EWB-OSU

El Salvador water project
Assessment of site #2
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Progression to the Second Site Assessment

First site assessment

EWB-OSU's first site assessment trip to the communities of Las Mercedes and El Naranjito took place in March of 2006 with the intent of acquainting the chapter with the communities involved. Three student members and one professional from EWB-PDX were sent to conduct acquire data and observations regarding the communities' health, to create a GIS map of the area by which future trips could be conducted, to locate important community infrastructure especially regarding to water, and in general to get to know the people and the area. The chapter's hope was to eventually conduct a potable water project in these communities, and these pieces of information were vital to understand the feasibility of any such project.

The first site assessment proceeded very well, with no significant setbacks. The information gathered regarding health indicated that accessibility to clean water was indeed a significant issue in the area. Team members were able to conduct house visits with community members to locate water sources, discuss health, and investigate the potential for community buy-in for a project. GPS data was collected and converted into a rough map upon which populated areas and other infrastructure was marked, for the purpose of communicating with the rest of EWB-OSU. Finally, team members attended an ADESCO General Meeting, in which the EWB-OSU representatives were presented to the community officially, as a group investigating water projects.

The team was surprised by the size of the land encompassed by the community, and noted that any project would have a much larger scope than initially anticipated. However, the team was also able to point out specific locations that could prove helpful in the completion of a project, including stronger springs, existing water tanks, and optimal construction locations. However, it was discovered that the first team sent was not in a position to conduct a basic feasibility study, which requires some experience with demand studies, back-of-the-envelope calculations, and a sense of general implications for any given design.

Transition from data to planning a second assessment

Upon returning the Oregon, the chapter was debriefed on the trip's activities and successes, and the project team convened to analyze the data and determine possibilities for projects. After a matrix-based analysis of the various potential locations and distributions, it was decided that a second assessment trip should be sent during the summer to survey the area and conduct water quality tests in preparation for a phased implementation trip shortly thereafter. A team of five students and two professionals was created to complete these main goals, and began preparing for the trip during May 2006. A primary phase was selected from the matrix based on the assumption of land-owner support of the project, equipment training began, and a trip itinerary was set forth.

During this period of time, a lag in communication occurred between the chapter and the community, including EWB-OSU's primary contact, a Peace Corps volunteer. For one, the Peace Corps volunteer was under the impression that another team was traveling in June, when it was realistically not feasible to develop a plan, raise the appropriate funds, make contacts with the counterparts in-country, or pass TAC. However, due to issues in translation as well as simple cross-culture difficulties, it was later discovered that the community believed that the project had already progressed to the design phase, and was therefore assured. It is likely that this sentiment was contributed to by the numerous house visits and emphasis upon a "long-term relationship" that took place during the first assessment trip, but other areas of miscommunication certainly contributed as well.

Preparation for the second assessment

The second site assessment team prepared rather well, but with gaps, due to the summer months making communication difficult between team members in various parts of the state. However, appointments were made with a professor from the university, the Potters for Peace manufacturer and distributor, a local Rotary club in the capital: Cuzcatlan, as well as with the community members so that they were made well aware of our itinerary and trip intentions, via telephone calls with the Peace Corps volunteer and the ADESCO president.

There were two significant gatherings during the summer to prepare, each with a technical focus to train all travelers on the equipment that was to be used on-site. The first meeting was a Saturday-long orientation and BBQ at Dan and Jen Garbely's house, during which time we developed the rough calendar/itinerary as a group, had a workshop by a local professional about basic soil assessment and slope stability, were introduced to the GPS units and methodology, and developed a chemical testing plan that would be discussed in further detail when the Hach kits arrived. This was a very valuable orientation, as people were able to ask questions, get clarifications, and feel more involved in the whole planning process. The second training was very close to the travel dates, in Corvallis, to review the contents of the Hach kits and to further develop a simple methodology for the students who didn't have chemical testing experience. This too proved important, as we were able to discuss which elements should not be brought, and to plan how the kits would be packed for travel and customs issues.

