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Date:

To: Professors [NAME] and [NAME]

From: [NAME], Team X of Section XX [NAMES]

Subject: Progress Report for Week 6

Progress Report for Week 6

Designing a sustainable drinking water delivery system for cattle
Client: Aaron Greco
Location: Santo Domingo, Panama

Introduction

From April 14th to April 30th, Team X has made substantial progress researching and working with the IDEA 398 team, and our client, Aaron Greco. We have narrowed possible solutions to our project through research and asking questions to the CEASPA team in Panama in the following areas: pipes, trough, climate, filters support materials, cattle, and regional information. This report defines our problem, summarizes the findings of our research, and shows how we will use our research to move forward with our design.

Design Status: Defining the problem

Over the past three weeks, we have worked on the following:

- Researching information on pipes, filters, support materials;
- Communicating with our client, Aaron Greco;
- Communicating with the IDEA 398 team, who is working with us and will be focusing on supplying power to our design to ensure that we do not overlap or conflict in our research and solutions;
- Communicating with Diego from the CEASPA team, who is currently working on the same project in Panama;
- Generating an alternative matrix;

Based on meetings with Aaron and the 398 team, we have interpreted our client's problem in the following way.

History: Aaron went to Panama last December to research the village of Santo Domingo and potential projects that engineers could tackle. Santo Domingo is a remote community of 100 that lacks electricity, telecommunication, and dependable roads. The village has around forty cattle grazing in the area and drinking from the local stream. When the cattle walk down to the stream to drink from the water, they are eroding the earth. This causes sediments to enter the stream and pollutes the river upstream of the community. The people of Santo Domingo depend on the stream for water, and so do the cattle.

Project: Santo Domingo needs a sustainable drinking water delivery system for cattle. This will prevent cattle from walking down to the stream, thereby preventing erosion and pollution. Aaron has divided the project into two parts. Our team will work on designing the water delivery system, and an IDEA 398 team will give our ideas a power source.

Definition: Our goal is to develop general guidelines for a sustainable system that enables cattle to drink water from a stream without polluting the stream or eroding the surrounding land. Our designs will not include any information about supplying power. The IDEA 398 team is working solely on the best power source to attach to our designs.

Deliverables: Aaron wants to apply our design to areas other than Santo Domingo that have similar problems. Our final report will suggest the best design for Santo Domingo, but it will also outline general guidelines to be applied in other locations. Our final deliverable will be an instruction manual that describes how to build our system. The IDEA 398 team is preparing an instruction manual describing electrical power, and we have coordinated projects to complement each other. When the project shifts to the building phase, the engineers will have a complete instruction manual describing how to set up the water delivery system with the energy source.

From researches and brainstorming ideas (Appendix E), our team was able to generate an alternatives matrix (Appendix H). This alternatives matrix will lead us to make decisions on our design specifics and write our final deliverable (instruction manual). As we do more research, the alternatives matrix will develop and the final deliverable will cover all of the parts needed to build a sustainable drinking water system.

Research Methodology and Results

Research Methods

We used four main sources for our research—our client (C), Diego from the CEASPA team in Panama (D), the internet (I), and the past reports (PR)—to search for information outlined in the categories below (see the Reference section for sources). The question list we asked to Diego is in Appendix I, and the part of the answers to it is in Appendix J.

Research Results

Cattle Information (I, PR, D) (See Appendix J for more details)

Table 1: Average and Maximum Daily Water Intake for Herd of Cattle

	Liters a Day (L/day)	Liters per minute (L/min)
Avg. Water Requirement	1677	6.50
Max. Water Requirement	2669	10.35

(Buhara, 54)
(Water requirements for Beef Cattle)

- Cattle Rotation Method: the time spent at each subsection of the pasture varies from 7-20 days.
- There are approximately 45 cows in total.
- They drink 2-3 times a day, for about 3-4 minutes (each cow drinks about 10 L each time they go to the river)

