UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

# UBC Farm Water Monitoring Project – Term 2

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# UBC Farm Water Monitoring Initiative

Submitted to Dr. Susan Nesbit

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# EXECUTIVE SUMMARY

"UBC Farm Water Monitoring Initiative"

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The UBC Farm expressed concern regarding water quality beneath the farmlands, mainly due to chlorine-based soap used at the harvest hut. Also, they considered the ecological effects of percolating chemicals from compost and fertilizer use. Thus, we are testing water contaminant levels, including pH, calcium, nitrate, ammonia, and phosphate, by use of the PushPoint Sampler. Afterwards, the UBC Farm will continue monitoring groundwater cleanliness with the purchased equipment. Included within this report is further introductory and background information, along with an implementation plan, sampling methods, test results, recommendations, and measures of success. The implementation plan consists of purchasing and assembling the necessary equipment, locating a drainage culvert, installing three sample stations, extracting groundwater, exporting samples to the laboratory, and analyzing the results obtained from various tests. The methodology elaborates on the implementation plan to ensure quality of sampling; moreover, it specifies sampling protocol, preparation, site assessment, techniques for extraction, sample analysis, sampling frequency, quality control, storage and transport. The results of the initial tests are also included in this technical report. All contaminants read at acceptable levels, with the exception of chlorine, which approaches maximum recommended levels. This raises concern for the type of soap used at the harvest hut. Recommendations to reduce contaminant levels include regular groundwater sampling; this will require preliminary reading of the PushPoint Sampler Operators Manual and participation of two people when performing the proposed sampling procedure. Lastly, employment of environmentally friendly soap is recommended to reduce chlorine levels. Overall, the project was a success on several measurable levels. Based on stakeholders' interests and sustainability principles, we designed objectives, delegated responsibilities, and compiled our work and research. All objectives were completed within time and budget constraints, and a long-term water monitoring system was established.

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# 1.0 INTRODUCTION

Groundwater monitoring is often used to determine the severity of groundwater contamination; thus, in this report, we will propose a groundwater monitoring system to determine the cleanliness of the water flowing beneath the UBC farmland. This, the project's purpose, is in accordance with UBC Farm's vision and corresponding mission, goals, and objectives: by investigating the cleanliness of the water flowing beneath the farmlands, we will contribute to the ongoing integration of sustainable practices at the farm, influence positive environmental and agro-ecological change by promoting better, alternative farm methods, and build community interest and involvement by sharing our applied research and methodology for responsible water use. The groundwater monitoring system that we propose in this report is made in recognition of the potential for groundwater contamination at the UBC Farm. Such contamination is a consequence of local farm and human activities including the washing of farm goods at the UBC Farm Harvest Hut, and the regular additions of mulches, composts, and fertilizers to the farmland.

In this technical report, a background section will provide project context and outline project deliverables. Further, we will present the plan and schedule that was used for project implementation. To fulfill the main objectives of our project, we will assert a groundwater sampling protocol; this protocol will describe the sampling technique, and outline the requirements for sampling preparation, quality control, extraction, and storage. We will suggest a sampling frequency, sampling locations, and a sample log. We will explain how field tests are conducted, and recommend a laboratory for more extensive sample testing. We will interpret the results obtained from our own field and laboratory tests, and we will compose recommendations based on our findings. Lastly, we will discuss the measures of success for our project.

This report is requisitioned as part of the CIVL 202 course at the University of British Columbia. It focuses on a groundwater monitoring system that will be used to determine the severity of groundwater contamination at the UBC Farm. Our research includes publications accessed in the library, in online scholarly databases, and in UBC Farm archives. Faculty expertise was also used in the composition of this report. Our audience includes Dr. Susan Nesbit, a respected civil engineering professor, Andrew Rushmere, academic coordinator at the UBC Farm, Geoff Hill, environmental science graduate student, Paula Parkinson, senior technician at the Environmental Engineering Laboratory, Roger Beckie, associate professor in geological engineering, as well as other students, faculty members, and UBC Farm employees.

## 2.0 BACKGROUND

UBC Farm is committed to integrating sustainable land management and food production practices; however, less emphasis has been placed on sustainable, responsible water usage. Consequently, concern arose for the quality and cleanliness of the water that flows around, and through, the UBC farmland. To further promote the farm's image of sustainability, and to further attest to the farm's vision, goals, and objectives, the farm proposed a Water Monitoring Initiative as a Community Service Learning Project for a group of second year civil engineers.

The ultimate intent of the project was to create a water monitoring system that would detect and assess the extent of groundwater contamination at the farm. As the project progressed, new objectives presented themselves, and a broader, more accurate representation of the farms groundwater was obtained. The objectives were as follows: postulate possible contaminants; research the effect of the contaminants on the agro-ecosystem and downstream marine life; observe farm topography and hypothesize groundwater flow directions; using a hydrology map, locate the culvert that transports water from the Harvest Hut to the drainage ditch; propose various sampling techniques and recommend the most practical, simplistic, representative, cost-effective option; create a sampling protocol, including sample preparation, assessment, location, frequency, documentation, quality control, extraction, storage, and transport; determine how to inexpensively test for the contaminants of interest using field tests or by exporting samples to a laboratory; interpret results obtained with respect to the impact of the findings on the ecosystem; determine whether contaminant levels are within safe bounds by comparing them to guidelines for groundwater quality; postulate sources of contaminants; make recommendations for future work or, if needed, treatment options; create a poster that summarizes the project and display it on the Harvest Hut wall to illustrate the farm's responsible water use practices to visitors.

