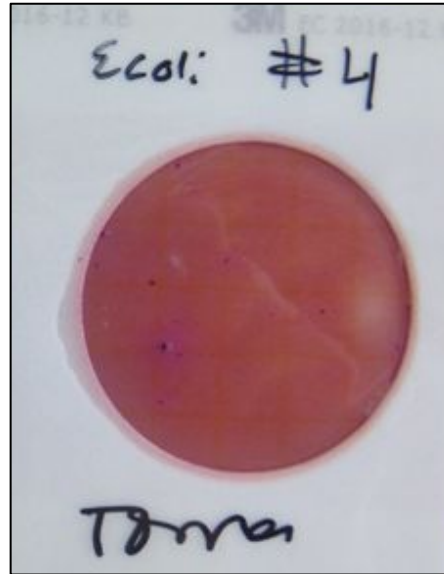
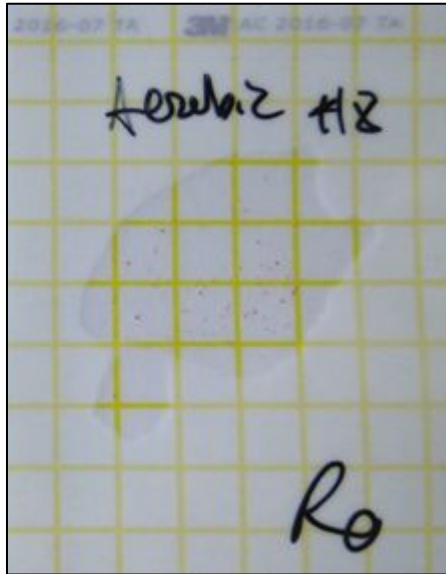
Data Collection and Analysis

Data Collection Objectives

- △ Perform water quality analysis
 - Test for types of bacteria in water
- △ Map the micro-watershed protection
 - Delineate watershed
 - Locate contamination sources
- △ Evaluate existing distribution system
 - Gravity fed distribution system



Water Quality Data Collection



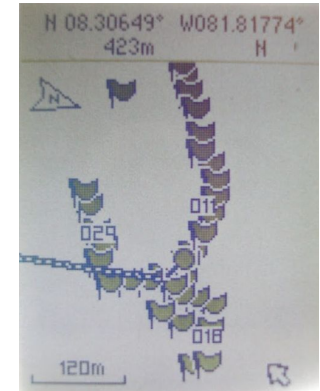
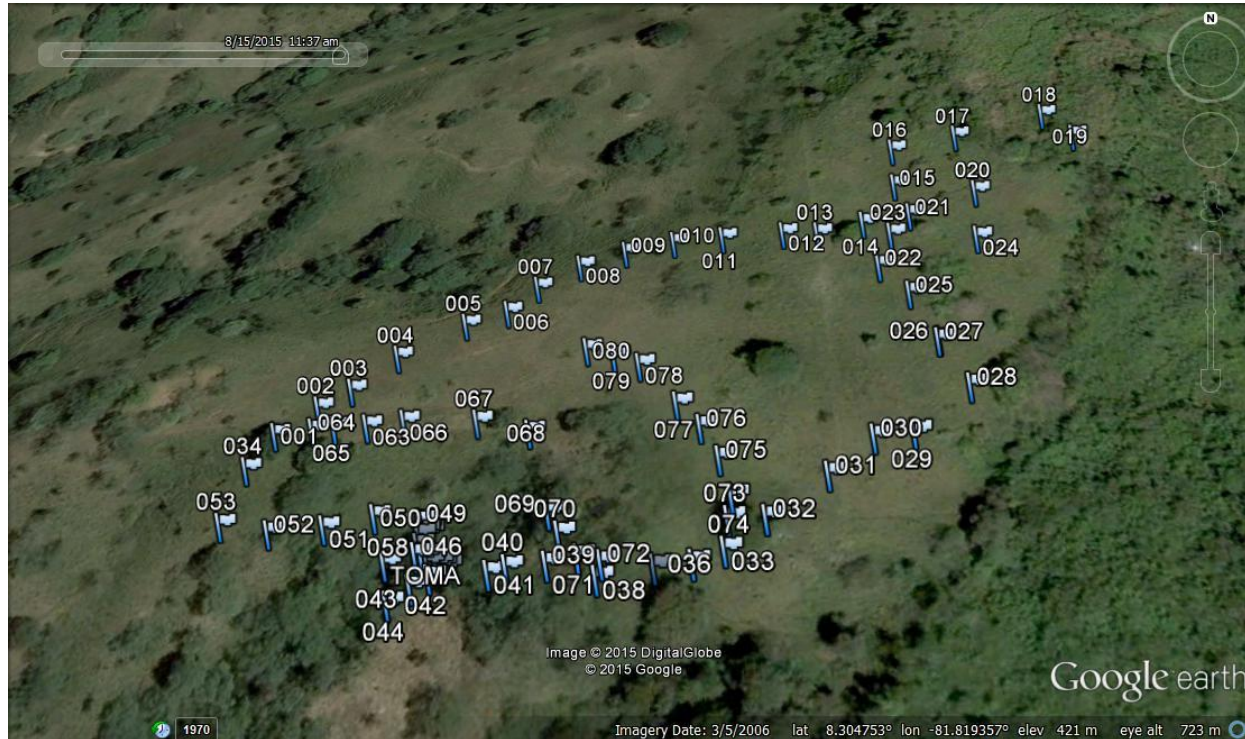
Water Quality Analysis