Pipe Alternatives (I, PR)

Materials used for drainage pipes include cast iron (CI), glass-fiber reinforced plastics (GRP), high density polyethylene (HDPE), concrete, asbestos, pitch fiber, PVC (polyvinyl chloride), CPVC (chlorinated polyvinyl chloride) and ABS (acrylonitrile butadiene styrene). Among these, plastic pipes (HDPE, PVC, CPVC, ABS) are the most popular types of pipes since they are much lighter and therefore easier to handle. The following are the basic information of each type of pipe:

- PVC is a white plastic pump that is typically used only for vents and drains
- ABS is a black plastic pump that is also typically used only for vents and drains
- CPVC is another rigid plastic used for hot and cold water supply lines because it can handle normal water pressure loads. Compared to copper lines, CPVC is lightweight, easy to work with, doesn't corrode and may be priced about 3/4ths less compared to other plastic pipes.
- HDPE is a type of plastic pipe that is light and strong against physical and chemical changes. It does not corrode, and its service life is from 50 to 100 years. Compared to PVC pipes, it is less prone to crack in cold weathers.

More specific information about plastic pipes can be obtained from Drainage Installations, Fitting Plastic Pipe, Introduction (See Reference Page)

Also, specific numbers for friction loss in pipes is obtained from the past report, Panama Solar Recharge Project, page 56. Friction loss data according to different pipe sizes and fitting sizes are in Appendix K.

Pump Alternatives (I, PR)

A diaphragm pump will function better than other pumps. They require little maintenance, can handle limited dry pumping, and use a small amount of energy (Budhraja, 53). We are currently deciding between two diaphragm pumps (see table 2 below), both of which meet the following standards.

- Flow rate is at least 10.5 L/min in order to constantly supply the trough with enough water for cattle to drink
- The pump cannot require more than 24 volts to operate. The 398 team is designing a power source with that voltage, so we cannot exceed that limit.

Table 2: Kyocera compared to Dankoff

	Kyocera SD 12-30	**Dankoff Slowpump 2507**
Price	$700	$450
Flow Rate	13 L/min	14 L/min
Wattage Required	100 W	100 W
Voltage	12 to 30 volts	12 or 24 volts
Submersible?	yes	No, works on the surface of the water but was designed to work in streams
Debris toleration	Unknown at this point, but likely much more tolerable of dirt and debris	Not tolerant of dirt or debris over 10 microns

Information taken from Kyocera and Dankoff Websites (see Reference Section)

We decided to use the Dankoff Slowpump 2507 in our design. As in Appendix J, the stream contains sediments. Considering the fact that the sediment might block the filter and therefore the water flow, we decided to use the pump that works on the surface of the water, which has a less possibility of sucking up the sediment.

Filter Alternatives (C, I)

Flowmax filter cartridges will work better than filter bags. The Flow max filter cartridges remove sediment up to 5 micrometers, and the filter bags remove sediment up to .180 micrometers. The filter bags do not meet the requirements of sediment removal.
(See Appendix L for more information about filters and sediment removals)

Trough Requirements (refer to Appendix C and Appendix J for full details) (C, I, D)

- Minimum perimeter
  - Circular trough: 5 ft.
  - Rectangular trough: 7.5 ft
- Minimum reserve capacity
  - 340 liters, or 0.34 meters cubed.
- Available space:
  - Circle with radius of 15 ft.

According to the conversation with Diego (Appendix J), the trough could be installed in a central location between pastures. There are a couple of flat areas (~200m^2) about 80-100m from the river where the trough can be installed. Also, there are plastic containers (dimensions: 16" – 16" – 22") that could be used as troughs in the local area, which hold 55 gallons of water. If this container has no problem to be used as a trough (so far it meets all the specifications required), we will decide to use this in our system.

Local Materials (D)

- Concrete, wood (found in the area) and metal sheets are easily accessible from the local area.
- There are small solar panels on top of a chapel that charge a battery which in turn is used to power some small light bulbs at night.
- Electrical wiring/supplies can generally be obtained in Panama city.