In term one, we proposed a groundwater monitoring system. In term two, we implemented the proposed groundwater monitoring system. Improvements were made to our sampling method and protocol, and a more comprehensive, functional groundwater monitoring initiative is presented in this report. Additionally, with the help of the UBC's Environmental Engineering Laboratory, we have tested for more contaminants than we had originally planned, and have uncovered other information about the groundwater at the UBC Farm. More specifically, we tested for calcium, nitrite, nitrate, ammonia, phosphate, fecal coliform, and various metals listed on our data sheet (Appendix A); we also determined the pH, conductivity, turbidity, and dissolved oxygen content of the pore-water samples – refer to the Appendices and Results and Interpretation of Results sections.

# 3.0 IMPLEMENTATION PLAN

Each Community Service Learning Project required a three-day implementation phase. For our project, this phase consisted of six main tasks. First, we had to purchase the equipment outlined in our term one report: a PushPoint sampler, a screen sock, three sampling syringes, rebar and PVC pipe, and various field test kits. The sampling equipment was purchased from an online manufacturer located in Michigan, while the other equipment was purchased at local stores. All additional equipment – gum boots, gloves, shovels, hammers, flagging tape, sample bottles, and electronic sample meters – was provided by either the UBC Farm or UBC's Environmental Engineering Laboratory. Second, we had to locate the drainage culvert that deposited wastewater from the Harvest Hut into the drainage ditch; the drainage ditch flows along the farmland's southern perimeter (Figure 1). Since various soaps and bleaches are used to clean food and food containers at the Harvest Hut, the culvert was identified as possible contaminant emitter. The location of the culvert had not been documented previously. Third, we had to build sample stations at the locations specified in our term one report: one in the low-elevation areas, one at the culvert, and one downstream of the culvert (Figure 1). To install each sample station, we pre-probed a hole using the rebar pole and hammer. We then withdrew the rebar and inserted a PVC pipe into the vacant hole. The PVC pipe was cut a foot above ground surface and marked with flagging tape. When the water table re-assumed atmospheric pressure, the PushPoint Sampler and sampling syringe were used to obtain a groundwater sample. Extraction of a groundwater sample is the fourth step in implementation. Fifth, we conducted field tests using electronic meters and simple titrations; the testing is explained in the Sampling Analysis sub-section. Samples are then exported to the laboratory for further analysis. Lastly, after all data from field and laboratory tests is collected, the results are analyzed and interpreted. A three-day implementation schedule is included in Appendix C.

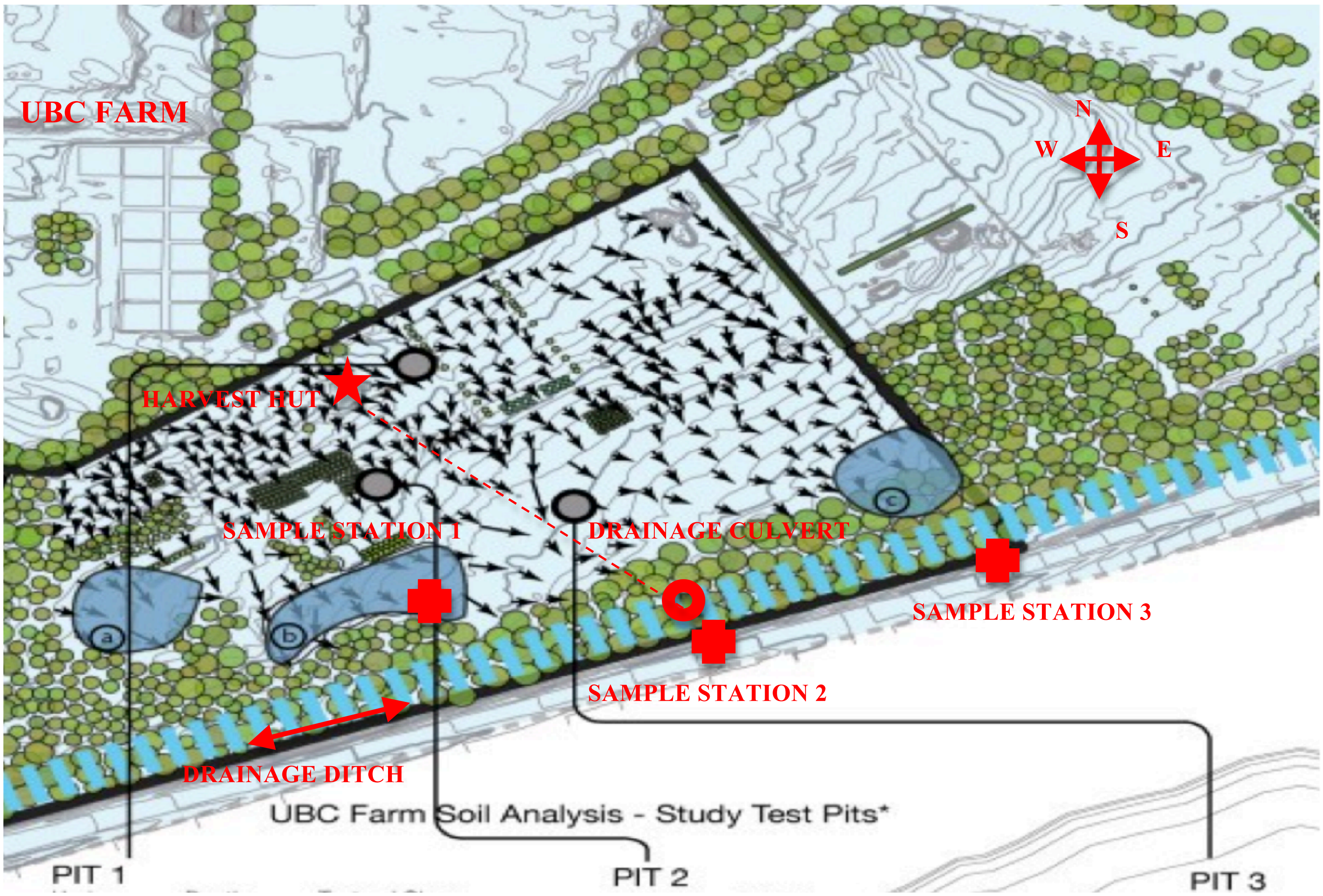



Figure 1: UBC Farm Groundwater Flow Diagram (approximate locations of the drainage ditch, drainage culvert, Harvest Hut, and sampling stations are shown)
Source: UBC Farm Archives

