# D.C. Water Resources Research Center
# Annual Technical Report
# FY 2004

## Introduction

This report summarizes the activities of the District of Columbia (DC) Water Resources Research Institute (the Institute) for the period of March 1, 2004 through February 28, 2005. This was a critical year for the Institute where results from the review panel assessing our five year evaluation report from1998-2002 were not favorable. In fact, the Institute was placed on probationary status without eligibility for additional grant until remedial actions are completed to ensure that it meets the requirements of the provision of section 104 of the Water Resources Research Act of 1984, as amended. However, an appeal of this decision was submitted to USGS by the Director of the Institute who highlighted changes and progress made within the two years of the new leadership. The appeal was denied, but the provision of probation was relaxed such that the Institute is now eligible to apply for FY 2005 grant by June 1, 2005. The application must include:

1. A description of the steps to be taken to: establish an Advisory Committee; establish a technical peer review committee; and establish an information transfer program, including a regularly updated website.

2. A description of the efforts to be undertaken to draw upon and utilize the expertise at other universities in the District of Columbia in establishing research and information transfer programs.

The application must include a time line for each action and a monthly progress report provided to USGS if award is granted. The Institute has accepted the conditions and will submit its application for the 2005 104G grant.

The five research proposals submitted to USGS for 2004 fiscal year were approved and funding provided. Our matching requirements were met with $300,000 non federal in-kind contributions from the DC Water and Sewer Authority (WASA). This technical report includes a final report for one completed project and four progress reports on projects approved for no cost extension until the end of the summer or for projects continuing into the 2005 fiscal year. These research projects were related to DC drinking water quality, water chemistry and bio-monitoring of pollutants, vadose zone water quality as related to nutrient management in vegetable production, and an assessment of soil erosion in a DC Park and its impact on water quality. These projects provided training for over twenty undergraduate student interns. The Institute and researchers continue to accumulate valuable experiences in water resource management as related to water quality and quantity in the District of Columbia.

Water resources information transfer via the Institutes website remains a problem and a major obstacle to serve our stakeholders. We have submitted all changes to the Universitys webmaster and anticipate a new site as well as procedures for regular updates. The Institute has completed and electronically disseminated its first issue of the revamped Water Highlights Newsletter, Winter/Spring 2005. This twenty page document designed and published by student interns is very informative and highlights current research and educational projects sponsored by the Institute along with interactions among faculty members and their student interns on projects and conferences.

A new water quality extension agent hired by UDC Cooperative Extension Service in November 2004, has had a significant impact on the Institutes outreach capacity already. In collaboration with the Institute, a strategic plan for implementing a program to monitor DC drinking, surface, and ground water quality has been established. Our goal of serving as an unbiased monitor of the quality and quantity of DCs water resources is gradually being implemented. Some fact sheets and brochures related to DC drinking water problems have been completed and will be published soon.

To compliment the monitoring program, the School of Engineering and Applied Science has provided space to establish an EPA Certified Water Quality Testing Laboratory that will serve the research, extension, and training needs of the faculty and students at the University of the District of Columbia. The Director of the Institute also served on the selection committee to hire a new Environmental Engineering faculty member with specific expertise in water resource engineering. The environmental engineering faculty will begin in fall 2005 and will contribute significantly to capacity building of the Institute.

Recent involvement of the Institute with the Chesapeake Watershed Cooperative Ecosystem Studies Unit (CESU), of which UDC is a partner, indicates a promising future for additional research and technical funding to address DC water resource problems, educate future water resources experts, and better serve the residents of DC through outreach programs. For example, Dr. Harriette Phelps of the Biological and Environmental Science Department at UDC has received two grants from the National Park Service, a partner in the CESU, through the Institute. The Institute has also taken advantage of the USGS WRRI Student Internship Program and received internship funds for a junior student from American University. He is now working with Dr. Nancy Simon at the USGS Reston, VA office on a project entitled Biogeochemistry of Nutrients and Metals in Sediments.

Strengthening the internal structure of the Institute remains a primary goal. We have hired several student interns especially in the areas of Accounting and Management Information System to accomplish this goal. The Institute developed a survey using Flashlight Survey Software to update our Directory of Water Resources Faculty members in the Consortium of DC Universities. The new electronic directory has over one hundred experts and is being constantly updated. Seventy five percent of all past publications have been scanned and are being edited for conversion to pdf electronic files. We have also developed a Blackboard forum for sharing and discussing water resources related issues with our stakeholders.

Guidelines for forming a Technical Peer Review Committee to complement our new Advisory Committee, being established, are in progress. This committee will assist and guide the Institute by peer reviewing proposals, reports and articles with the intent of publishing them in refereed journals.

Collaborations with DC and Federal Agencies, DC Council of Government and the Chesapeake Watershed Cooperative Ecosystem Studies Unit indicate a promising future for additional research and technical funding for capacity building to address DC water resource problems, train students, and better serve the residents of DC through outreach programs.

# Research Program

In an effort to assist in ascertaining and maintaining high drinking water quality in the District, the Institute decided to continue its partnership or collaboration with WASA to assist in providing solutions to their problems. Critical areas identified for research were:

1. Determining sources and remediation processes of heavy metals, especially lead, in drinking water; 2. Evaluating biofilm as a process of mitigating heavy metals; 3. Impact of chloramines vs. chlorine as disinfectants on biofilm; 4. Determining new mechanisms or indicators for identifying and eliminating dead-ends; 5. Determining or evaluating diagnostic methods of leaks leading to water main breaks; and 6. Assessing the economic impact of DC drinking water quality.

A commitment for $300,000 non-federal in-kind contributions was again provided by WASA to fulfill the Institutes matching requirements and our 2005 fiscal year research focus will continue in this direction. Though a new directory of faculty experts in the consortium of DC universities was established and the request for proposal sent to this mailing list, the response from researchers outside UDC in term of proposal submitted or request for additional information was little to none. Our inquiry indicates that the seed grant funds available, is little and some researcher mentioned, not worth their time. The Institute will conduct another survey to determine causes of the low responses and implement suggestions to increase participation of other faculty members in the consortium.

Below are the titles, funds requested and principal investigators of proposals to be submitted for FY 2005 grant.

Title: Integrated Data Acquisition and Sensor Design for Biomonitoring Systems Funds Requested: $15,000.00

Principal Investigators: Dr. Esther T. Ososanya and Dr. Wagdy Mahmoud Electrical and Computer Engineering Department University of the District of Columbia

Title: Air-Deposited Pollutants in the Anacostia River Watershed

Funds Approved: $15,000.00

Principal Investigator: Dr. Abiose Adebayo : Dr. Lily Rui Liang Dr. Katya Verner Department of Engineering, Architecture, & Aerospace Technology University of the District of Columbia 4200 Connecticut Avenue, NW, Washington, DC 20008 Tel: (202) 274-5039

Title: An Economic Impact Analysis of DC Drinking Water Quality

Funds Requested: $15,000

Principal Investigator: Sharron L. Terrell, Ph.D. Department of Accounting, Finance, and Economics School of Business and Public Administration University of the District of Columbia (202) 274-7064

Title: An Analytical Study of the Anacostia and Potomac Rivers

Funds Requested: $15,000

Principal Investigator: Dr. Julius Anyu Ndumbe Visiting Associate Professor, School of Business and Public Administration University of the District of Columbia Washington, DC 20008 (202) 274 7175

Title: Effect of Pelletized Poultry Manure and Vegetable Production on Vadose Zone Water Quality

Funds Approved: $13,000

Principal Investigator: James Allen, Ph.D. Agricultural Experiment Station University of the District of Columbia

The DC Water Resources Research Institute will continue to provide the District with inter-disciplinary research support to both identify and contribute to the solution of DC water resources problems. These research and educational projects provide students with essential practical skills required for future job opportunities and also allow faculty members access to new technologies and equipment that develop their expertise in water resource management. The Institute and researchers continue to accumulate valuable experiences in water resource management as related to the social, economic, and environmental aspect of water quality and quantity in the District of Columbia.