Climate and River (I, D)

We have detailed charts of climate information for Balboa Heights, Panama, a city relatively close to Santo Domingo. These charts can be found in Appendix D.

A rough estimate of the climate and river information is obtained from Diego. More specific information can be found from Appendix J.

Climate information

- There is some strong wind (although not strong enough to blow down a tree)
- During rainy season, it rains ~ 4hrs per day, sometimes in the morning, other times in the afternoon.

River information

- The fence charger is about 160-200m from the river.
- River water level changes from 1ft to 3ft during rainy season.
- River in mud is too sandy to be used as construction material.

Next Steps: Furthering Our Research and Making Decisions

Our team recently researched pipes, pumps, trough, filters, local materials, and cattle information. Also, we obtained specific regional information (geographical, climate information) by contacting a person currently in Panama. With this information, we designed an alternatives matrix to help our decisions in building a sustainable drinking water system. This will help us over the next three weeks to accomplish the following:

Week 6:

- Send client an email update about our project
- Conduct further intensive research
  - Emily: Materials
  - Edward: flow switch, rain collectors
  - Paul: Piping design
  - Andrew: Water filtering methods
- Write a detailed outline describing our set of instructions, and start writing parts that we have enough information to write
- Draw oblique and isometric sketches of brainstorming ideas for graphics portfolio

Week 7:

- Revise alternatives matrix from further research information
- Consider specific facts for the design (calculations on pipe diameter, length, etc)
- Discuss and make decisions for design using alternatives matrix
- Write out first draft of final deliverable(instruction manual)

Week 8:

- Develop performance test plan
- Contact experts in respective fields to “test” our design and perform more research
- Revise final deliverable(instruction manual)

Week 9:

- Write progress report (Edward)
- Revise final deliverable(instruction manual)

Conclusion

During the past three weeks, our team has made significant progress on conducting researches and setting our design directions. Much of our project focuses on researching Santo Domingo, their environment, and their needs so that we can recommend specific parts (i.e., pumps, troughs, filters, piping, draining systems) to use in building the drinking water delivery system. Therefore, doing research and designing an alternatives matrix is important for us to make reliable decisions. As we move forward with additional research, more specific information will be required and client feedback will be important. We will continue to maintain close contact with the client and the IDEA 398 team to produce our final deliverable (instruction manual).

References

Internet Sources:

Average Conditions: Balboa Heights, Panama. BCC Weather. 6 April 2006. <http://www.bbc.co.uk/weather/world/city_guides/results.shtml?tt=TT001900>

Dankoff Solar Slowpump. Dankoff Solar. 9 April 2006. <http://www.sierrasolar.com/prod _store/WP_slowpump_specs.pdf>

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Flowmatic Flow-Max Filter Cartridges. H2O Distributors, Inc. 26, April 2006. <http://www.h2odistributors.com/flow-max.asp>

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Kyocera Solar Pumps. Kyocera Solar Pumps. 9 April 2006. <http://www.kyocerasolar.com/pdf/specsheets/sdseries.pdf>

Making a River Forcast. National Weather Service. 6 April 2006. <http://www.srh.noaa.gov/wgrfc/resources/making_forecast.html>

US Filter Bags. US Fabrics, Inc. 26 April 2006. <http://www.usfabricsinc.com/media/products/USFILTERBAGS.pdf>

Water Requirements for Beef Cattle. The Cattle Pages. 4 April 2006. < http://www.cattlepages.com/references/beef_water_requirements.asp>

Past reports:

Budhraja, Anita, Dave Dunkman, Wenhong Neoh, and Jared Satrom. Panama Solar Recharge Project. Northwestern University: Institute for Design, Engineering and Application, 2006.

Client Interview:

Greco, Aaron (2006, April 3). *Initial Client Interview*. PowerPoint presentation presented to outline the project at the EDC Ford Motor Building on Northwestern campus, Evanston, IL.