# 4.0 SAMPLING METHODOLOGY

Detection and assessment of contaminated groundwater bodies is the basis for groundwater monitoring. In UBC Farm's case, the groundwater monitoring system employed will not only detect and assess contaminated groundwater bodies, but it will also promote responsible water usage. This will be achieved, in part, through the groundwater monitoring protocol and sampling procedures outlined in this section of the report. Ultimately, the groundwater monitoring efforts proposed will permit the UBC Farm staff to monitor groundwater conditions, including fluctuations in chemical contaminants, throughout the year. Such monitoring efforts will be essential in determining the most appropriate methods for groundwater rehabilitation.

## 4.1 Sampling Technique

For effective sampling and representative results, the method of sampling must be simple in design, provide sampling reliability and sample reproducibility at different locations, and be both cleanable and repairable. Further, a sampling method should cause little disturbance of the samples, possess operational simplicity, and minimize the exposure of the sample to foreign material. The sampling technique that embodies these characteristics best is the PushPoint sampling device, manufactured by MHE Products (Figure 3).

## 4.2 Sampling Protocol

PushPoint apparatus' are useful for quick collection of pore water samples. These pore water samples must be taken from beneath bodies of surface water or the saturated areas surrounding them; our sample locations reflect this requirement (Figure 1). The PushPoint consists of a tubular, semi-perforated shell, an inner strengthening rod, and a syringe; the strengthening rod provides structural support to the perforated zone while temporarily blocking water from entering the hollow shell; the perforated zone allows water to infiltrate the shell once the strengthening rod is removed; the syringe attaches to the sampling port and allows for manual extraction of water that infiltrates the shell (Figure 3a and 3b). Based on the apparatus' user guide, and our own sampling experiences, we have composed a sampling protocol. This protocol can, and should, be followed in the future when extracting pore water samples from the three pre-probed sampling locations.

#### 4.2.1 Preparation

Before samples are collected, the sampling equipment must be cleaned and decontaminated: sample bottles must be emptied, washed, and dried, and the pore-water sampler must be rinsed free of sediment and residual pore-water. This is especially important at the UBC Farm since the contaminants of interest are likely low in concentration. Secondly, labels indicating the sample location should be placed on each sample bottle. The sample log should also be filled in where possible – at a minimum, the *date, sampled by*, and *contaminants of interest* sections. The contaminants of interest will vary depending on what tests are being conducted: for example, heavy metals will not be considered as a contaminant of interest if the samples are not going to be exported to a laboratory for analysis. The sample log should be carried with the sample person so that information can be added at the time of pore-water extraction.

#### 4.2.2 Site Assessment and Documentation

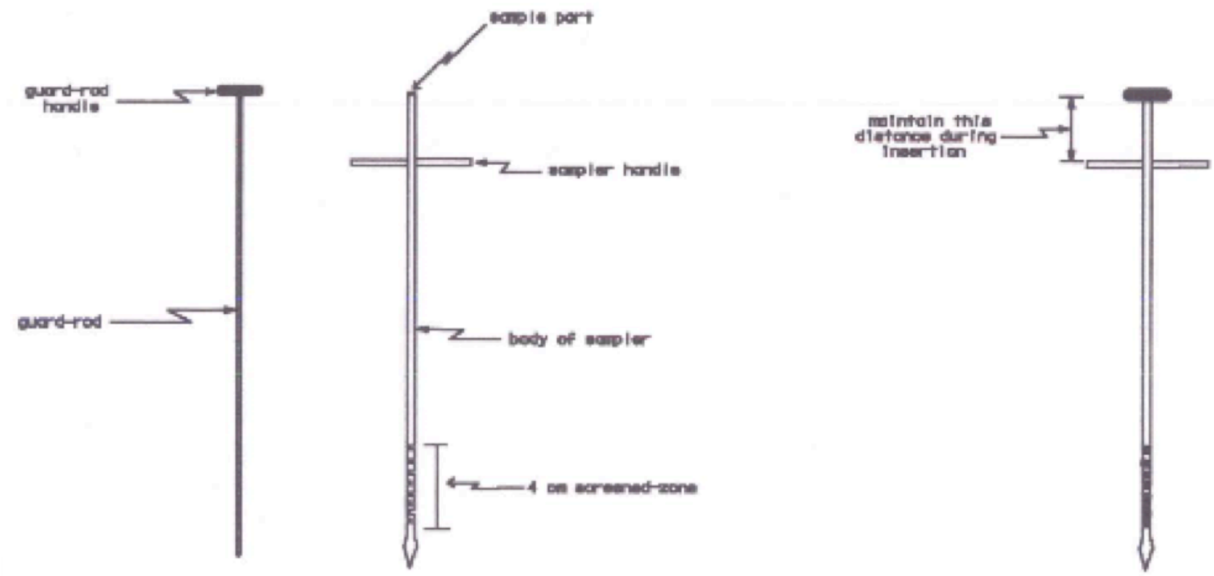
When the sample person is at the sample location, they should first document their observations. For example, the sample person should make note of the weather, the depth of the water table, and the depth of the surface water, as well as any visible contamination in surface water bodies or any apparent odour. Documenting such observations can aid in the explanation of test results. As groundwater samples are being taken, the amount of sediment in the sample should be recorded, as should the time at which the sample was taken. The time at which the sample was tested should also be recorded when field or laboratory tests are conducted. The sample log we used when we conducted our own tests is shown in Figure 2.