Spring Box				
Sample #	Aerobic Bacteria	E. coli/total coliforms		Enterobacteriaceae
	Colonies per 1 mL	# of counted E. coli colonies	Total Colonies per 1 mL	Colonies per 1 mL
1	482	0	11	5
2	169	0	6	9
3	96	0	11	14
4	26	1	13	14
5	57	0	25	22
6	44	0	8	35
7	34	0	31	26
8	39	0	25	12
9	19	0	8	10
10	41	0	23	20

Runoff				
Sample #	Aerobic Bacteria	E. coli/total coliforms		Enterobacteriaceae
	Colonies per 1 mL	# of counted E. coli colonies	Colonies per 1 mL	Colonies per 1 mL
1	263	0	73	49
2	112	0	87	58
3	56	0	62	58
4	77	1	70	43
5	83	0	80	53
6	2181	0	58	51
7	242	0	60	56
8	130	0	30	55
9	136	0	38	67
10	748	0	41	40

Potable Water Standards			
	World Health Organization	US Environmental Protection Agency	Panama Regulations
Units			
Total Coliform	Colonies/ 1 mL	0	<0.01
Fecal Coliform (includes E. coli)	Colonies/ 1 mL	0	0

Watershed Delineation



Watershed Analysis

- △ Total Area of 55,000 m²
- △ Peak Discharge = 58.0 L/s
 - Runoff coefficient = 0.62
 - Intensity = 178 mm/day