# Effect of Pelletized Poultry Manure and Vegetable Production on Vadose Zone Water Quality

## Basic Information

| | |
|---|---|
| **Title:** | Effect of Pelletized Poultry Manure and Vegetable Production on Vadose Zone Water Quality |
| **Project Number:** | 2003DC35B |
| **Start Date:** | 3/1/2003 |
| **End Date:** | 2/28/2004 |
| **Funding Source:** | 104B |
| **Congressional District:** | District of Columbia |
| **Research Category:** | None |
| **Focus Category:** | Water Quality, Solute Transport, Nutrients |
| **Descriptors:** | None |
| **Principal Investigators:** | James R. Allen, William W. Hare |

## Publication

# Effect of Pelletized Poultry manure on Vegetable Production and Vadose Zone Water Quality

## Annual Progress Report for FY 2004

**Prepared by:** Dr. James R. Allen, Researcher
Agricultural Experiment Station
University of the District of Columbia

Mary Farrah, Student, Research Assistant
Department of Environmental Sciences
University of the District of Columbia

**Date:** May 2005

**Prepared for the DC Water Resources Research Institute**
**Funds provided by USGS through the US Department of Interior**

# Effect of Pelletized Poultry manure on Vegetable Production and Vadose Zone Water Quality

## Introduction

Poultry produced from the Delaware, Maryland, and Virginia (DELMARVA) poultry industries in applied on farmland along with chemical fertilizer for crop production. However, a significant amount of unused manure is stored for future usage or remains to be disposed of. Perdue AgriRecycle Inc. has cleaned, sterilized, and pelletized poultry manure for easy handling and movement in crop and vegetable production. This material has been analyzed for nutrient content; however, not much data is available to demonstrate its effectiveness in crop and vegetable production as well as its effect on ground water quality or pfeisteria proliferation. Residents of Washington DC grow vegetables in their backyard and could potentially use this material as a soil amendment. Therefore, this experiment is designed to determine the effectiveness of pelletized poultry manure as a soil amendment in vegetable production and its potential effect on DC water resources. Information generated will be used for extension and outreach to benefit the residents of Washington DC. This project will impact both our sustainable agriculture project of recycling waste as a soil amendment and our efforts in enhancing environmental quality.

The Chesapeake Bay Agreement signed by leaders of Delaware, Maryland, Washington DC, and Virginia promises a 40% reduction in the Bay's nitrogen and phosphorus level by the year 2010. This reduction campaign was initiated particularly because of a chemical fertilizer and poultry manure in crop production areas. Eutrophication, caused by excess nitrogen and phosphorus, has also reduced the Bay's sub-aquatic vegetation significantly. The most recent Chesapeake Bay report, July 2002, indicates no improvement in the Bay's water quality. On a scale of 100, the Bay's environmental quality was graded as 27, which is extremely low. In fact, this grade did not change from the previous year regardless of clean up efforts.

**Objectives:**

1. To determine the extent to which pelletized poultry manure affects water quality when used as a soil amendment in growing vegetables.
2. To determine the feasibility of using pelletized poultry manure as a substitute for commercial fertilizer in the growing of vegetables in urban areas.

**Progress Toward Achieving Objective 1**

To achieve experimental objectives, an experimental plot has been established with soil of silt loam. The experimental design is a randomized block with three replications per treatment. This design has six blocks with each block representing one of six treatments. This six treatments being used are:

1. 1800 lbs/acre of chicken manure pellets + 400 lbs/acre of commercial fertilizer (10-10-10).
2. 400 lbs/acre of commercial fertilizer (10-10-10) only.
3. 900 lbs/acre of chicken manure pellets + 400 lbs/acre of commercial fertilizer (10-10-10).
4. 1800 lbs/acre of chicken manure pellets.
5. 900 lbs/acre of chicken manure pellets.
6. No chicken manure pellets or commercial fertilizer. (Control or check plots).

In the experimental design, main plots are the six above named treatments and the crop varieties are butterbeans and collards as subplots. After clearing seed beds of surface debris, chicken manure pellets were added by broadcasting over the field surface with a manually operated garden seed spreader. Each main plot is 60ft. x 15ft. and subplot 15ft. x 10ft.

After treatments were added (Nov 20, 2004), two lysimeters were added to sample the water of vadose layer in each main plot at the distance of 20ft. apart. These lysimeters were each placed at two different depths, one 18 inches and the other 36 inches (Figs. I, II, III). The lysimeters installed were model 1920 FI pressure/vacuum soil water sampler. Each lysimeter at the 36 inch depth had a 1.5ft. long PVC pipe 1.5 inches in diameter. They both had a 2 bar porous ceramic cup at the bottom end and two ¼ inch tubes protruding from the top (area about one foot above the soil surface) which was otherwise sealed. One of the tubes is

**Figure I.** **Lysimeters being installed in the poultry pellet amended plot by William Hare and James Allen.**

**Figure II.** **Lysimeter in place at a depth of 18 inches.**

connected to a 2006 G2 pressure/vacuum hand pump which will be used to collect water samples. The lysimeters were put in place on November 20, 2004.

**Figure III.** **Lysimeter placement at the experimental site being reviewed by James Allen.**

To protect the field from erosion, and ordinary cover crop variety of rye was broadcasted on the field plot at about a rate of four bushels per acre. They were planted on December 10, 2004 and the field plot is now well covered with the rye vegetation.

Water sampling of the Vadose layer of each plot will begin in mid-January, 2005 and continue on a regular basis from that time onward. Collards will be planted from seedlings on April 15, 2005 and butterbeans from seeds on the same date. The two crop varieties will be planted in each main plot. These main plots will each have six subplots 15ft. x 10ft. with 36 inches wide rows. Collards will be planted 18 inches apart within rows from seedlings approximately 4.0 inches high while butterbeans will be planted from seeds within rows about 12 inches apart. During the growing season plots will be kept well cultivated with the use of a garden cultivator or by hoeing.

Data to be collected during the growing season will be Vadose water sample, soil Bulk Density, soil porosity, seed yield of butterbeans and biomass data of both butterbeans and collards. Vadose water samples will be analyzed for nutrients such as phosphorus, nitrogen and heavy metals where feasible. Data collected will be statistically analyzed, using the analysis of variance (ANOVA) to correlate the amount of chicken pellet manure added to crop yield and water quality (amount of the above named chemicals in the soil water samples).

Research findings will be communicated by paper presentations in professional meetings and the publications of journal articles.

**Progress Towards Achieving Objective 2**

Experimental plots seeded to rye as a cover crop in November, 2004 are now well covered with lush vegetable growth (Fig. I). Soil samples were taken from experimental plots on April 26, 2005. Sampling techniques included the following:

a) Sampling at depths 0-6", 6-12" and 12-18".
b) The field was divided into sections and duplicate soil samples were taken from each treated section in order to increase accuracy of analysis. (Figs. IV, V, VI, VII, VIII, IX).