Appendix A: Project Definition

Our team's project definition defines who the clients are, the mission of the project, the users and stakeholders and the constraints, requirements and specifications of the solution.

Project Name: Sustainable Drinking Water Delivery System for Cattle

Client: Aaron Greco

Team members: [NAMES]
Team X, Section YY

Date:

Version: Z

Mission Statement:

- To develop general guidelines for a sustainable system that enables cattle to drink water from a stream without polluting the stream or eroding the surrounding land.

Constraints:

- Must use power
- Cannot use more than 24 volts
- Cost needs to be minimized
- Built with local supplies
- Built by hand or with small machinery

Users and Stakeholders

Primary Users:
- Cattle of Santo Domingo
- People who raise the cattle

Other Stakeholders
- Our client, Aaron Greco
- The people of Santo Domingo
- The builders of our design

Requirements	**Specifications**
• Water requirements o Meets water needs of cattle	• Must supply 2667 liters per day • Pump delivers water at the minimum rate of 10.5 liters per minute
• Pump requirements	• Can pump up 25 vertical feet • Water must be filtered to 10 microns before entering the pump
• Piping	• Must withstand/be protected from ultraviolet radiation from the sun • Should be between ½ and ¾ inches in diameter to allow for the minimum flow rate
• Storage Tank o Provides enough water for cattle to drink in case of cloudy days	• Needs to hold at least 8 cubed meters of water (8000 liters) • Must be easily emptied for cleaning
• Drinking trough perimeter	• Minimum perimeter for 5 cattle to drink o 5 feet for a circular trough o 7.5 feet for a rectangular trough
• Power	• System cannot use more than 120 watts of power • Float switch cannot use any power
• Minimal maintenance	• Parts do not need to be replaced in the short run • Replacements or changes do not need to be made in less than one week intervals • Replacing parts (such as filters) require very little instruction
• Construction	• Cannot require any machinery • Requires minimal people and time to build

Table A.1: Requirements and Specifications for Design

Appendix B: Client Interview Summary

Attending: [NAMES] (Team)
Aaron Greco (Client)
Meeting Location/Time: Ford Building, 6:30 pm April 3, 2006
Minutes Taken By: [NAME]

Agenda:
Mr. Greco will do a PowerPoint presentation outlining the main goals of the project, giving us the geological data and describing what he wishes us to accomplish this quarter. Afterwards, Section 15 Team 1 will ask questions.

Population:
Santo Domingo- remote and rural town in the mountains of Panama
Population: ~100 people
Main source of income is cattle ranching

Problem (Current Situation):
Cattle walk down steep embankments to streams for drinking
-Causes erosion of the slope
-Increases turbidity and contamination of town's drinking water

Constraints:
Cost→
Use locally available materials (including bamboo)
Shape of Area for Trough→
Stream is ankle deep at the bottom of a 60-degree incline. The land plateaus after 30 ft up the incline into a 15-20 ft radius pasture (where the trough should be located).
Number of Cattle→
Needs to be built for 43 cattle
Power→
Ranchers use car batteries for electric fences to keep cattle in (can use the batteries for pumping water)- Run on 12 Volts (160 amp hours)

Appendix C: Trough Requirements

This appendix outlines the trough requirements in terms of cattle drinking space, storage capacity, and available space. All of the information is summarized at the bottom of the page in the section marked "Summary". The information outlined below was obtained through research into Water Requirements for Beef Cattle (10) and The Panama Solar Recharge Project (15). Calculations were performed by [NAME] and [NAME].

Cattle Drinking Space

The trough must have a large enough perimeter to allow for at least 5% of the cattle to drink at once. Each animal drinking space should be at least 20 inches in perimeter if the trough is circular and 30 inches if the edges are straight lines. We have a fifteen foot radius of available space to dig a trough, so room is not an issue.