After preparation, the team for the second site assessment departed for El Salvador in early September 2006. Upon arrival, the misperception of the community was discovered through a meeting with the Peace Corps volunteer. Additionally, the Peace Corps volunteer revealed to the group members that although the majority land-owner for the primary selected phase did support the project, the particular spring about which the selected phase was based was not available to the group for use. This completely disregarded the itinerary set forth by the project team, which then set forward re-analyzing the entire community and project feasibility in each area. Other land ownership issues were discovered.

Demand Study

Upon arrival to the village, we were greeted by several members of the ADESCO of the community (government organization in order to facilitate communication with nearby municipal governments). Introductions were exchanged, and Eric Anderson (PCV) reiterated the role of our organization and how this differs from government sponsored relief aid that funded house construction in the region after the January 2001 earthquake. He reiterated how we are not 'bringing water', but are rather a student-lead organization who plans to design a sustainable water storage system for the community. We received some input from members regarding their idea of an ideal system, and the rainwater collection/storage seemed to be a popular option, given the quantity of rain in that region during the winter season, as well as the economic efficiency of not paying for maintenance and electricity for pumps.

A brief demand study was preformed, by means of asking the family for their estimate of quantity of water used per family per day. Not including washing clothing, it was estimated that 50 gallons were used (for drinking, cooking, and bathing). The following calculation was performed:

50 gallons x 55 families x 6 months x 30 days/mo = 495000
A 500,000 gallon tank would amount to 66840 ft^3. In order to utilize the roof for rainwater catchment, the tank would need to be on the order of 92 ft in diameter, and 10 ft tall. This was a very harsh realization to make, as this sheer size would require very precise engineering designs, with all variables accounted for.

We proceeded to visit several possible locations for tanks, mainly on the tops of the hills, where the roof would be open to the sky for uninterrupted rainfall, and to decrease the amount of debris able to fall on the cover. The locations visited were as follows: next to the cell phone and radio towers on the top of the hill, at the 'old finca' where a corroded and chipped concrete cistern is dug into the ground at the hilltop, and near the futbol field which is on the same hilltop as the cistern.
Another option visited was a stream near the community of El Naranjito. El Naranjito is a more consolidated community than Las Mercedes, because there is a street on which many houses (on the order of 18 homes) lie. The possibility for this stream discussed was to create an earth dam, and washing/treatment station to store water during the dry months, when the stream flows less but still steadily.

Processes for option selection

In order to evaluate the options, and the feasibility of completing each for our chapter, we devised a matrix to compare the relative benefits and variables of each of the options. Having not yet had the chance to further discuss our findings with the community, it was a means for us to present our concerns and estimates to Eric (PCV) to get his feedback. Firstly, the discussed options were listed:

1) Damning the stream at El Naranjito
2) Tank renovation at Los Patios and gravity fed piping to homes in the area
3) Tank renovation and washing station/ treatment at Los Patios
4) Several large rainwater catchment tanks
5) Individual rainwater catchment tanks
6) Pumping to a reservoir from year-round springs

Secondly, the pros and cons for each of the options were listed

1) Damning the stream at El Naranjito:
    a. Pros
        i. Possibility of gravity feed
        ii. Good flow quantity
        iii. Year Round
        iv. Geographic: close to El Naranjito community
        v. In valley: earth wall is possible
        vi. Operation and maintenance (cleaning) is relatively simple
        vii. Concentration of homes at El Naranjito
        viii. Possible wash/fill station at the top of the street for the use of all residents
    b. Cons
        i. No treatment (unless a tank is built)
        ii. A damn is technically challenging to build (phasing)
        iii. Equipment is required to move boulders
        iv. Land ownership: stream zone above the road is owned privately
        v. Potential to wash out the road if it were to fail
        vi. Low-flow season may not have enough water to cover demand 18 homes

2) Tank renovation at Los Patios and gravity fed piping to homes
    a. Pros
        i. Existing infrastructure of tank
        ii. Year-round steady flow
        iii. 25 homes or so would benefit
    b. Cons
        i. Land ownership: cannot use it by message from the engineer

   ii. Quantity of PVC required
   iii. Line inspection, and maintenance required to ensure each piping system functions properly