**Figure IV. Experimental plots covered with rye showing early lush spring growth.**

Soil samples are now being air dried and will be sent to analytical labs for analysis to determine concentration of N, P and organic matter (OM) content of the soil given the palletized poultry manure compared to that amended with commercial fertilizer.

**Figure V.** **Student Assistant Raphil Billy take soil samples at the 0 -6" depth.**

**Figure VI.** **William Hare taking soil sample at the 6-12" depth.**

**Figure VII.** **Soil samples being collected by researchers James Allen and William Hare.**

**Figure VIII.** **Soil Sample being examined before sent off to a laboratory for chemical analysis.**

Water samples from Lysimeters located in each treatment block at depths of 18 and 36". In addition to the N and P concentrations mentioned for the soil samples, the water samples will also be tested for coliforms.

**Figure IX.** **Student intern, Mary Farrah, taking water samples.**

After soil and water sampling are completed, plots will be planted to collard greens and lima beans. These two crops varieties were chosen to see if they reduce or increase the amount of N or P entering the vadose zone of the soil. On a long term basis, different types of crop varieties will be tried so that more detailed comparisons can be made so that recommendations can be made concerning crop culture when pelletized poultry manure is used as the soil amendment. Planting of these crops will be done on May 15th, 2005.

**PLANS FOR FY 2005-2006**

1. Yield data will be collected from the two test crops, collards and lima beans. Harvesting of collards is expected to begin by mid-June and that of lima beans by the end of June to the first week in July. Data to be collected and analyzed will be exclusively fresh market collard leaves and lima beans.
2. Soil and water samples will be taken at specific intervals during the year. The next soil sample will be taken on June 15th. Water sampling may be done at the same time depending on when it rains. Both water and soil sampling will be done again at the end of August when harvesting is expected to be ended.
3. In the fall of 2005, plots will be lightly disked and poultry pellets added. The amount to be added will depend on preliminary soil and water test results.
4. Soil and water sampling data will be analyzed statistically and correlated to fresh weight of marketable yield of collards and lima beans to determine how well the pelleted poultry manure does as a soil amendment in the growing of fresh vegetables.
5. As mentioned before, in the fall, plots will again be seeded to cover crop rye and more poultry pellets added.
6. All fresh market yield and soil and water analytical data will be analyzed using ANOVA along with appropriate test of significance techniques.
7. Test crops for FY 2006-2007 will remain collards and lima beans. However, to institute a rational rotation system, the crops will be changed to sweet corn and black-eyed peas in FY 2007-2008.

# The Development of a MEMS-based Integrated Wireless Remote Biosensors

## Basic Information

| | |
|---|---|
| **Title:** | The Development of a MEMS-based Integrated Wireless Remote Biosensors |
| **Project Number:** | 2004DC56B |
| **Start Date:** | 3/1/2004 |
| **End Date:** | 2/28/2005 |
| **Funding Source:** | 104B |
| **Congressional District:** | Washington DC |
| **Research Category:** | None |
| **Focus Category:** | Water Quality, Non Point Pollution, Toxic Substances |
| **Descriptors:** | None |
| **Principal Investigators:** | Esther T. Ososanya, Esther T. Ososanya |

## Publication

# The Development of a MEMS-based Integrated Wireless Remote Biosensors

## **Phase I:** The Development of Instrumentation and Data Acquisition System for Bioelectric Signals Monitoring

**Prepared by:** Dr. Esther T. Ososanya, Professor
Electrical and Computer Engineering Department

Mary Pierre, Student, Biosensor Research Assistant
Department of Electrical Engineering

Jeffrey Zulu, Student, Biosensor Research Assistant
Biology Department

Oluwakayode Bamiduro, Student, Solar Lab Research Assistant
Department of Mechanical Engineering

Anis Ben Ayed, Student, Solar Lab Research Assistant
Department of Mechanical Engineering
**University of the District of Columbia**

**Date:** May 5, 2005

**Prepared for the DC Water Resources Research Institute**
**Funds provided by USGS through the US Department of Interior**

# The Development of Instrumentation and Data Acquisition System for Bioelectric Signals

## Introduction

Over the past decade, research has been active in developing methods for measuring the levels of stress in aquatic animals for the purpose of monitoring water pollution. This research proposes, in two phases, the design and implementation of an integrated wireless, low-power embedded biosensor monitoring system for the acquisition and transmission of biological functions from aquatic animals. These signals can be used to measure the stress induced in aquatic animals due to water pollution.

The minimization of power consumption is a critical issue in the design of electronic systems for portable battery-operated applications or remotely powered applications as employed in biomonitoring systems. In this study, a MEMS-based biosensor was integrated with a mixed-mode ASIC chip comprising of preamplifier, band-pass filter, analog amplifier, D/A module, modulator, transmitter, and a digital controller. The design integrated MEMS, wireless communication, VLSI, and system-on-chip (BioSilico) technologies in the design of a low power environmental monitoring device. The system will be designed as a solar/battery-powered device.

Techniques for analyzing the acquired data were developed. The embedded integrated sensors were used in the on-line acquisition of myoneural signals from bivalve mollusks. This design is expected to miniaturize several discrete modules and eliminate coaxial cables used in existing biomonitoring setups, and in a significant reduction in the overall system power consumption. A receiver system will be used to receive the signal transmitted from the sensor device. The receiver system will be designed and built using off-shelf components. When completed, the design will be able to automate the process of in situ environmental data gathering needed to monitor the safety of the drinking water resources.

**Phase I Objectives:**

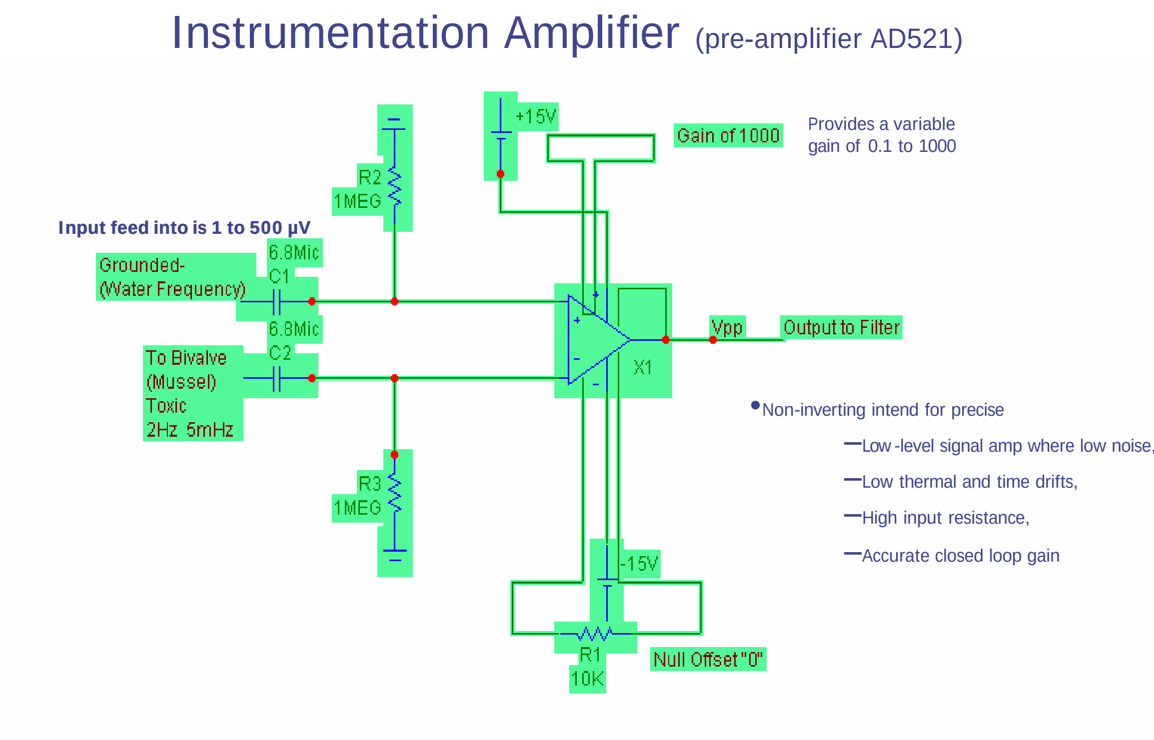
- To design instrumentation system for Bio-monitoring
- To identify toxins in estuaries
- To initialize research to determine types of toxins