Current Distribution System



Spring Box



Distribution Line



Storage Tank

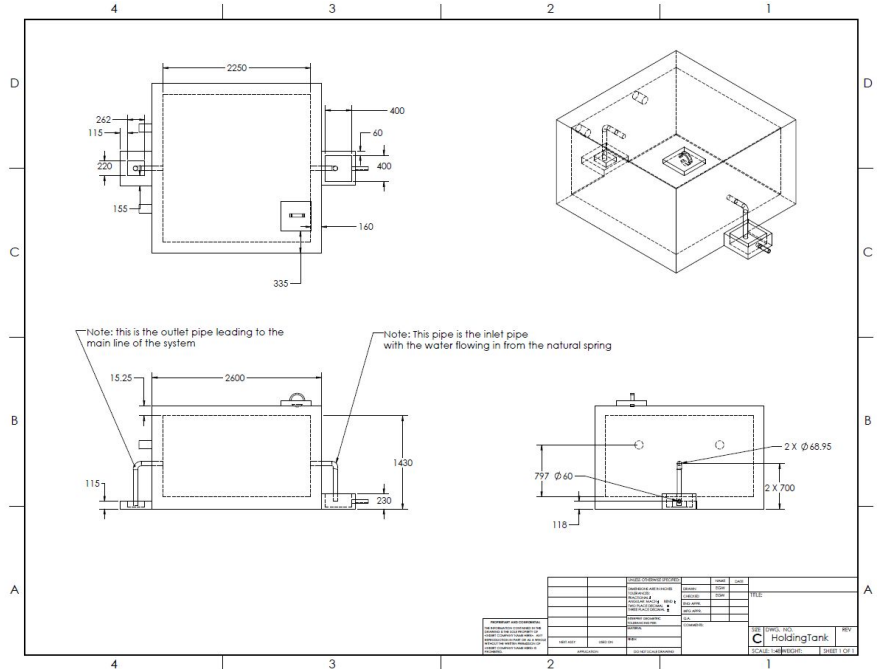


Chlorination

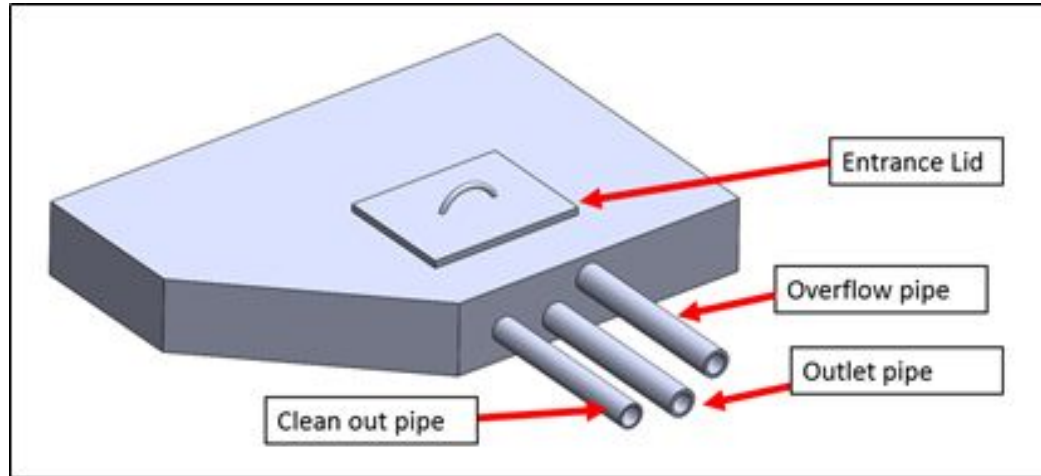


Outsource

Infrastructure Evaluation

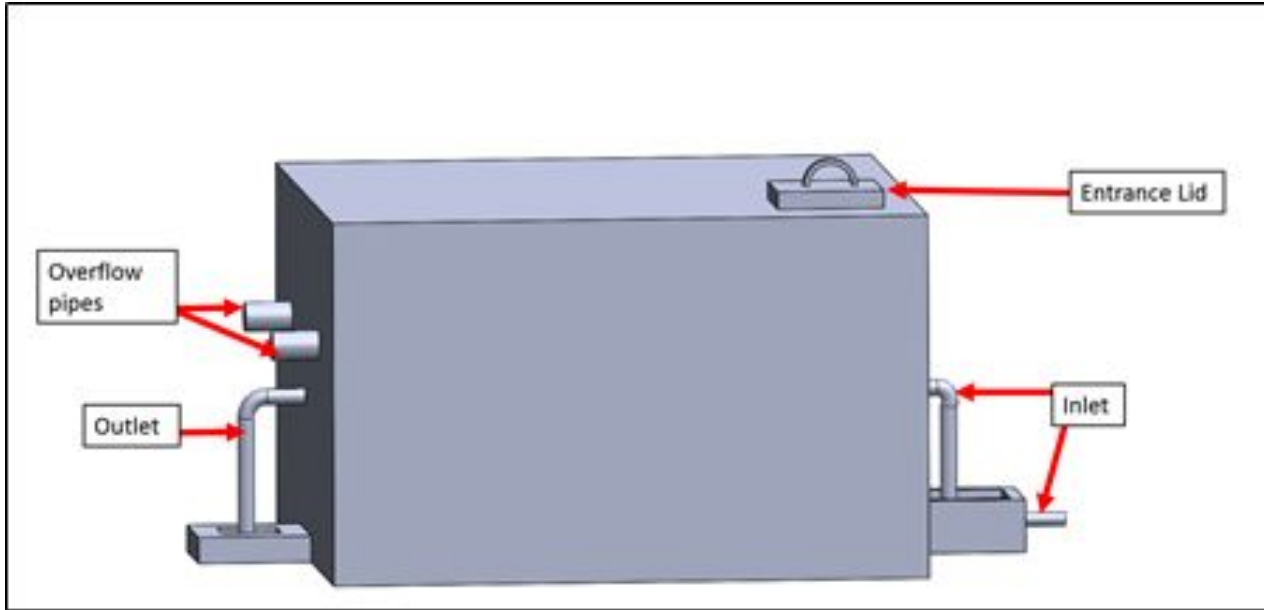


Spring Box



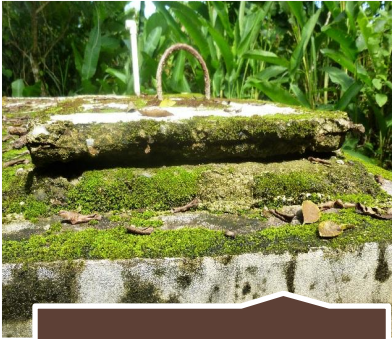
Spring Box design with key components labeled