3) Tank renovation and washing station at Los Patios
   a. Pros
      i. Existing infrastructure of tank
      ii. People walk that distance already, so it would just provide cleaner water
      iii. Owner Tom Hawk could still use it for coffee processing
      iv. Low cost
      v. Feasible for our chapter
      vi. Minimal maintenance

   b. Cons
      i. Residents would still need to walk, so the distribution demand would not be met
      ii. Ownership: permission to build as well as usage for community members
      iii. Would there be buy-in given that the walking distance would remain unchanged

4) Several large rainwater storage tanks
   a. Pros
      i. Sustainable
      ii. Low-maintenance
      iii. Rainwater is relatively clean
      iv. Gravity-fed: no electricity required

   b. Cons
      i. High cost to construct
      ii. 6 months of storage required
      iii. Land ownership
      iv. Accessibility/Constructability
      v. Cleaning roof of catchment system
      vi. Foundation design
      vii. Cut/excavation quantity
      viii. Possible disastrous failure
      ix. Slope stability
      x. Regulation of usage

5) Individual rainwater storage tanks
   a. Pros
      i. Everybody regulates personal tank and water usage
      ii. Sustainable
      iii. Convenient

iv. Clean water / little treatment required

b. Cons
   i. High cost
   ii. Land availability / space for tank
   iii. Many tanks required
   iv. 6 months of storage needed
   v. Custom design for each house
   vi. Transportation of tanks
   vii. Infrastructure

Selection Matrix

	Damning Stream / El Naranjito	Los Patios and Gravity	Washing Station / treatment a	Several large rain catchment	Individual rain storage	Stream pumps
Capital Cost	3	4	5	1	1	1
Maintenance Cost	4	4	3	2	4	1
Ease of use / buy-in	4	5	2	4	3	2
Constructability	3	2	5	1	2	1
Chapter feasibility / scope	3	4	5	1	2	1
Sustainability / longevity	4	2	4	3	3	2
Benefit (# homes)	18	15	40	60	95	60
Score for # homes	2	1	4	4	5	4
Total (high = good)	**23**	**22**	**28**	16	20	12

This was presented to the Peace Corps volunteer, Eric, prior to the community meeting in order to explain our concerns about feasibility and project scope

Design options

As noted in the first assessment trip report, the community is divided geographically into several house clusters, and it is necessary to implement different potable water systems near each house grouping. The three main groupings which are located within Las Mercedes and El Naranjito are composed of about 20 homes each. The first group made a few assumptions and found that water could be provided in the next form:

- The school of El Naranjito and houses surrounding it.
  - Pumps, reservoir, spring box, piping, and three faucets.
- Los patios.
  - Rehabilitation of current spring box and reservoir, extensive piping, pumps, and 6 faucets.
- El Naranjito.
  - Two faucets with a dual system, pumping and gravity fed.

In this second assessment trip it was noted that some of this options would not be feasible. This was due to conflicts in land ownership and the tremendous amount of water needed to supply the communities for the whole year. They use about 40 gallons of water per family per day. Doing the math, 288,000 gallons of water per year would be necessary for every cluster of 20 homes. Constructing something this massive brings many complications since this area is known for very high seismic activity, the soil is very much a silty clay, and there is not enough flat ground to build something this size.

We met with the ADESCO committee and presented what we had found and our concerns. They were very aware of the situation and told us that their biggest need for water is in the dry season when the ground water level drops and the creeks do not carry as much water, which means the communities have to travel even further to find a source of water. This season has a duration of three months; therefore the amount of water needed to be stored is much less.

We came up with three options to store water:

- 72,000 gallon tank at old Finca
- 72,000 gallon tank at Church
- Dam at El Naranjito

The dimensions of the two tanks would be 8ft tall and 40 feet in diameter, constructed from reinforced concrete. The water would be collected from rain water and then kept turbulent with a low-energy or solar-power agitator to keep introducing oxygen in to the water. Some of the conflicts still to be solved for the two tanks are finding ownership and acquiring the land, and a more thorough geotechnical report of the soils found in each location in order to design the footing of the structure. There is also some engineering information that needs to be found such as seismic activity and, wind loads. Lastly we would need to make sure that there are no regulations against building this type of structures with US codes. The cost of these tanks could be estimated to be about $1.00 (US) per gallon, $72,000 each.