This document gives a summary report on the Instrumentation system and the Solar Lab developed for remote biosensing in the summer of 2004 through the 2005 Spring semester. The instrumentation board captures myoneural (muscle-nerve) signals from fresh water bivalve mollusks. Typical signals are in the range 5mV to 20mV. The design was partitioned into 5 stages:

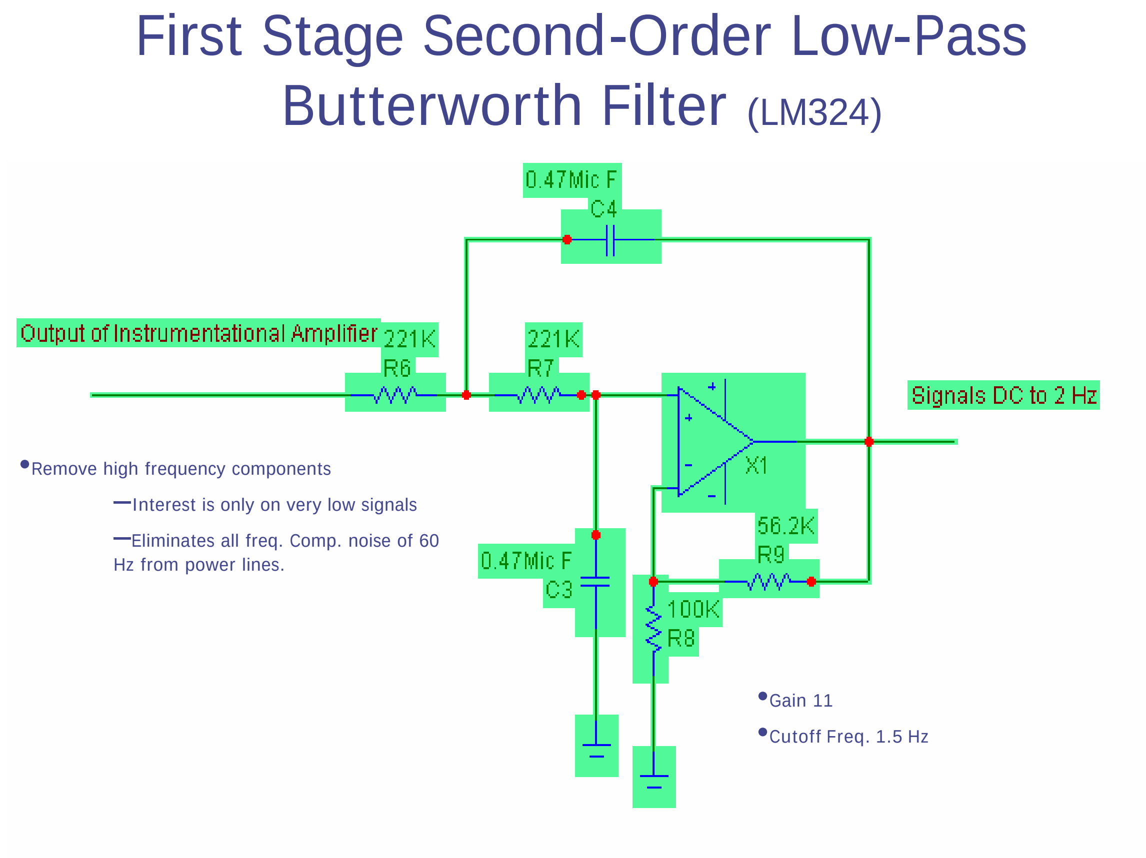
1. The Pre-amplifier stage with closed loop amplification gain of 10.
2. The Second-order Low-Pass Butterworth Filter which filters out High frequency noise and electronics noise.
3. The Butterworth High-Pass Filter which filters out the unwanted low-frequency noise.
4. The variable-gain main Amplifier stage with signal amplification gain of 100 to 1000.
5. The Voltage Detector which limits or attenuates signals to 5V.

The instrumentation board was designed with discrete components and tested in the lab. The different stages of the design are shown below:

1. The Pre-amplifier stage

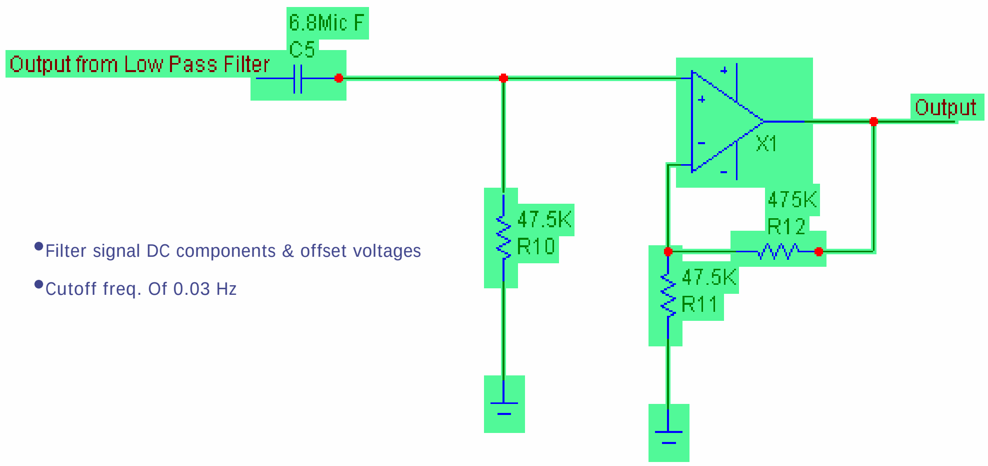


2. The Second-order Low-Pass Butterworth Filter



3. The Butterworth High-Pass Filter

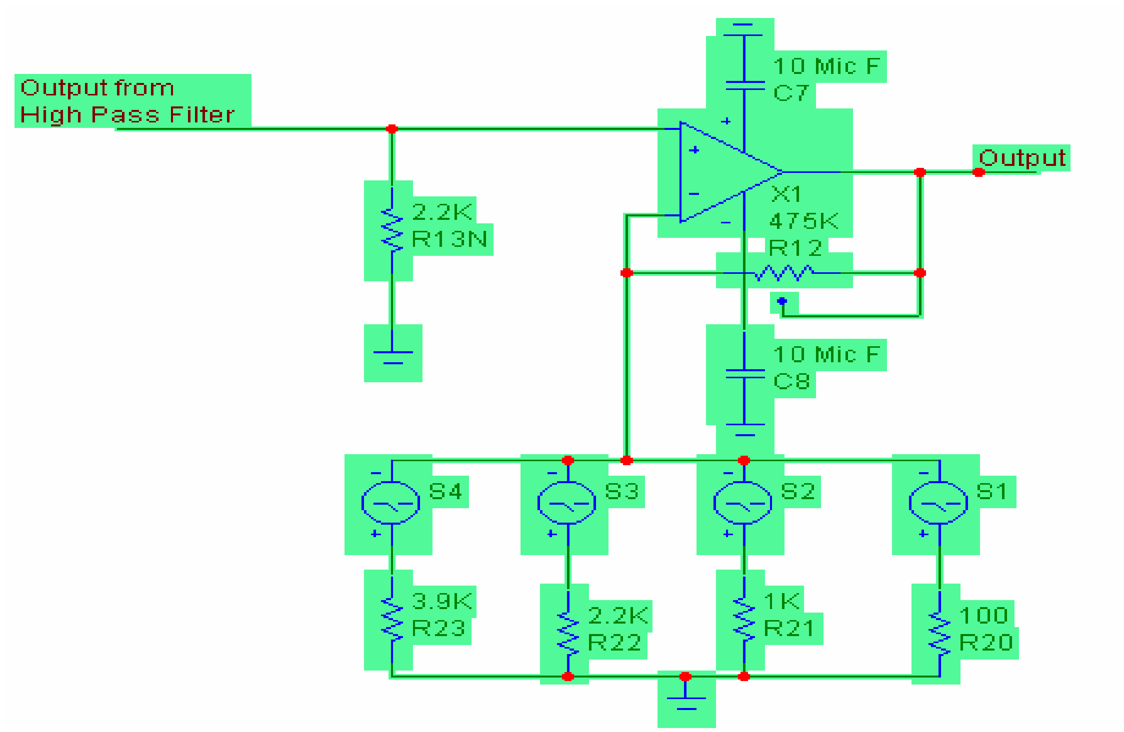
## Butterworth High-Pass Filter (LM324)




- Filter signal DC components & offset voltages
- Cutoff freq. Of 0.03 Hz

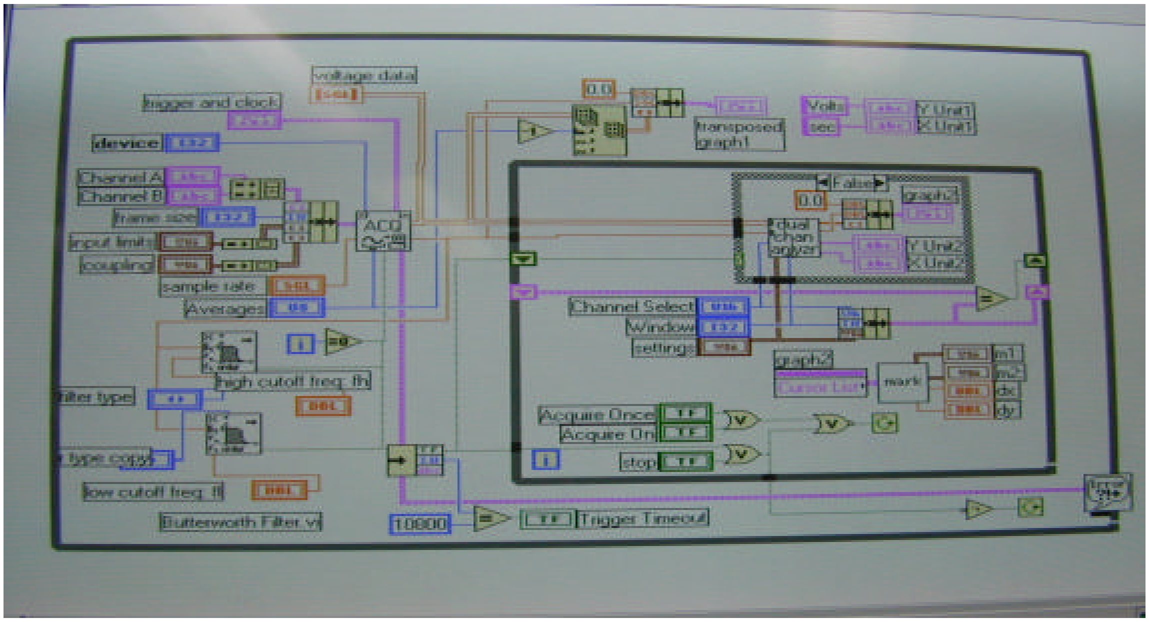
4. The variable-gain main Amplifier stage

# Variable Gain Amplifier Stage

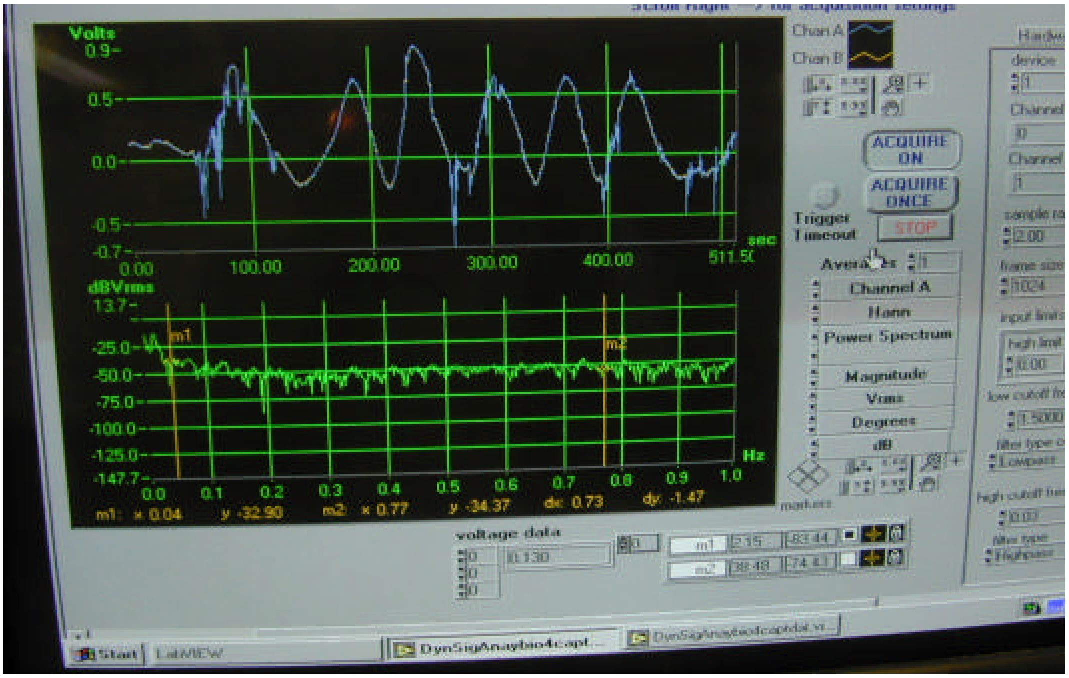



The above design was also configured and tested using the LabView Data Acquisition system:

# Labview 4.1 –
# Schematic Diagram

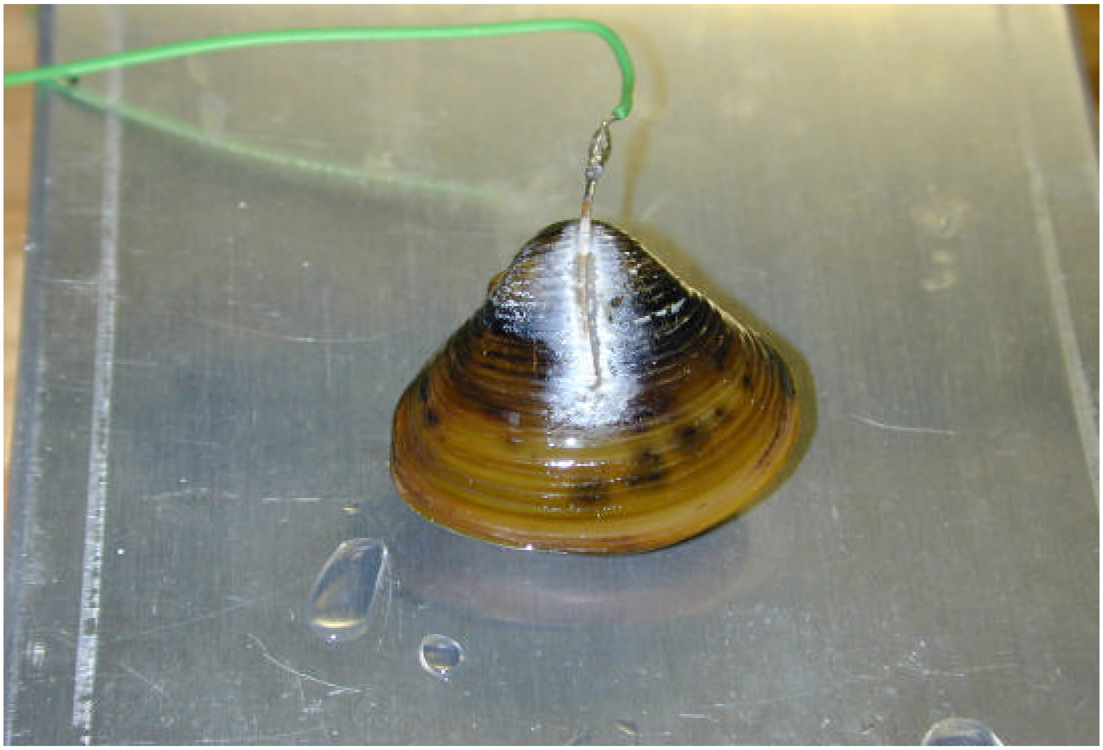


# Front Panel data collection




What is Muscle-nerve (Myoneural) signatures—movement, respiratory, and cardiac activities of Bivalves

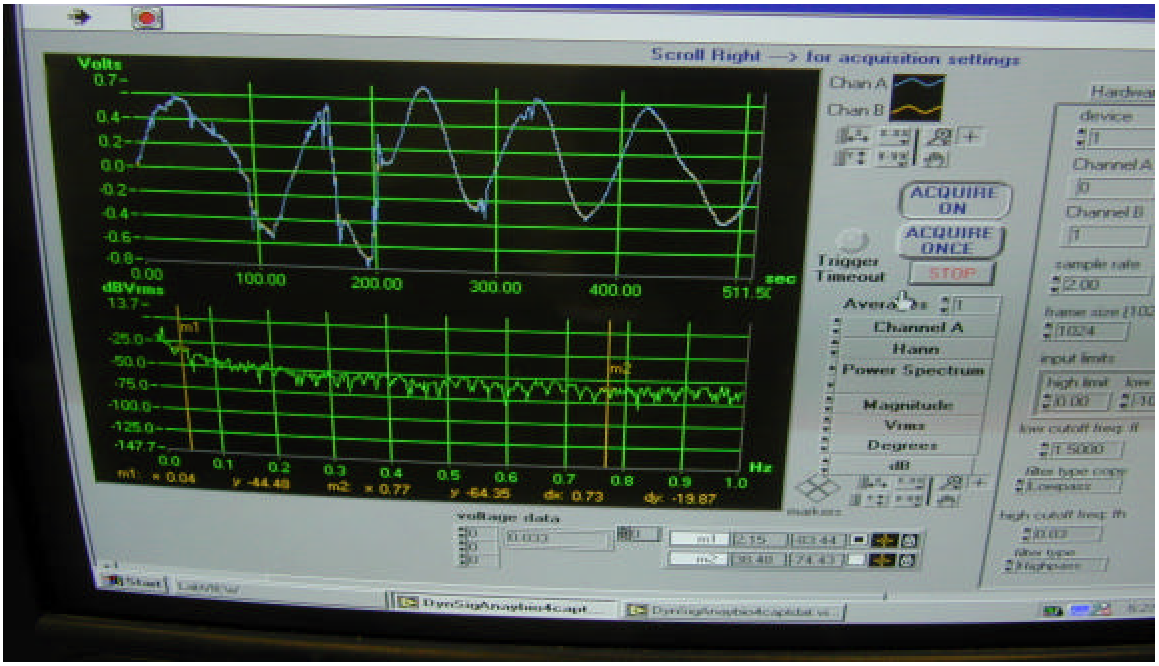
# Probing of Clam



# 24 hrs acclimatization after electrode implantation

# Sampling environment

# Data Collection




# Experiment Conditions

- 48 hr acclimatization in lab tank
- Water at 19+/- 0.5 degrees Celsius
- Water air equilibrated
- Solution of dog food mixture

## Characteristics of Bivalves that Make Them Suitable Organisms For Bio-monitoring Application

- Very Abundant
- Relatively Inexpensive
- High sensitivity to environmental impacts
- High Filtration Rates
- Limited mobility

# Behavior Under Stress

- Shell Closure
- Adductor Muscle Contraction (Gape Closing)
- Action Potential captured by electrode

**Phase II of Research Project**

- **Apply Toxins**
- **Compare results to determine toxins types**
- **Package the instrumentation circuit in a micro chip**

## Conclusion:

- Bio-monitoring Applications can be used to determine toxicity in estuaries
- A data acquisition system was designed and implemented to continuously acquire and display the myoelectric data for multi-species aquatic animals.

# Solar Lab Project

**The Solar lab was developed to remotely power the Data Acquisition System when conducting field work at a river bank.**

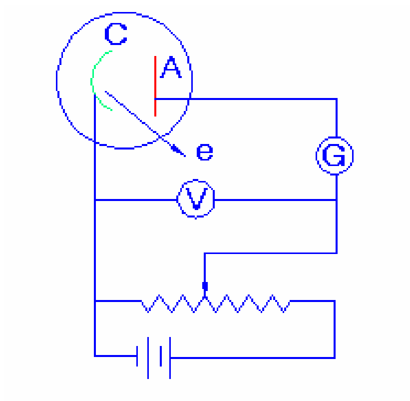
**Objectives:**
The primary intention of this project was to show how solar energy is a way of powering devices. In doing so, the following steps were executed:

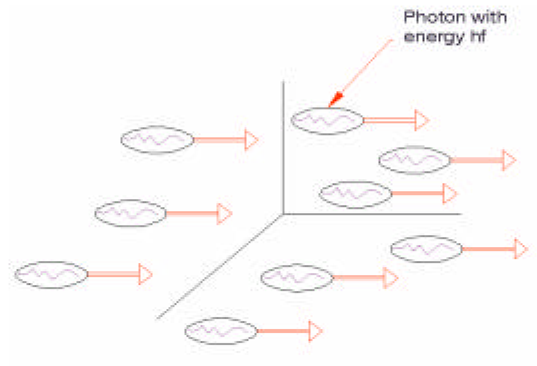
1) How electricity, solar cells and panels are created
2) How the solar kit was assembled
3) Data gathered, and obstacles encountered