Storage Tank



Storage Tank Design with Key Components Labeled

Sources of Contamination



Poorly fit lids



Lack of screening



Damaged pipes

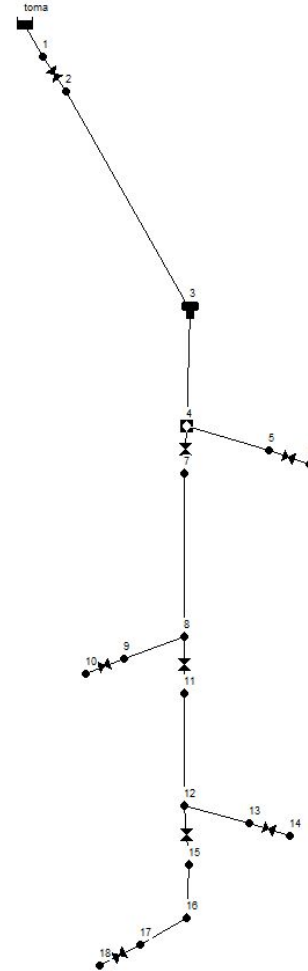
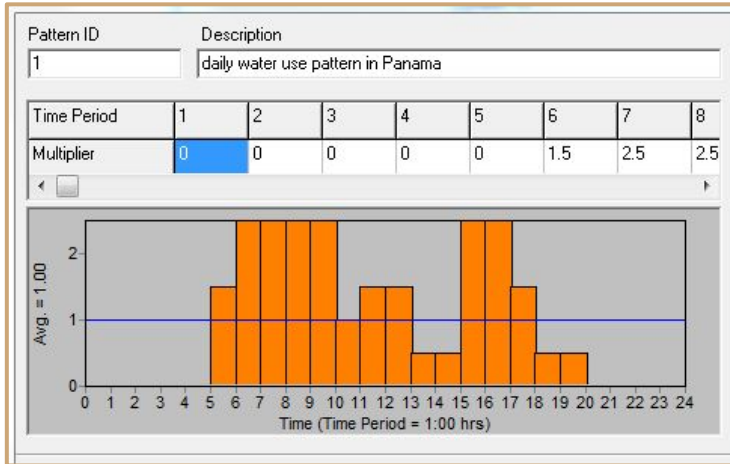


Runoff

Design

Hydraulic Model

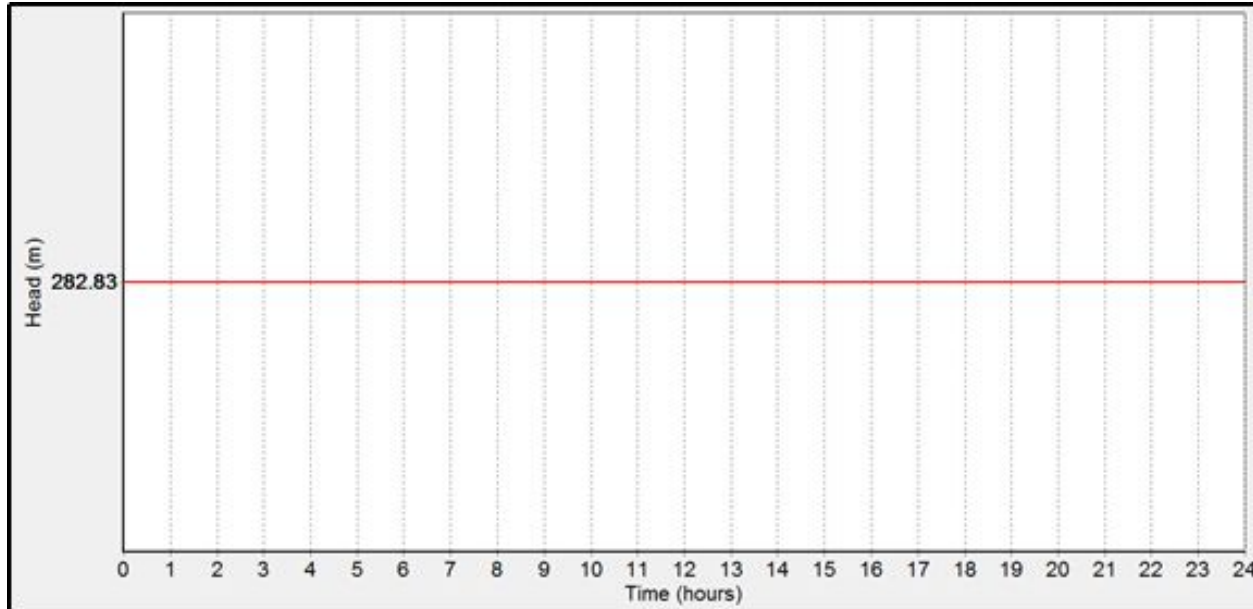
- △ Modelled using EPANET
- △ Performance with four extensions
- △ Determined a water demand pattern



EPANET Analysis

$$\frac{30 \text{ gal}}{\text{person} \cdot \text{day}} * \frac{8 \text{ people}}{\text{household}} * \frac{3.79 \text{ L}}{1 \text{ gal}} * \frac{1 \text{ day}}{24 \text{ hr}} * \frac{1 \text{ hr}}{60 \text{ min}} * \frac{1 \text{ day}}{24 \text{ hr}} = 0.63 \frac{\text{Lpm}}{\text{household}}$$