Storage Capacity

The trough must have some reserve storage capacity. If not, we would have to provide two gal/min flow rate per available drinking space to ensure that water would always be available for cattle to drink. If we allow for as low as two drinking spaces, we would need to supply four gal/min, or 15 L/min, which is over the maximum flow rate for the selected pumps. So the trough must have some reserve capacity.

Each cow will drink no more than 7.5 liters per hour, so at least 340 liters of water must be replenished in an hour. Since our pumps can supply up to 780 liters per hour, we will only need 340 liters of reserve capacity.

Available Space

There is a small area of flat land located thirty feet from the stream where we can dig a trough. The circular area has a fifteen foot radius and is 25 vertical feet above the stream. See the diagram below

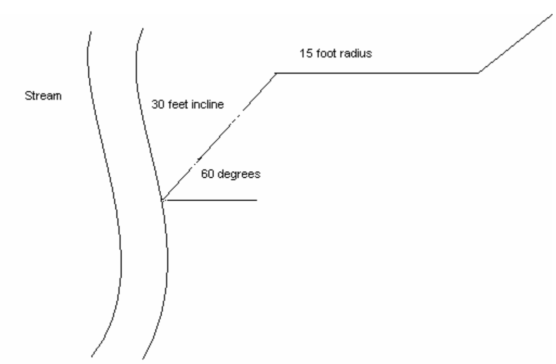


Figure A.1: Available Trough Area- Drawn by: Andrew Wien

Summary

- Minimum perimeter: At least 5 feet for a circular trough and 7.5 feet for a rectangular trough

- Minimum reserve capacity: 340 liters, or 0.34 meters cubed.
- Available space: A circle with radius of 15 feet and circumference of 95 feet

Appendix D: Climate Charts

This appendix contains information pertaining to the temperature and climate of the area and of Panama in general. These charts were used to determine which types of materials to use and the potential height of the stream during rainy/dry season. See Reference 1.

Month	Average Sunlight (hours)	Temperature Average Min	Temperature Average Max	Temperature Record Min	Temperature Record Max	Discomfort from heat and humidity	Relative humidity am	Relative humidity pm	Average Precipitation (mm)	Wet Days (+0.25 mm)
Jan	10	22	31	17	34	Extreme	88	84	25	4
Feb	9	22	32	18	35	Extreme	85	81	10	2
March	8	22	32	18	36	Extreme	81	78	18	1
April	7	23	31	18	36	Extreme	81	81	74	6
May	5	23	30	21	36	High	87	88	203	15
June	4	23	31	21	35	Extreme	90	90	213	16
July	5	23	31	19	35	Extreme	90	91	180	15
Aug	5	23	30	20	34	Extreme	90	91	201	15
Sept	5	23	29	20	34	High	91	91	208	16
Oct	5	23	29	20	35	High	90	92	257	18
Nov	5	23	29	19	34	High	91	92	259	18
Dec	7	23	31	19	34	Extreme	90	89	122	12

Table D.1: Temperature Chart for Balboa Heights Panama

The following bar chart shows the years average weather condition readings covering rain, average maximum daily temperature and average minimum temperature.