## Conversion Of Light

- Nature of Sun Light
  * Photons
- Semiconductors
  - Properties

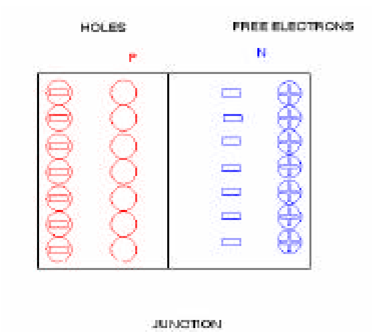
# The Photoelectric Cell

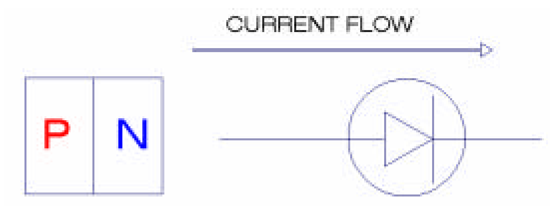



Einstein's photon picture of "a traveling light wave"

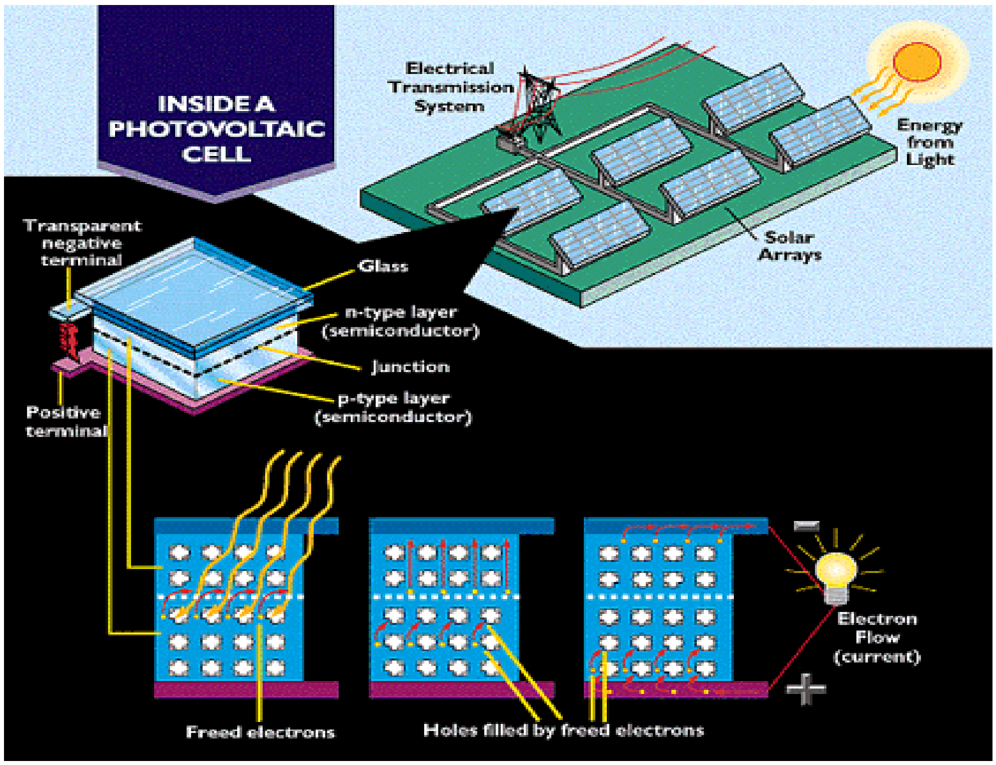
# PN Junction, Diode



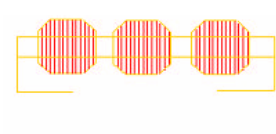




# The Structure and Mounting of Solar Cells

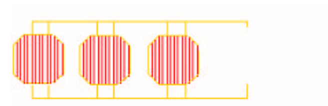
- Inside the Cell
  * Glass / protective layers
  * Semiconductor P and N type
- Parallel and Series Circuit


INSIDE A PHOTOVOLTAIC CELL
Electrical Transmission System
Energy from Light
Solar Arrays
Transparent negative terminal
Glass
n-type layer (semiconductor)
Junction
p-type layer (semiconductor)
Positive terminal
Electron Flow (current)
Freed electrons
Holes filled by freed electrons

- Solar Cell Parallel and Series Circuit



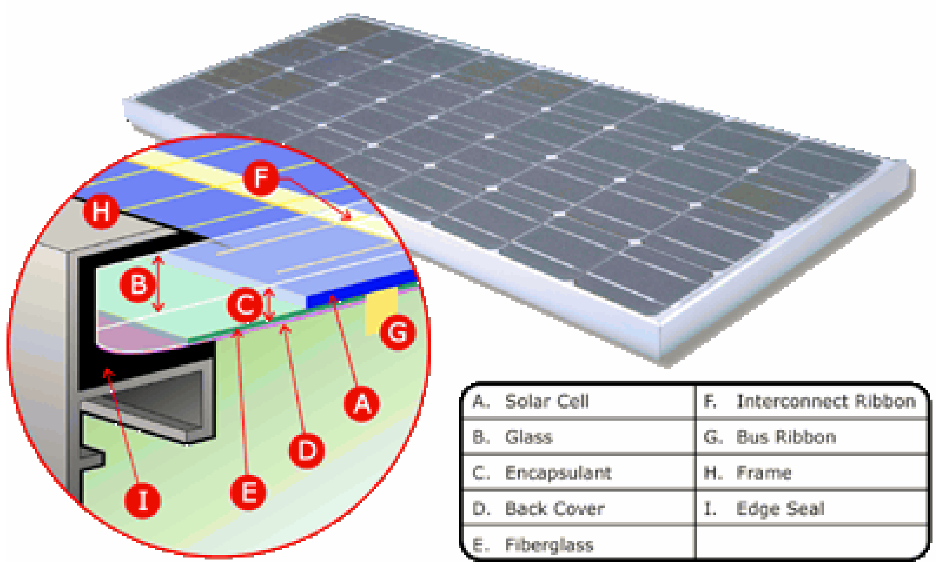
Current = I (Cell)
Voltage = 3 V (Cell)



Current = 3 I (Cell)
Voltage = V (Cell)

# Solar Lab

## The Solar Panel



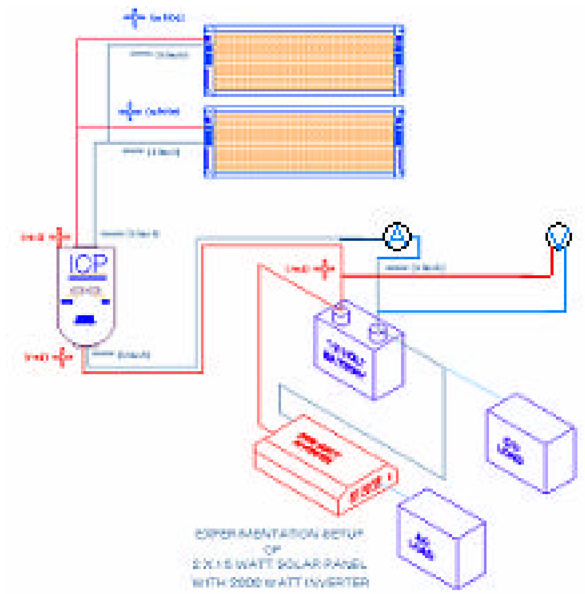
# Solar Lab

## Building Solar Lab

- Circuit Diagram
  * Wiring the Equipment
- Building the Tower
  * Measuring, Cutting, Welding, Painting … the structure
- Mounting the Equipment
  *Wiring, soldering, testing … the components