| UBC Farm Water Monitoring Initiative: Sample Log | |
|---|---|
| Date: | Sample No.: |
| Sampled By: | Sample Station: |
| Contaminants of Interest: | |
| Time Sample was Taken: | |
| Time Sample was Tested: | |
| Observation/Field Information:<br>(ie. odour, visible contamination, amount of sediment in sample, weather, depth of water table, depth of surface water) | |

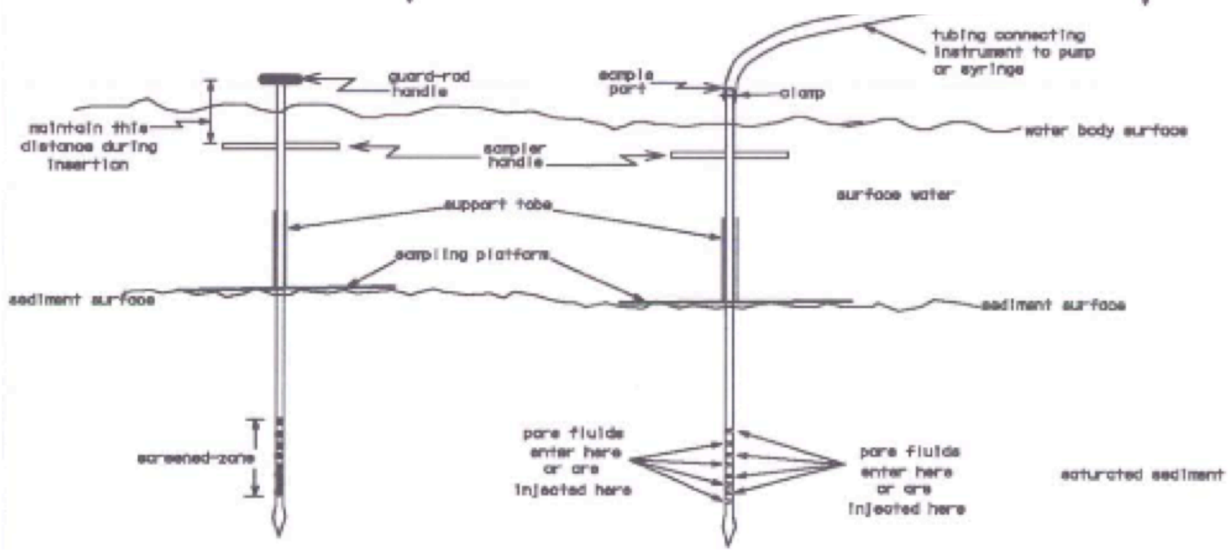
Figure 2 Sample: Log
Source: Modified From *Practical Guide for Groundwater Sampling, 1985*

### 4.2.3 Groundwater Extraction

Hold the PushPoint device firmly as to keep the strengthening rod fully inserted into the semi-perforated shell. The PushPoint can then be inserted into, and gently lowered to the bottom of, the PVC pipe; the gentle lowering of the sampling device minimizes the disturbance of sediments and therefore lowers the turbidity of the sample. Once the bottom of the pre-probed sample hole is reached, the PushPoint is withdrawn approximately two inches; this also decreases how much sediment is extracted with the pore-water. Subsequently, the strengthening rod is removed, and a syringe is attached to the sample port (see Figure 3a and 3b). Pore-water can then be withdrawn at a low-flow sampling rate. Once a representative sample is obtained (approximately 50 ml), the syringe can be detached from the sample port and pore-water can be transferred to pre-labeled sample bottles.




a)




b)

c)

d)

Figure 3: PushPoint Sampling Device
a) PushPoint Pore-Water Sampling Apparatus
b) PushPoint Sampling Apparatus with Syringe
c) Groundwater Extraction via PushPoint Sampler
d) Syringe Assembly with Plug
Source: www.mheproducts.com

### 4.2.4 Sample Analysis

After obtaining groundwater samples, on-site field tests can be conducted, or the samples can be exported to the Environmental Engineering Laboratory for more extensive sample analysis. On-site field test kits for pH, calcium, nitrite, nitrate, ammonia, and phosphate are available. Such field tests consist of simple titrations, and the method for conducting these titrations is as follows:

- pH

  Locate pH testing equipment which should include a small vile, pH indicator solution, color comparison chart and pH testing instructions. Follow instructions and record data on appropriate sheet.

- Calcium

  Locate calcium testing equipment which includes small water sampling container, three calcium testing chemicals, and set of instructions. Follow the set of instructions and record data on appropriate sheet.

- Nitrite or Nitrate.

  Locate nitrite or nitrate testing equipment, which should include a small vile, two chemical solutions for each of nitrite and nitrate, set of instructions and a colour comparison chart. Follow instructions and record data on appropriate data sheet.

- Ammonia

  Locate ammonia testing equipment which should include, small vile, an ammonia testing solution, colour comparison chart, and set of instructions. Follow the instructions and record data on appropriate data sheet.

- Phosphate

  Locate phosphate testing equipment, which should include two testing solutions, a set of instructions, and a colour comparison chart. Follow the set of instructions and record data on appropriate data sheet.

Note: Latex gloves should be worn when conducting field tests so that no new contaminants are introduced to the sample.

We emphasize that this sampling protocol be followed closely as to ensure accurate analytical results. After all, laboratories and persons conducting field tests can only report data based on the quality of the samples: sampling errors decrease the accuracy of laboratory and field tests. Other sampling procedures relevant to the success and accuracy of our groundwater monitoring system are outlined below.