The dam at El Naranjito would consist of a retaining wall collecting water from a source next to Cerro Caballo just above the El Naranjito cluster of homes. A wash station next to the dam would also be provided with tow faucets one for washing clothes and the other with potable water where “cantaros” could be filled. This project also has many complications since a dam is considered a complex superstructure. Information needed for this project also includes, ownership, geotechnical report, seismic loads, wind loads, and any complications against using US codes. Again the cost of this could be estimated at $1.00 (US) per gallon.

These options are not final as it is true for any new project where the most cost and labor effective structure needs to be built. The team will stay in contact with some local professionals and professors to get their input and we will keep trying to design something that is both feasible for us and sustainable by the community.

Water Quality

General water quality parameters were measured in various potential water sources. Sources tested included select springs in the area, rainwater, and springboxes (pilas) currently in use by the community. Parameters tested with the Hach 850 field kit were: pH, total dissolved solids (TDS), total chlorine, free chlorine, hardness, alkalinity, nitrate, nitrite, ammonia, and orthophosphate. Additionally, a YSI 55 dissolved oxygen (DO) meter was used to measure DO and temperature. Total and fecal coliforms were analyzed using the 3M Petrifilm® E. coli/coliform count plate. Additionally, treated water was tested. A filtron purchased from “Potters for Peace” was used during the stay to assess its effectiveness in removing contamination. Some rudimentary flow data was also collected using a plastic tarp, stopwatch and calibrated bucket.

Generally, water quality of the sources tested was excellent. pH in all surface waters was between 6.6 and 8.0. Dissolved oxygen in all surface waters was between 7.4 and 8.9, indicating healthy ecologies with good aeration and little nutrient or organic loading. Minimal if any phosphate was detected in most sources. Most sources had phosphate concentrations less than 0.2 ppm, which was in the same range as pure rainwater tested. It is therefore likely that readings at or below 0.2 ppm are negligible and possibly the result of matrix interference. The only two sources with orthophosphate concentrations measured to be over 0.2 ppm were the spring feeding into the large tank at Los Patios, and the spring near El Naranjito known locally as Cerro del Caballo (referred to in data sheets as “Naranjito Dam”). Their phosphate concentrations were 0.3 ppm and 0.4 ppm, respectively. With the large amount of coffee plants observed in these areas, it is possible that some minimal fertilizer runoff was impacting the water. However, the DO in these sources were both above 7.4, and no algae or excessive aquatic vegetation were observed. Minimal nitrogen loading was observed in surface water sources. Most sources had ammonia concentrations at or below 0.1 mg-N/L; the same concentration measured in pure rainwater (again indicating a possible matrix interference). Only the stream between the Finca house and Las Mercedes had ammonia concentrations measured at 0.2 mg-N/L. Nitrate at this source was measured between 0 and 2 mg-N/L, and D.O. was above 8.5 mg/L, indicating good aeration and minimal overall nutrient loading. The US-EPA MCL for nitrate is 10 mg-N/L. The highest nitrate concentration measured in all surface water sources was 4 mg-N/L. This was found at the Cerro del Caballo site; another indication of some nutrient loading in the region, but still at acceptable levels. No nitrite was ever detected in any water source. Organic loading was not measured due to lack of field-friendly techniques for C.O.D. or B.O.D. However, low ammonia, nitrate and phosphate concentrations, coupled with high D.O., no observed color, algae, turbidity or foam in the sources strongly suggests organic loading is negligible.