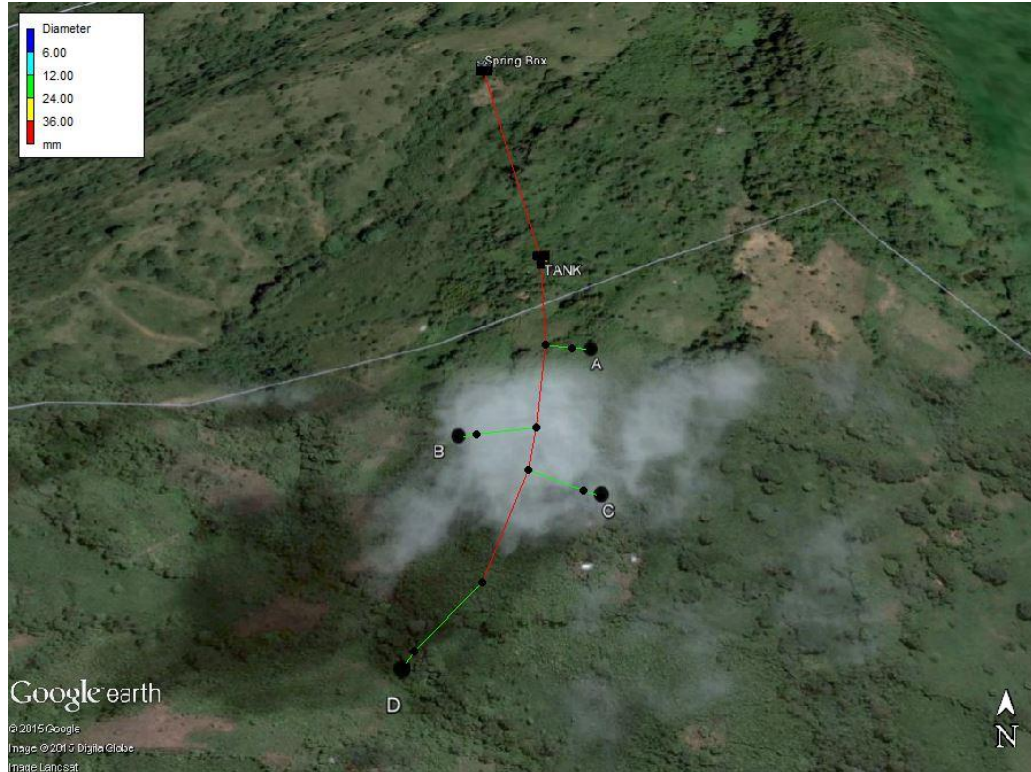
EPANET Graph of Water Level in Storage Tank



Static Pressures

Node	Pressure
PSI	
Toma	0.0
3	1.2
4	18.2
5	28.2
6	26.8
7	19.7
8	78.0
9	85.1
10	83.7
11	79.4
12	90.8
13	87.9
14	86.5
15	92.2
16	110.7
17	157.6
18	156.2

Aerial View of Water Distribution System



Suggested Improvements

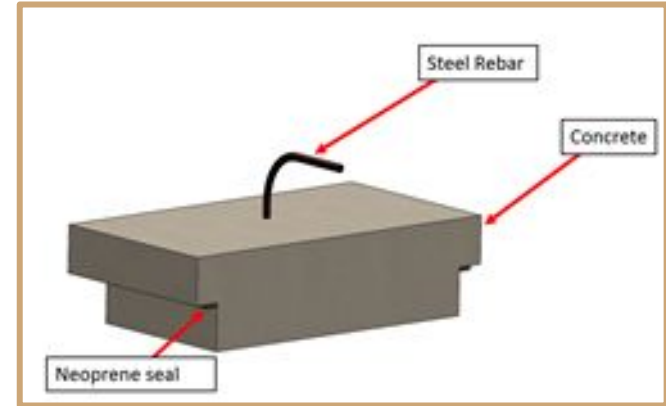
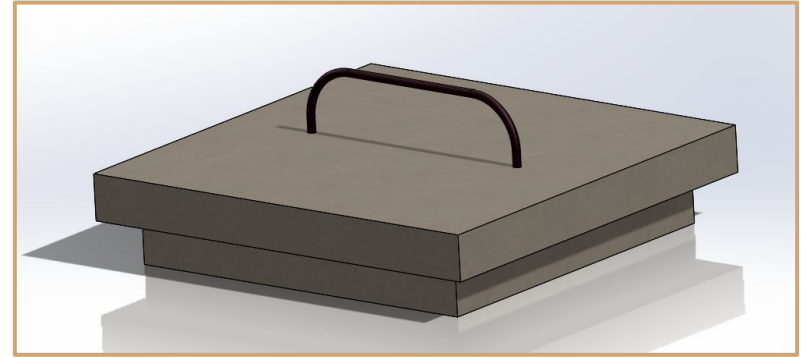
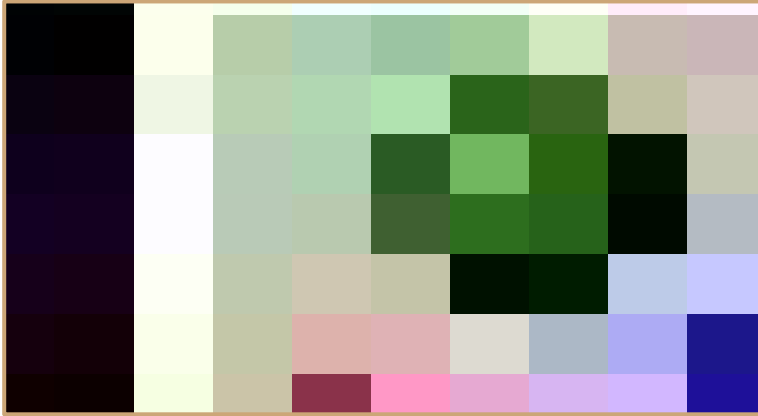
Chlorination System