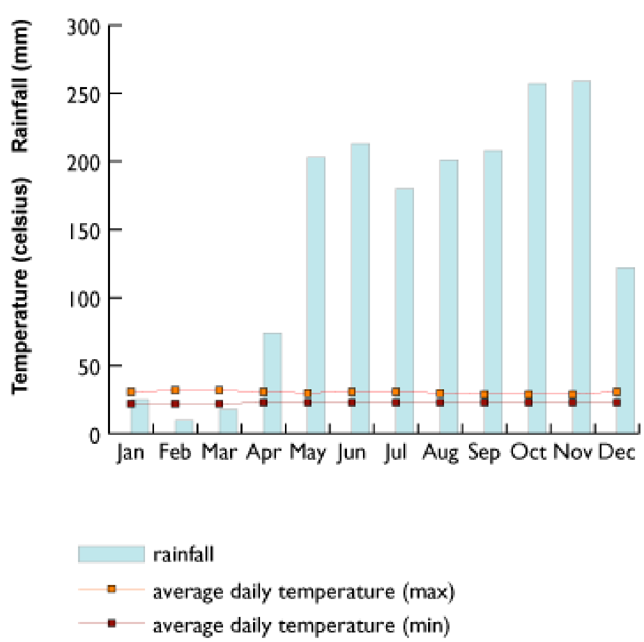


Figure C.1: Graph of Average Rain and Temperature in Panama

Appendix E: Brainstorming Ideas

Appendix E is the original list of ideas garnered from the brainstorming session held on April 11th 2006. The first page is the list of un-clustered ideas while the second page is the same list separated into groups based on the type of solution it is.

1. Pump Upstream
2. Trough Turbine
3. Settling Pond
4. Pre-Trough Water Storage
5. Support For Pipe
6. Multiple Troughs
7. Filter
8. Log Ride Trough
9. Self-Circulating Trough
10. Dual Pipes
11. V Filter
12. Underground Pipe
13. Bamboo Pipe
14. Suction Effect from Drain Pipe
15. Easy-Empty Trough
16. Elongated Trough
17. Rectangular Pipe
18. Sedimentation Trough
19. Water Circulation
20. Underground Drain
21. Float Switch
22. Separate Storage
23. Simple Pump ‘n’ Drink
24. Overfill Pipe
25. Mini-Stream

Water Circulation

2. Trough Turbine
8. Log Ride Trough
9. Self-Circulating Trough
10. Dual Pipes
19. Water Circulation
24. Overfill Pipe

Filtering System

3. Settling Pond
7. Filter
11. V Filter
18. Sedimentation Trough
19. Rectangular Pipes

Pumping System

1. Pump Upstream
12. Underground Pump
14. Suction Effect from Drain Pipe
20. Underground Drain

Pipes

5. Support for Pipe
13. Bamboo Pipe

Trough System

4. Pre-Trough
6. Multiple Troughs
15. Easy Empty Trough
16. Elongated Trough
21. Float Switch
22. Separate Storage
23. Simple Pump ‘n’ Drink
25. Mini-Stream

Appendix F: Team Contract for Team 1

[NAMES]

Goal:

We are committed to earning an A by:

- Designing a prototype that meets our goals discussed in the mission statement

Communication:

- Read and reply to emails from group members, other students, clients, and professors no more than 24 hours after they are sent
- Copy emails to every member in our group
- Listen openly to group members' ideas, even if we do not agree with them
- Ask other team members before buying anything using the team fund

Record Keeping:

- Keep detailed meeting minutes and send them out to the group no later than 24 hours after the meeting (Emily)
- Hold all documents, sketches, brainstorming ideas, meeting minutes, gantt charts, ram charts, receipts of team purchases, and scratch notes in a project notebook (Paul)
- Date all items and documents for reference

Work Habits:

- Finish all work on time and to the highest quality possible
- Notify all team members at least 48 hours before if we cannot finish the work delegated to us
- Divide work evenly and fairly and utilize each members strengths and weaknesses
- Divide work at least two (2) weeks before the due date, and record how the work is divided

Meeting Standards:

- Hold meetings on Tuesdays at 7:00 PM (location TBA)
- Decide time and topic on Wednesday in class
- Be punctual
- Take minutes of meetings

Appendix G: Ethics Appendix

Ethical Implications of the project:

- Is this project moral?
    - Yes. We are simply answering the needs of a rural cattle farming community, in this case, the community's need to prevent erosion of the steep bank of a stream. This project is for the good of the community and is certainly moral.
- Is it legal?
    - Yes. We are operating through a local NGO (Non-Government Organization) with the consent of the local landowners.
- Other tests mentioned in April 10 lecture to determine ethics of decision
    - Would you care if your decision/project was in the newspaper?
        - No. The local people in Panama desire the improvements this project makes, and it only positively affects everyone and everything in the area.
    - How does it make you feel?
        - This project significantly benefits the local people, so it is something we feel good about doing.
    - Secondary and tertiary consequences?
        - We can discern no negative secondary or tertiary consequences of this project. It positively impacts the environment (it prevents erosion), helps the local people (they will have cleaner water due to the lack of erosion), and helps the cattle (they do not have to walk down a 60 degree incline to get a drink of water).