#### 4.2.5 Sampling Location

The geologic setting, site hydrology, water level information, and direction of surface water flow influenced our choice of sampling locations. Also, from consultation with UBC Farm staff, we knew that wash water from the Harvest Hut was deposited into the drainage ditch via a culvert, and that chemical constituents from mulch, fertilizer, and compost additions were migrating toward the lower elevation regions of the property. Thus, it appeared logical to sample the groundwater in the low elevation areas and at various points along the drainage ditch. As a result, three sample stations were built: one at low elevation area b, one at the culvert outflow, and one downstream of the culvert. Sampling locations must also be documented, as is shown in Figure 1. If, in the future, sampling of other locations is desired, another pre-probed sample station should be constructed. The PushPoint sampler should not be directly inserted into the ground due to the glacial till deposits common to the region; damage to the sampling apparatus could result. Locations of new sampling stations should also be documented.

#### 4.2.6 Sampling Frequency

Seasonal changes, time, and money place constraints on the frequency of sampling at the UBC farm. For example, during the summer months when the crops are plentiful and the Harvest Hut is in regular use, sampling frequency may increase; this sampling increase is resultant of increased chemicals being washed down the Harvest Hut drain and the increase in composts, fertilizers, and mulches – in addition to increased irrigation – added to the fields. Also, if sampling is too frequent, information will be redundant and consequently time and money will be needlessly used; likewise, if sampling is too infrequent, information may be omitted and the objective of monitoring may not be achieved. Based on this, we recommend sampling occur monthly, or perhaps quarterly, depending on the availability of UBC Farm staff to perform sample collection and on-site field testing. Further, samples should be exported to the Environmental Engineering Laboratory once a year for more comprehensive testing. It would be strategic to export these samples when contamination is the highest – presumably during the summer months, as was mentioned above.

**4.2.7 Quality Control**

To ensure quality of the samples and accurate analytical results for the majority of the sample tests, we advise that turbidity in the samples be minimal. Turbidity, the amount of suspended solid particles, can drastically affect testing results by absorbing dissolved solids and inhibiting their detection in analysis. Such dissolved solids could be, but are not limited to, Ca, N, K, P, Mg, Hg, and Cl. Therefore, if overly turbid samples (by observation) are obtained, new samples must be collected. This may require the sample person to leave, and then return once the sediments have settled in the pre-probed sample hole.

**4.2.8 Storage and Transport**

Proper storage and transportation of the samples collected guarantees that the water quality of the sample is not compromised between the time of collection and the time of analysis. For our sampling objectives, however, this precaution is not necessary: the tests we are conducting are not significantly affected by variables such as exposure to light or temperature changes. Nonetheless, testing and analysis of groundwater samples should be conducted the same day the sample was taken.

# 5.0 RESULTS AND INTERPRETATION OF RESULTS

This section will discuss the results from both field and laboratory tests.

The pH was found to be at the expected levels of close to 7.0, which is considered neutral. The pH also remained close to constant from site to site which means that there is likely nothing leaching into the sampling stations that would change it. The pH must be monitored year round to get a better idea of pH trends since it will likely change throughout the seasons. The pH should remain between 6.5 and 9.0 without large fluctuations in a short period of time.

For nitrite, we did not find detectable levels at any of the sites; this is not surprising since at this time of year there is little nutrients on the fields to leach nitrogen into the drainage ditch. The nitrite levels should remain almost undetectable all year round sine the maximum detectable level is 0.6 mg/L. We did detect levels of nitrate at the culvert, however.  The levels were very low, though, so there is no risk of negative effects on the aquatic ecosystem. The most sensitive aquatic life are comfortable with levels above 3 mg/L, and the detected levels at the culvert were 2 mg/L.

The ammonia levels at all tests sites were undetectable which is good since we want the levels to be as low as possible. The acceptable levels are dependant on water temperature as seen in Table 2 of our term 1 report.

Phosphate also had undetectable levels which is likely to change later in the year when more compost is put on the fields. There are no typical guidelines for phosphate in the groundwater, but we would hope to see only small fluctuations throughout the year.

The calcium in the water was surprisingly low but this could be attributed to the little amount of compost in the fields at this time of year. Low levels of calcium are not cause for concern. Calcium in water does help balance to pH, however, so we would hope that the low calcium does not lead to large fluctuations in pH.

Dissolved oxygen at all the sites were at acceptable levels. They were all between 9 and 10 mg/L; the minimum acceptable level is 5mg/L.

Surprisingly, we did detect chlorine at the culvert. Chlorine concentration was measures as 0.1 mg/L, which is the maximum acceptable level. This level does raise some concerns since this time of year is when we expected to find a minimum concentration; therefore, in the summer when more bleach is deposited into the culvert the levels may go above acceptable levels. Because of this, we recommend not using bleach at the harvest hut. Instead, an environmentally friendly soap should be used.

Turbidity throughout the stream appears to vary significantly with location, but it appears to remain close to constant at each site, which is what we desire. It should be noted that turbidity can vary significantly with human disturbance of sediment: natural turbidity levels would be difficult to obtain.

Nitrogen and Carbon analysis at the Environmental Engineering Laboratory showed no worrisome contaminant concentrations: the IL-550 analyzer has detection limits for total inorganic carbon (TIC), total organic carbon (TOC), and total nitrogen (TN) at 1 mg/L, 1 mg/L, and 0.5 mg/L, respectively, and the values we obtained were only slightly above this. We therefore assume that nitrogen and carbon concentrations at the sampling locations aren't an immediate concern, but further research should be conducted to determine their affect on the agro-ecosystem and downstream environment. Lastly, as was the case with chlorine, the TN, TOC, and TIC concentrations were highest at sample station two – the drainage culvert. Therefore, we emphasize that more research be carried out to determine what affect the drainage ditch is having on the surrounding ecosystem; such research is outside the scope of this report. TOC, TN, and TIC values are presented in Appendix A, Laboratory Data 2.