- Δ New chlorination system upstream of storage tank
- Δ Concentration Time = 84 mg-min/L
 - Sufficient time to disinfect water from common pathogens



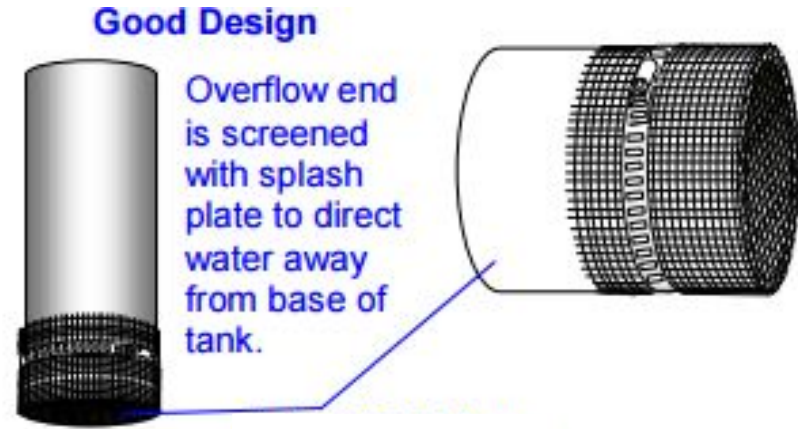
Redesign Lids

- △ Redesign lids of storage tank and spring box for a more secure fit



#24 Stainless Steel Mesh over outlet pipes

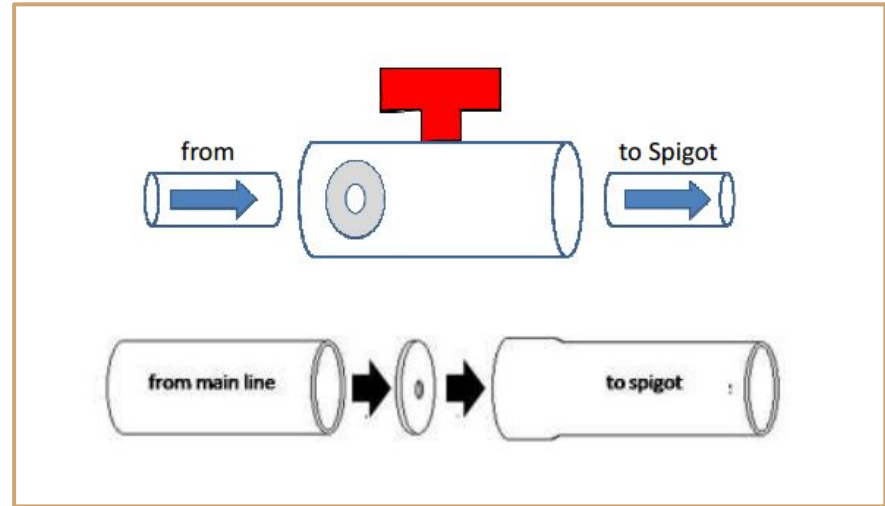
- Δ Vent/Outflow screening
#24 stainless steel mesh used to screen mesh overflow
- Δ \$75.00 per 15 square feet of mesh



EPA Region 8 Drinking Water Unit Tech Tips
Sanitary Protection of Drinking Water Storage Tanks:
24 Mesh Non-corrodible Screen

Pressure Reduction via Flow Reducing Discs

- △ Flow-reducing discs sizes designed using previous metrics defined by masters student, Briana Drake
- △ Regulates flow with flow-reducing discs as opposed to widely varying pipe sizes



System Analysis with Flow Reducing Disks

Node	Pressure with no discs (psi)	Number of discs to be added	Pressure with discs (psi)
10	83.7	1	58.7
14	86.5	1	61.5
18	156.2	4	56