Appendix H: Alternatives Matrix

Appendix H is the alternatives matrix our team put together April 26th 2006 to outline our design options and to determine which areas needed more research to make an informed design decision.

Alternatives	**Pumps/Water Source**	**Sediment Removal**	**Piping Materials**	**Drains**	**Support Materials**
1	kyocera pump	settling pond	HDPE	Float Switch	mud
2	dankoff pump	homade cloth filter	CPVC	Safety Drain	concrete
3	rain water drainage	metal wiring	PVC		underground pipe
4		reusable filter	ABS		bamboo

Table E.1: Design Alternatives Matrix

Appendix I: Interview Question List

1. How often are the farmers able to clean/replace filters?

2. How much does the water level of the stream vary in the rainy/dry seasons? (Rough estimates would be fine)

3. Is mud brick a possible building material?

4. What other materials do the farmers build their houses out of?

Appendix J: Summary of Diego Rivera Interview (CEASPA Team)

Appendix J is a summary of the information received via teleconference between Diego Rivera and the IDEA 398 Team working on solar energy. The IDEA 398 Team is powering our system and the electric fences in the surrounding area. They interviewed Diego on May 1st 2006 and sent our team the information garnered.

Cattle/Drinking

- Cattle Rotation Method: the time spent at each subsection of the pasture varies from 7-20 days.
- There are approximately 45 cows in total.
- They drink 2-3 times a day, for about 3-4 minutes (each cow drinks about 10 L each time they go to the river)

Trough

- As of now, the cows drink water from the river in different locations, depending on what subsection of the pasture they're grazing at. Yet, according to Diego, a trough could be installed in a central location.
- The **plastic containers** that could be used as troughs hold 55 gallons. (16" – 16" – 22"). They are generally cut in half length-wise.

Regional Information

Flat Areas

- Most areas of the pasture are not flat. However, Diego says there are a couple of flat sections (~200m^2) about 80-100m from the river where the trough could be installed. He will send us pictures of these areas by next Monday.
- He first suggested installing the trough at the "corral", a flat region where the cows are vaccinated and washed.
- Water to wash the cows is brought up from the river with buckets.
- There is no problem with the corral getting dirtier from converting it into a the drinking station. Diego also suggestions we could fence off a separate small portion of the corral to install the trough.

River

- The fence charger is about 160-200m from the river.
- River water level changes from 1ft to 3ft during rainy season.
- River in mud is too sandy to be used as construction material.

Weather

- There is some strong wind (although not strong enough to blow down a tree)
- During rainy season, it rains ~ 4hrs per day, sometimes in the morning, other times in the afternoon.

Materials:

- Most houses in Santo Domingo are built of concrete. The small shack that houses the fence charger is built of wood (found in the area) and Metal sheets.
- There are small solar panels on top of a chapel that charge a battery which in turn is used to power some small light bulbs at night. Diego will find out the model and serial number this week.
- The angle of the roof of the shack that houses the fence charger is ~ 35degrees and faces west.
- Electrical wiring/supplies can generally be obtained in Panama city.
- Ranchers can easily clean/replace filter pumps when necessary (once a week)
- No detailed maps with elevations are available (that he knows of). There is an ongoing project to make one.

Appendix K: Friction Loss from Pipe Size and Fitting Size

Appendix J is made up of two tables from the Panama Solar Recharge Project (see Reference 15). These tables outline the friction loss due to the flow through PVC piping.