We were unable to acquire a turbidimeter for this trip. Visual inspection of water indicated very slight turbidity in the spring at Cerro del Caballo, and a great amount of turbidity do to clay/colloids at the large tank at Los Patios, as well as the pila near the stream between the Finca House and Las Mercedes, which the large tank at Los Patios is plumbed to. All other surface waters investigated had great clarity and lack of color. Hardness was in a moderate range that one can expect in surface water, generally between 40 and 110 mg/L as $CaCO_3$. Only one day of measurements at Cerro del Caballo yielded hardness of 140 mg/L, which is not excessive. Alkalinity was generally rather low, between 0 and 40 mg/L as $CaCO_3$. This is likely due to the fact that the majority of the flow during September is due to rain. However, pH values in the sources were neutral. Thus, while the surface water has little buffering capacity, it is unlikely to contribute to deterioration of concrete structures. Only the spring and tank at Los Patios had higher alkalinities of approximately 200 mg/L as $CaCO_3$. TDS for all surface waters was between 25 and 75 ppm. Two sites had erroneously high TDS measurements due to the use of the supplied WhirlPaks (with sample preservative tablets) for sampling. Such TDS measurements exceeded 700 ppm. Similar results were obtained with distilled water in the WhirlPaks. Reanalysis of TDS at the site with the erroneous TDS data (Los Patios) yielded an average TDS of 33 ppm.

Coliform analyses of the surface waters were somewhat challenging. Complications at the site of our analytics included power outages (affecting proper incubation) and fecal contamination due to numerous chickens present. The following assessment of coliform analyses must therefore be viewed with care and caution. The spring feeding into the large tank at Los Patios was very clean. Two of the three samples had no coliforms, though one of the triplicates produced 66 colony forming units (CFUs) in the no-dilution 1 mL sample, and 29 CFUs in the 1:10 dilution, or 290 CFUs/mL. This sample likely was contaminated with some soil, since there were no fecal coliforms, only total coliforms. The large tank at Los Patios that the spring feeds into appears to have 100s of total and fecal coliforms per mL. This water had a great amount of suspended colloidal and clay particles that did not settle, so large amounts of biota were expected. The spring at Cerro del Caballo was very clean in appearance. Replicate samples gave mixed results however, with no coliforms present after 24 hours of incubation at 35^oC, but 48 hour incubations ranging from 10 to 100 CFUs per mL in the 9/7 sample. However, the sample collected on 9/9, after significant rain produced between 300 and 1000 total coliform CFUs after 24 hours. Only 2 or 3 fecal coliform CFUs were detected after 24 hours of incubation, indicating soil particles and organisms were washed into the drainage, but that little fecal matter is in the area. For the stream between the Finca house and Las Mercedes, multiple day replicates yielded 15 to 50 CFUs/mL in the no-dilution samples after 24 hours of incubation, and similar numbers in the 48 hour results. Overall, total and fecal coliform counts were fairly low in surface waters and at treatable levels.

The "Potters for Peace" filtron was tested on water from the large tank at Los Patios. The water from that sample had an average of 55 total coliform CFUs after 24 hours of incubation, with half of those coliforms showing up as E. coli. Samples from the filtron, incubated for 24 hours produced 13 total CFUs per mL, with an average of 2 fecal coliforms per mL. These samples were prepared on the last day of sampling, when much contamination of equipment had been observed. Thus, it is unclear if the filtrons produce near-complete removal of bacteria, or only removal of a majority. The fact that none of the 7 EWB travelers became ill suggests the filtron treatment was adequate. Further testing of the filtron is highly recommended.

Flow data was collected from two sources during this high-flow visit. The spring near El Naranjito (Cerro del Caballo) had a flow rate of 2.7 liters per second, or 161 liters per minute (42.5 gpm). The flow is actually higher at that site, because it was observed that the tarp was only able to capture approximately 90% of the flow. This is the site where a dam is under consideration, and such a flow would easily supply adequate water for the nearby community of El Naranjito. Low flow measurements will be necessary to ensure adequate storage is possible during the dry season. The flow was also measured at a small spring accessed by a few nearby households, known as El Fuente Galacia. This small spring serving a few homes is typical of the region. The flow at this spring was measured to be 0.3 liters per second, or 18 liters per minute (4.7 gpm). Many of these small springs are dry by the end of the dry season, causing people to hike longer distances to obtain daily water.