Calculations for Flow Reducing Discs

- Δ h is the change in pressure head desired in units of pascals
- Δ θ is a coefficient given by Drakes report
- Δ Q is the flow in m³/sec
- Δ d is the diameter of the hole to be made in the flow reduction disc

$$\Delta h = \theta \frac{Q^2}{d^4}$$

Runoff Diversion

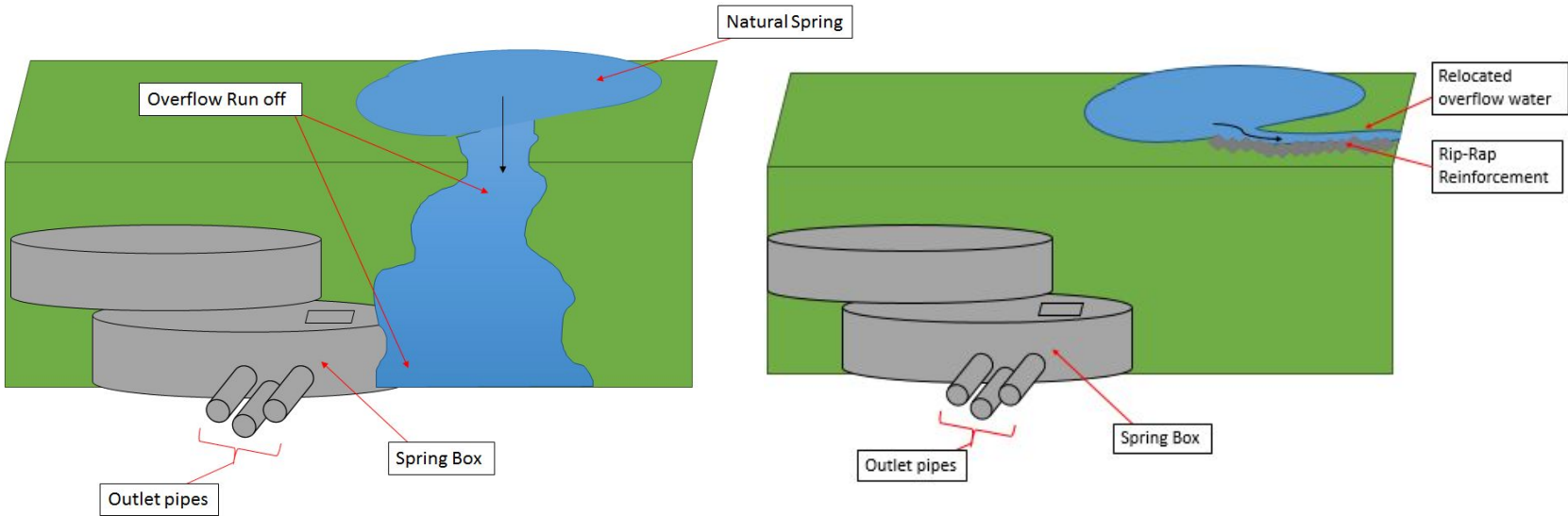
- △ Reason: Runoff water is from spring designated for cow use
- △ Plan: Divert runoff with a trench and rip-rap reinforcement



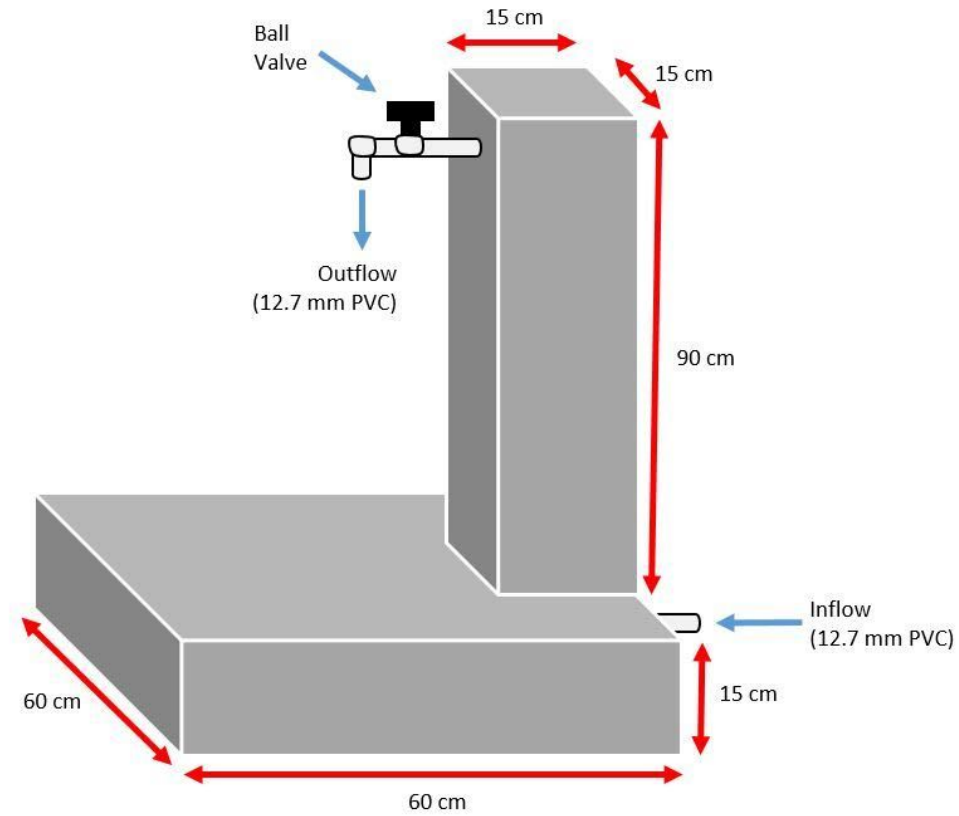
Runoff Diversion

Before

After



Tap Stands



Material and Labor Costs

Task	Price
Piping Improvements	\$ 4,350.00
Chlorinator Improvement	\$ 100.00
Lid Improvements	\$ 255.00
Tap Stands	\$ 200.00
Tools and Equipment	\$ 680.00
Total	\$ 5,585.00