# 6.0 RECOMMENDATIONS

There exists several research opportunities to better understand, among other things, groundwater conditions, hydrology, contaminant plume migration, and soil distribution; nonetheless, many of the these investigations are beyond the scope of our report. Therefore, we will only make recommendations for future research. If such research is conducted, the success of sampling is certain to increase as a broader, more accurate representation of the farm's groundwater will be obtained. Accordingly, in this section of the report, we will outline opportunities for future work, share sampling tips, suggest treatment options, and make other relevant recommendations relating to the sample test results.

- We recommend that other students trace the exact sources of the contaminants found during sample testing and analysis; this will require an investigation of the composition of soaps and other cleaning products used on the Farm or at the Harvest Hut. The chemical and organic mixtures – the mulches, fertilizers, and composts – should also be studied to determine their composition and to more comprehensively explain their effect on the groundwater and surrounding ecosystem.
- We recommend that the sample person read the PushPoint Sampler Operators Manual and Applications Guide to supplement the sample procedures outlined in this report. Our first term report, entitled *UBC Farm Water Monitoring Project*, should also be read if a person wishes to better understand this project's purpose and it's application to sustainability, or wants to review the design and implementation plan for our water monitoring system.
- We recommend that two people participate in the sampling process. It is much easier to document activities and obtain representative samples when more than one individual is present; for example, when sampling, one person should hold the sampling device two inches above the bottom of the sample hole while the other person uses the syringe to manually extract a sample.

- We recommend that gumboots be worn while sampling: it is inevitable that a sample person will have to trek through saturated soils and surface water bodies to reach the sampling location.
- Based on the analytical results, the chemical constituents present in the fertilizer, mulch, and compost will not require additional treatment to that of natural treatment processes. Natural treatment consists of utilizing the low elevation marshlands as a medium for filtration, which reduces the concentrations of K, P, N, Ca, and Mg to natural levels before being leached into the drainage ditch.
- With respect to the additions of mulch, fertilizer, and compost, we recommend numerous hours of leaching by rainfall before vegetation is planted. This will allow for the initially high, and potentially harmful, salt and nitrate concentrations to subside.
- Based on the levels of chlorine found at sample location two (Figure 1), we recommend that new, environmentally friendly, low chlorine soaps be used.
- We recommend that sampling occur monthly, or perhaps quarterly, depending on the availability of UBC Farm staff to perform sample collection and on-site field testing. Further, samples should be exported to the Environmental Engineering Laboratory once a year for more extensive testing; if this monitoring initiative is to be continued, the UBC Farm budget should account for this yearly expense.
- Pore-water samples should contain minimal turbidity if accurate analytical results are desired. We therefore recommend that care be taken not to disturb sediments at the bottom of the PVC pipe at each sample station.

# 7.0 MEASURES OF SUCCESS

The groundwater monitoring initiative presented in this report succeeded on numerous levels: through the design and planning stages, through application of sustainability practices and stakeholder analysis, and through project implementation and project management. The success of these individual, but connected, aspects contributed to the completion of the organization's objectives and goals.

Initially, our group met with the client – UBC Farm – and established goals for the proposed Groundwater Monitoring Initiative. The farm desired to contribute to the ongoing integration of sustainability practices, and to influence positive environmental and agro-ecological change by improving their farming methods. Based on the farms concern for bleaches and soaps, that are used at the harvest hut, flowing downstream and negatively affect ecosystems, we determined that the ultimate objective was responsible water usage. Thus, our group was successful in considering farm needs and weighing farm interests, and then establishing project goals and objectives based on the same needs and interests.

Once such goals and objectives were established, our group began to design a groundwater monitoring system that would allow for the detection and assessment of groundwater contamination. We collaborated to brainstorm different sampling methods and discussed, based on possible sources, which contaminants were of interest. Our group then delegated research and writing roles, and composed an initial sampling protocol. Thus, our group was successful in designing a groundwater monitoring system, considering alternative solutions, and then choosing the most feasible one. Further, our group was successful in project management since we worked together towards a desired outcome and delegated individual roles to complete a large-scale project.

After we proposed a groundwater monitoring system, and after a project budget was established with the UBC Farm, our group had to devise a plan for project implementation. We contacted online manufacturers and local stores for equipment price quotes, and found an on-campus laboratory to conduct our lab tests. We also determined where we could borrow equipment from to reduce expenses. Subsequently, we created a three-day implementation schedule. This implementation schedule was planned in conjunction with the UBC Farm and the Environmental Engineering Laboratory. Thus, our group was successful because we illustrated how project design carries over into project implementation, and how constraints such as cost can be accounted for without compromising the feasibility of the design. Further, our group was successful because we made a schedule that was coordinated with stakeholder availability, and that would allow us to complete the project on time.

In the final stage of project implementation, our group sampled the groundwater and conducted field and laboratory tests. We then analyzed and interpreted the data obtained, and made recommendations for groundwater rehabilitation and suggestions for future work. A poster was also made to share our project's purpose, our sampling methodology, and our findings with the public; the poster was mounted on the Harvest Hut wall. Thus, our project was a success because we carried out our plan for project implementation, and in doing so made recommendations to the farm that promoted responsible water usage. Further, our project was a success because we shared our findings with the public.

Ultimately, our project was a success because we promoted sustainable practices, exercised project management, design, and planning skills, and accomplished the objectives and goals outlined by the UBC Farm.