FLOW IN LITERS PER MINUTE	NOMINAL PIPE SIZE LOSS IN METERS OF HEAD PER ONE METER OF PIPE					
	15.8 mm 1/2"	20.9 mm 3/4"	26.6 mm 1"	35.1 mm 1 1/4"	40.9 mm 1 1/2"	52.5 mm 2"
5	0.0058					
10	0.021	0.0053				
15	0.044	0.011				
20	0.076	0.019	0.0057			
25	0.11	0.029	0.0086			
30	0.16	0.041	0.012			
35	0.21	0.054	0.016			
40		0.069	0.021	0.0055		
45		0.086	0.026	0.0069		
50		0.1	0.031	0.0084		
60		0.14	0.043	0.012		
70		0.19	0.058	0.016	0.0073	
80			0.074	0.020	0.0093	
90			0.092	0.025	0.012	
100			0.11	0.030	0.014	0.0047
125			0.17	0.046	0.021	0.0071
150				0.064	0.030	0.010
175				0.085	0.040	0.013
200				0.11	0.051	0.017
225				0.14	0.064	0.021
250				0.17	0.077	0.026

Table J.1: Metric Friction Loss for SCH 40 PVC pipe in Equivalent Meters

TYPE OF FITTING AND APPLICATION	NOMINAL SIZE OF PIPE FITTING (NPT)					
	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"
	EQUIVALENT LENGTH OF PIPE (IN METERS)					
INSERT COUPLING	0.9	0.9	0.9	0.9	0.9	0.9
THREADED ADAPTER (PLASTIC TO THREAD)	0.9	0.9	0.9	0.9	0.9	0.9
90° STANDARD ELBOW	0.6	0.6	0.9	1.2	1.2	1.5
STANDARD TEE (STRAIGHT FLOW)	0.3	0.6	0.6	0.9	0.9	1.2
STANDARD TEE (90° FLOW)	1.2	1.5	1.8	2.1	2.4	3.3
GATE VALVE	0.3	0.3	0.3	0.3	0.6	0.6
SWING CHECK VALVE	1.5	2.1	2.7	3.7	4.0	5.2

Table J.2: Metric Friction Loss for Fittings in Equivalent Meters of Pipe

(Tables from Panama Solar Recharge Project, page 56)

Appendix L: Sediment Removal Research and Direction

This appendix shows the research on sediment removal and filters for the Dankoff 2507 pump. For more information see References 2, 5 and 7.

Minimum Sediment Removal:

The Dankoff Slowpump 2507 cannot handle sediment larger than ten micrometers, so any filter must filter out particles over that amount.

Sedimentary Pool:

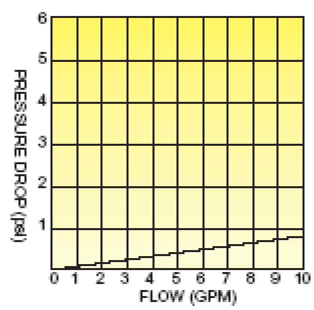
Our team decided that a settling pool will not work in Santo Domingo. There is not sufficient room to dig out a pool that will collect water by means of gravity. All settling pools would require a pump to get the water to them, defeating the purpose of the pool.

Information taken from meeting with Aaron Greco on Tuesday, April 25th

Filters:

Flowmax Filter Cartridges

- Are relatively cheap: price ranges from $8-$45 depending on the size of the pipe
- Removes sediment up to five micrometers
- Can be washed off and reused
- Flow rates range from 7-25 gpm



Flow-Max® cartridge (5 µ)

Figure K.1: Chart comparing Flow Rates and Pressure Drops for 5 µm filters

Filter Bags

- Made of a polypropylene fabric
- Designed to remove sediment from water
- This specially designed fabric will only filter .180 mm, which does not meet requirements
- We cannot use local fabrics as filters for the same reason. They will not remove enough sediment from the water.