Task	Work hours	Labor Value
Buy and Transport Materials	26	\$ 208.00
Runoff Diversion	32	\$ 256.00
Existing Storage Tank Updates	24	\$ 192.00
Piping	108	\$ 864.00
Total	190	\$ 1,520.00

Construction Schedule

- Δ 35 days to construct the system
- Δ 8 people working full time
 - 30 hours/week
 - No work on Saturday and Sunday
- Δ 2 month duration



Conclusion

Δ Data Collection

- Water quality
- Watershed analysis
- Infrastructure analysis

Δ Design

- Improvements to current system
- New chlorinator
- New lids
- Runoff diversion
- Extension to three additional homes
- Pressure reduction at taps
- Tap stands

Thank you!

Clean
Water
Consulting  

Acknowledgements

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Leigh Miller

References

1. Miller, Leigh. "Quebrada Caracol Analysis and Development Plan." (2015). Print.
2. "3M™ Petrifilm™ Aerobic Count Plates." *3M™ Food Safety Website – Product Catalog*. N.p., 2015. Web. 20 Aug. 2015.3M.
3. "3M™ Petrifilm™ E.coli/Coliform Count Plates." *3M™ Food Safety Website – Product Catalog*. N.p., 2015. Web. 20 Aug. 2015.
4. "3M™ Petrifilm™ Enterobacteriaceae Count Plates." *3M™ Food Safety Website – Product Catalog*. N.p., 2015. Web. 20 Aug. 2015.
5. "Drinking Water Contaminants." *United State Environmental Protection Agency*. N.p., 29 Oct. 2014. Web. 16 Sept. 2015. <<http://water.epa.gov/drink/contaminants/#Microorganisms>>.
6. "Shigella Food Poisoning." *About Shigella*. Ed. Marler Clark. N.p., n.d. Web. 28 Oct. 2015. <<http://www.about-shigella.com/>>.
7. "Typhoid Fever." *Health Topics*. World Health Organization, n.d. Web. 28 Oct. 2015. <http://www.who.int/topics/typhoid_fever/en/>.
8. Waite, Marilyn. *Sustainable Water Resources in the Built Environment*. N.p.: IWA Publishing, 2010. 162-64. Web. 16 Sept. 2015. <https://books.google.com/books?id=MeYmo5L6ecFC&pg=PA162&lpg=PA162&dq=panamanian+drinking+water+standards&source=bl&ots=mwwKdBy054&sig=vS_bNIMhaPRkIvBp1PySoR1gFAI&hl=en&sa=X&ved=0CD0Q6AEwBwVChMlj72x08>.
9. "What Is a Watershed?" *EPA*. N.p., n.d. Web. 25 Aug. 2015. <<http://water.epa.gov/type/watersheds/whatis.cfm>>.
10. EasyGPS. Computer software. EasyGPS. Vers. 5.48. TopoGrafix, 17 Aug. 2015. Web. 20 Aug. 2015. <<http://www.easygps.com/>>.
11. "Watershed." 8.304753 N and 81.819357 W. Google Earth. March 5, 2006. August 20, 2015.
12. Environmental Protection Agency, 'EPA Region 8 Drinking Water Unit Tech Tips, Sanitary Protection of Drinking Water Storage Tanks: # 24 Mesh Non-corrodible Screen'. [Online] Available:http://www2.epa.gov/sites/production/files/2014-05/documents/tech_tip_24_mesh_screen.pdf. [Accessed: 28-Sep-2015].
13. Compatible Technology International, 'Effectiveness of CTI Water Chlorinator at controlling bacterial contamination in rural Nicaragua's drinking water', 2015. [Online]. Available: <http://www.compatibletechnology.org/images/Nicaragua%20Water%20Study%20.pdf>. [Accessed: 21- Sep- 2015].
14. *Empresa de Transmision Eléctrica, S.A.*. Unimos Panama con Energia, n.d. Web. 18 Nov. 2015. <http://www.hidromet.com.pa/datos_diarios.php?estacion=6&mes=11&ano=2010>.
15. *Rational Equation Calculator*. LMNO Engineering, Research, and Software, Ltd., n.d. Web. 18 Nov. 2015. <<http://www.lmnoeng.com/Hydrology/rational.php>>.



Questions?