# 8.0 CONCLUSION

The UBC Farm Water Monitoring Initiative aims to create a water monitoring protocol to ensure chemical fluctuations stay within recommended ranges throughout the year. After extensive research, we found that the most efficient method for sampling is the PushPoint method. In addition, we have outlined which contaminants could be present at the farm, and proposed methods to test for them. The farm will be responsible for future groundwater monitoring, but our group conducted initial tests. As was expected, no major contaminants were found; however, the chlorine concentration approached the maximum recommended level. This shouldn't cause too much alarm as it was within the typical range, but the levels must be monitored during future tests. Furthermore, using data obtained from groundwater analysis, the farm can continue to modify both farming and washing methods to promote sustainability. The water monitoring initiative proposed in this report is the beginning of a multistep project to achieve responsible water usage at the UBC farm.

# LIST OF REFERENCES

MHE Products. (2009). Pore Water Sampling Equipment. Retrieved February 20, 2009, from www.mheproducts.com

Pore-Water Sampling. (2007). SESD Operating Procedure. Retrieved February 23, 2009, from http://www.epa.gov/Region4/sesd/fbqstp/PorewaterSampling.pdf

UBC Farm, (2009) Retrieved February 21, 2009 from http://www.landfood.ubc.ca/ubcfarm/index.php

Barcelona, M., Gibb, J., Helfrich, J., Garske, E. (1985). Practical Guide for Groundwater Sampling. Retrieved November 23, 2009, from Google Scholar.

# APPENDIX A: DATA

| UBC Farm Water Monitoring Initiative: Laboratory Data 1 | | | | |
|---|---|---|---|---|
| Metals analysis - Units mg/L (ppm) | | | | |
| Element | Blank | Sample Station | | |
| | | #1 | #2 | #3 |
| Al | 0 | 0.047 | 0.081 | 0.01 |
| As | 0 | 0 | 0 | 0 |
| B | 0 | 0 | 0 | 0 |
| Ba | 0 | 0.016 | 0.026 | 0.025 |
| Ca | 0 | 4.828 | 8.008 | 12.653 |
| Cd | 0 | 0.002 | 0 | 0 |
| Cr | 0 | 0 | 0 | 0 |
| Cu | 0.005 | 0.012 | 0.007 | 0.015 |
| Fe | 0 | 6.307 | 10.5 | 3.116 |
| K | 0 | 21.04 | 2.598 | 17.473 |
| Mg | 0 | 10.061 | 18.455 | 20.25 |
| Mn | 0 | 0.064 | 0.179 | 0.034 |
| Na | 0 | 1.53 | 1.47 | 1.73 |
| Ni | 0 | 0 | 0 | 0 |
| P | 0 | 0.504 | 0.014 | 1.782 |
| Pb | 0 | 0 | 0 | 0 |
| Si | 0 | 2.119 | 4.523 | 3.986 |
| Zn | 0 | 0.051 | 0.132 | 0.038 |

*Samples were analyzed by ICP using a Perkin Elmer Optima 7300DV Optical Emission Spectrometer.

| UBC Farm Water Monitoring Initiative: Laboratory Data 2 | | | | |
|---|---|---|---|---|
| Laboratory Test | Units | Sample Station | | |
| | | #1 | #2 | #3 |
| TN (Total Nitrogen) | mg/L as N | 0.71 | 7.6 | 4.2 |
| TOC (Total Organic Carbon) | mg/L as C | 0.87 | 5.4 | 5.4 |
| TIC (Total Inorganic Carbon) | mg/L as C | 1.81 | 6.3 | 7.6 |

*Samples were analyzed by high-temperature oxidation method using an IL-550 TOC/TN infra-red analyzer.

Data Legend:
- Sample Station #1: Low Elevation Area
- Sample Station #2: Culvert
- Sample Station #3: Downstream of Culvert

| UBC Farm Water Monitoring Initiative: Field Data | | | | |
|---|---|---|---|---|
| Field Test | Units | Sample Station | | |
| | | #1 | #2 | #3 |
| pH | | | | |
| Field Test | | 7.18 | 7.26 | 7.23 |
| Electronic Meter | | 6.9 | 6.83 | 6.84 |
| Calcium | mg/L | 0 | 0 | 0 |
| Nitrite | mg/L | 0 | 0 | 0 |
| Nitrate | mg/L | 0 | 2 | 0 |
| Ammonia | mg/L | 0 | 0 | 0 |
| Phosphate | mg/L | 0 | 0 | 0 |
| DO | mg/L | 9.8 | 9.1 | 9.9 |
| Chlorine | mg/L | 0 | 0.1 | 0 |
| Conductivity | µS | 201 | 220 | 238 |
| Turbidity | ntu | | | |
| run 1 | | 3.51 | 43.9 | 8.84 |
| run 2 | | 3.33 | 41.3 | 8.93 |
| Fecal Coliform | # coliform | | | |
| 1 ml dilution | colonies | 1 | 0 | 0 |
| 10 ml dilution | formed | 8 | 0 | 3 |

# APPENDIX B: SAMPLE LOGS

| UBC Farm Water Monitoring Initiative: Sample Log | |
|---|---|
| Date: February 17, 2010 | Sample No.: 1 of 3 |
| Sampled By: Kevin, Matthew | Sample Station: Low elevation area |
| Contaminants of Interest: All | |
| Time Sample was Taken: 9:38 am | |
| Time Sample was Tested: field test = 11:05 am | lab test = 2:15 pm |
| Observation/Field Information: (ie. odour, visible contamination, amount of sediment in sample, weather, depth of water table, depth of surface water) Clear skies. No recent precipitation. No surface water. Ground beneath feet is saturated. Soil contains much organic matter (at least at the surface it does) due to "spongy" properties and rebound after walking on it. Water table is 2" below ground surface. No visible contamination or odour. Sample taken was not murky, but some particles were suspended. | |