In addition to surface water testing, pure rainwater, rain runoff from the (corrugated metal) roof at the Finca house, and the tap water at the Finca (from a spring-fed cistern) was tested. As one should expect, pure rain had zero alkalinity, hardness, nitrates, and TDS. Trace ammonia and phosphate measured is believed to be background interference of the Hach colorimeter. The pH of pure rainwater was 5.1. Pure rainwater is naturally at a pH of 5.6. Thus, the rainwater measured might be regarded as "acid rain". No methods for measuring sulfate were available to confirm is the pH was low because of sulfuric acid accumulation. The lack of alkalinity and low pH will have to be considered if concrete rainwater storage is used as a water distribution strategy.

Rain runoff from the roof was also collected. The 9/7 rainwater collected of the Finca House roof had a pH of 4.7, with no alkalinity. The pure rainwater collected that day was accidentally spilled, so it was not determined if the roof lowered the rainwater pH, or if precipitation was more acidic that day. The roof did apparently contribute some contamination, as the TDS of the roof runoff was 25 ppm, the nitrate concentration was 1 mg-N/L, and ammonia concentration averaged 1.5 mg-N/L. It should be noted that this rain event was after 4 days with no rain, allowing contaminants to accumulate on the roof. A sample collected later in the week off the roof did not significantly change pH or TDS compared to pure rain, and ammonia was increased to a lesser degree (to 0.3 mg-N/L). Thus, if roof runoff is to be used as a water source, a "first-flush" system will be an important component.

The cistern-fed tap water at the Finca house was also tested. Some TDS (103 ppm), nitrate (2 mg-N/L), and phosphate (0.4 mg/L) was recorded, and the pH was slightly low (6.2). Otherwise, the quality was excellent, with only 6 total coliform CFUs detected per mL after 48 hours of incubation, and no fecal coliforms. This was encouraging to see that a covered cistern would in fact maintain excellent drinking water quality.

Conclusions:
Water quality measured during the September visit to the community during the rainy season was excellent. With the exception of coliforms, all water quality parameters measured were well within the US EPA MCLs and MCLGs. Total coliform contamination was still generally quite good, in the range of 10^1 to 10^3 per mL, and fecal coliform contamination was generally 1 to 2 orders of magnitude lower. This indicates surface water collected during the rainy season has only modest biological contamination. A disinfection step may be necessary for surface water use, although the Finca tap water results suggest a simple settling process may supply adequate disinfection. The "Potters for Peace" filtrons definitely reduced bacterial content, but to what degree was unclear. It is possible that the filtrons do not supply complete disinfection, and this should be studied more carefully, and in greater detail. Additionally, it was not possible to coordinate analyses for *Giardia lamblia*. This is a common pathogen in El Salvador, but the only means for enumeration is cell counting via microscopy. If surface water is to be used for drinking water, the robustness and minuscule size of *Giardia* cysts will have to be considered at great length, and *Giardia* enumeration would be recommended prior to design. Rainwater storage may be a strategy for all or part of the community. If rainwater is used, it will be important to have a first-flush system, design for the acidity of the rain, and possibly take measures to avoid stagnation if the water is stored for prolonged periods.

Issues Developed During Assessment #2

In addition to the valuable information gathered during the second site assessment, there were many areas of improvement that were identified for the chapter and project. Of these, the one with the greatest impact was the discovery of land-ownership issues, especially regarding the spring at El Tanque/Los Patios. Our understanding was that the tank at Los Patios could be used, as per conversation with the owner's agronomist/engineer. However, upon discussing this further with the Peace Corps volunteer, and doubtless consideration by the owner, it was discovered that this site could not be used for the purpose of storing water for the villagers. This significantly set back the project's progress and was not discovered until the second time a team was on-site; a delay that can be attributed to attempted calls to the owner by the EWB project coordinator as well as the Peace Corps volunteer to no effect. The first assessment team was not instructed to seek out land owners to determine availability, but such information would have greatly improved the success of the second site assessment.

Cross-cultural communication

Of second greatest impact was the disconnect between the first assessment's intent and the communities' perceptions of our group. Miscommunication occurs readily when members of a different linguistic, as well as of a different cultural setting and history, are set to the task of developing a solution for a specific goal. Some inferences were made regarding a "long-term" relationship with the community, but also to the effect of a solution being in the shorter term than what is feasible given fundraising and design timelines. In addition to this, there is an emotional appeal for EWB-OSU, which is to not let the community down yet again. This resulted in the community perceiving that EWB-OSU had committed to the project and was already proceeding to design and implementation. In reality, the group was not nearly completed with its assessment of the community.