| UBC Farm Water Monitoring Initiative: Sample Log | |
|---|---|
| Date: February 17, 2010 | Sample No.: 2 of 3 |
| Sampled By: Kevin, Matthew | Sample Station: Culvert |
| Contaminants of Interest: All | |
| Time Sample was Taken: 10:05 am | |
| Time Sample was Tested: field test = 11:05 am | lab test = 2:15 pm |
| Observation/Field Information: (ie. odour, visible contamination, amount of sediment in sample, weather, depth of water table, depth of surface water) Clear skies. No recent precipitation. Some suspended material in surface water. Organic matter decomposing on slopes surrounding sample station. Surface water was 7" deep. No visible contamination or odour. Water from the culvert is flowing perpendicular to the flow of the creek. Sample taken was somewhat murky with observed suspended particles. | |

| UBC Farm Water Monitoring Initiative: Sample Log | |
|---|---|
| Date: February 17, 2010 | Sample No.: 3 of 3 |
| Sampled By: Kevin, Matthew | Sample Station: Downstream of culvert |
| Contaminants of Interest: All | |
| Time Sample was Taken: 10:36 am | |
| Time Sample was Tested: field test = 11:05 am | lab test = 2:15 pm |
| Observation/Field Information: (ie. odour, visible contamination, amount of sediment in sample, weather, depth of water table, depth of surface water) Clear skies. Some suspended material in surface water. Organic matter decomposing on slopes surrounding sample station. Surface water was 3" deep. No visible contamination or odour. Sample taken was vary clear with little suspended material. | |

## APPENDIX C: IMPLEMENTATION SCHEDULE

| UBC Farm Water Monitoring Initiative: Implementation Schedule | |
|---|---|
| Day & Date | Tasks |
| 1<br>February 16, 2010 | ·Gather, and assemble, all equipment (from the farm and laboratory)<br>·Change into the proper attire (put on gumboots and gloves)<br>·Carry all equipment down to sampling location#1 (low elevation area)<br>·Pre-probe a sample hole with rebar and hammer<br>·Insert PVC pipe into pre-probed hole and cut to appropriate size (approximately a foot about the ground or water surface)<br>·Mark PVC pipe with surveying tape<br>·Locate sampling location 2 (ie. find the drainage culvert)<br>·Install the second sampling station<br>·Proceed to third location and install the third sampling station<br>·Prepare all equipment (field test kits/sample bottles) for day 2 |
| 2<br>February 17, 2010 | ·Bring sample bottles and PushPoint down to southern end of farm<br>·Use PushPoint sampler to extract a sample from each sampling location (as is outlined in section 4.2.3); samples for field tests, lab tests, and coliform tests are collected<br>·Fill out Sample log at each sample location<br>·Take samples back to the Harvest Hut to conduct field tests<br>·Take samples to laboratory and prepare coliform tests and conduct turbidity tests. |
| 3<br>February 18, 2010 | ·Return to the laboratory to count the number of coliform colonies formed<br>·Prepare samples for analysis on ICP machine<br>·Return all borrowed lab equipment (electronic meters)<br>·Leave sampling equipment and field test kits at the UBC Farm for future use |

# APPENDIX D: TIME SHEET

| Date | Time | Members Present | Activities |
|---|---|---|---|
| January 6th | 10:00 – 1:00 | All | ·Discussed criteria for presentation on Monday |
| | | | ·Met with Dr. Nesbit to discuss future of project |
| | | | ·Started Power Point presentation |
| January 8th | 10:00 – 1:00 | All | ·Finished Powerpoint presentation |
| | | | ·Distributed roles for presentation |
| January 11th | 10:00 – 1:00 | All | ·Final adjustments on presentation |
| | | | ·Practiced presentation |
| | 3:00 – 5:00 | All | ·Continued preparations for presentation |
| | ~ 7:00 – 7:30 | All | ·Presentation to UBC Farm & CSL representatives |
| | | | ·Q & A |
| January 18th | 12:00 – 1:00 | All | ·Discussed next steps in project |
| | | | ·Arranged meetings with contacts |
| | 3:00 – 3:30 | Kevin, Brandon, Tim, Joseph | ·Talked to Roger about sampling method |
| | | | ·Received advise on other possible methods of sampling |
| January 21st | 1:00 – 2:00 | Kevin, Matt, Tim, Nav | ·Met with Paula Parkinson to talk about testing methods |
| | | | ·Learned two methods of testing (two prices) |
| | | | ·Arranged for general testing date |
| January 25th | 11:00 – 12:00 | Kevin, Brandon, Matt, Joseph | ·Met with Geoff, discussed other possible things to test for |
| | | | ·Confirmed method for sampling |
| January 27th | 12:00 – 1:00 | Kevin, Matt, Tim, Brandon, Nav | ·Met with Brenda Sawada, discussed adding our project to the SEEDS program |
| January 28th | 3:30 - 4:00 | Matt | ·Finalized the equipment order with Andrew Rushmere and got budget approval for the purchasing of other equipment |
| February 4th | 3:00 - 3:15 | All | ·Reviewed our implementation plan and discussed roles for both carrying out our implementation and writing the technical report |
| February 16th | 9:30 - 3:30 | Kevin, Matt, Brandon | ·Gathered all equipment, assembled the sampling device, and completed building the three sampling stations. |
| February 17th | 9:00 - 6:00 | Kevin, Matt | ·Collected three sets of samples from each of the three sample stations (one for field tests, one for the laboratory tests, and one for the coliform tests).<br>·Conducted field tests and brought the samples to the laboratory for further analysis. We participated in the analysis at the lab. |
| February 18th | 1:00 - 1:45 | Matt | ·Went back to the laboratory to analyze fecal colonies and prepared samples for metal analysis |
| February 19 - February 28 | / | All | ·Obtained laboratory results and composed the technical report |