Owner-CM communication

Another important issue within this process was the communication gap between EWB-OSU and the Peace Corps volunteer and primary community contact. After the second assessment, the chapter left the PC volunteer out of the loop for a brief period of time, at which point an email from him stimulated resumed contact. This fault led to discussions during the second assessment trip regarding appropriate communication with primary community contacts, which are now being established as general guidelines.

Preparation

The second site assessment team had a distinct disadvantage in terms of its preparation for the trip due to geographic dispersion and conflicting schedules during the summer. However, this was remedied by dividing up the tasks and working collectively to gather all important information. Inevitably, the people working on the trip preparation were those who were to travel, and this is an aspect that the club is attempting to change. All members must have a vested interest in the entire shaping and development of the project, and not be divided into those who travel and those who don't. Dividing up the work caused some disarray in the planning process for the trip. A couple of key items were not brought simply due to group forgetfulness or for not knowing, and members were not prepared to use key pieces of equipment until the week before the trip.

Lessons learned

- Clearly define the goals of each site assessment, and reiterate it to the group who will travel. There were cautions in the TAC review that were communicated to the team, but several more should have been discussed in great depth before travel, such as the presentation of water contamination to the community members.
- It is critical that EWB student members take responsibility for the project, and not verbalize ideas without devising a plan and delegating the tasks that the plan will entail. Ideas cannot be 'dumped' onto one person, but should rather be discussed, approved, and handed back to the originator to handle its completion.
- Bring a booklet for on-site receipts, in order to make reimbursement possible.
- Every student should have write-in-rain books, much paper, and should write AND sketch as much as possible.
- Mornings should be more routine, with a wake-up time, roundtable, and daily task list.
- Evenings should have another debriefing roundtable, and ideas for the following day.
- Students who speak the language of the community must be careful to discuss the items spoken with the professionals.
- Any sentiments or issues felt must be brought to the groups attention as soon as possible, to avoid post-trip adversity within the club, or deep-seated criticism.
- Bring Map - We had previously prepared a topographic GIS map that included references to important points, but we forgot it and arrived on-site with only a rough version. Fault lies mainly on the survey team for not coordinating to make certain that the map was brought.
- Effective daily itinerary communication
- Establish primary/lead team member, authority
    - On this trip of 7 people, we had a Project Coordinator (Appointed Student Member), a chapter Vice President (Elected Student Member), and a Regional President (Appointed Professional Member). We also had a

former chapter V.P. At any point, it was difficult to tell who was in charge, and it would help to define these roles better for future trips.

- Thinking of secondary/backup plans. - We at EWB-OSU had essentially committed ourselves to making a particular solution work, when in reality only inexperienced people had assessed that this was a possible solution. We had not thoroughly established backup plans or even an ‘out strategy’ before arriving on-site and discovering that all was not as we had thought.
- Acquire instrumentation early to thoroughly prepare selves - The water quality test kit arrived a few days before our departure, and we were not very well acquainted with it until we began using it, training on-site. This was due to external circumstances that could not be avoided, but could be noted for the future.
- Lack of project advisor - An at-hand dedicated project advisor might have been able to see that we were carrying out 1 design plan too far before determining that it was feasible.
- The Hach 850 kit does not include a turbidimeter. Turbidity would have been a valuable measurement to determine if filtering, settling, or other particle removal steps might be necessary.
- Bring a surface, such as a plastic tarp, that can be wiped down and sterilized with ethanol and/or bleach for a clean space to prepare microbial samples.
- Make room for more pipettes and nitrile gloves so equipment can more easily be kept sterile.
- A squeeze-bottle (as opposed to open beakers) for dilution water for microbial samples would have been helpful in avoiding contamination of dilution water.
- Hold a training workshop on aseptic techniques to make sure human error does not contribute to artificially high bacterial counts.
- Collect microbial samples in separate sample bottle, or *before* dipping pH, DO probes, etc. into sample. Dipping probes in samples might have significantly contaminated some samples.