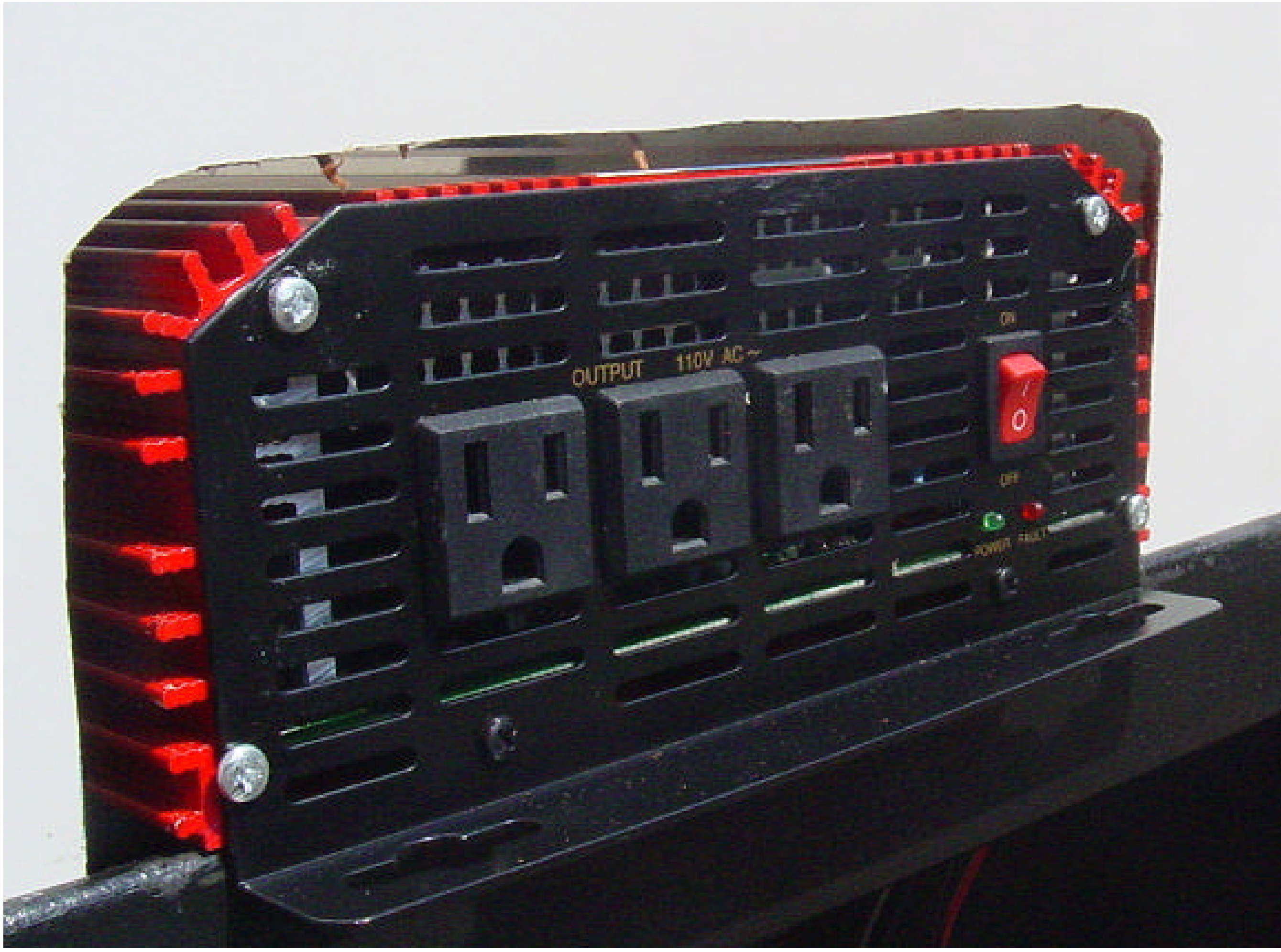
# Solar Lab

## Measurements




A: Solar Panel
B: Inverter
C: Controller
D: Battery
E: DC Out

E



# Solar Lab

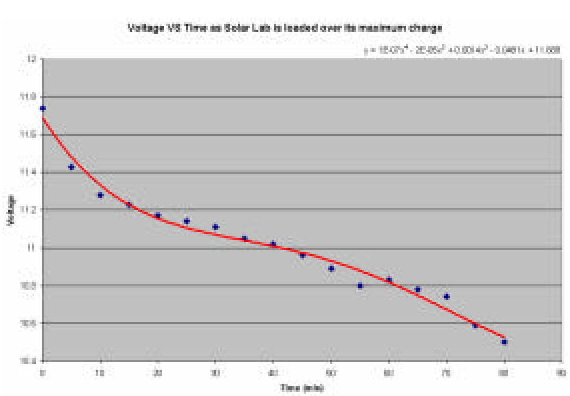
## Analysis

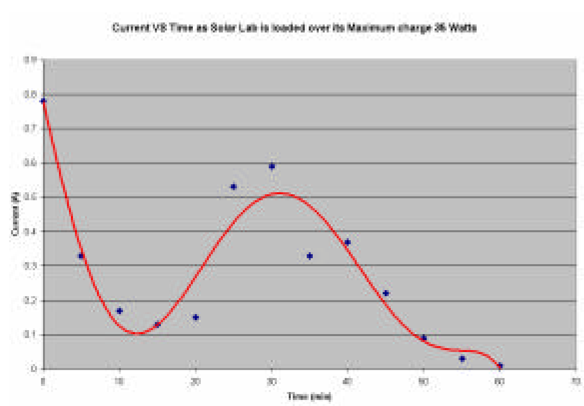
- Data:

| Time (min) | Voltage (V) | Current (A) | Weather Condition |
|---|---|---|---|
| 0 | 11.74 | 0.78 | S |
| 5 | 11.43 | 0.33 | PC |
| 10 | 11.28 | 0.17 | C |
| 15 | 11.23 | 0.13 | C |
| 20 | 11.17 | 0.15 | C |
| 25 | 11.14 | 0.53 | S |
| 30 | 11.11 | 0.59 | S |
| 35 | 11.05 | 0.33 | C |
| 40 | 11.02 | 0.37 | C |
| 45 | 10.96 | 0.22 | VC |
| 50 | 10.89 | 0.09 | VC |
| 55 | 10.8 | 0.03 | VVC |
| 60 | 10.83 | 0.01 | VVC |
| 65 | 10.78 | 0 | VVC |
| 70 | 10.74 | 0 | VVC |
| 75 | 10.59 | 0 | VVC |
| 80 | 10.5 | 0 | VVC |
| S: Sunny, PC: Partially Cloudy, S: Sunny, C: Cloudy, VC: Very Cloudy, VVC: Very Very Cloudy | | | |

## Analysis

- Graphs



# District of Columbia Drinking Water Blind Taste Testing Project

## Basic Information

| | |
|---|---|
| **Title:** | District of Columbia Drinking Water Blind Taste Testing Project |
| **Project Number:** | 2004DC58B |
| **Start Date:** | 3/1/2004 |
| **End Date:** | 2/28/2005 |
| **Funding Source:** | 104B |
| **Congressional District:** | Washington DC |
| **Research Category:** | None |
| **Focus Category:** | Water Quality, Treatment, None |
| **Descriptors:** | None |
| **Principal Investigators:** | Lillie Monroe-Lord, James DaWanna |

## Publication

**University of the District of Columbia**

Center for Nutrition, Diet and Health

# District of Columbia Drinking Water Blind Taste Testing

## Annual Progress Report for FY 2004


**Prepared by:** **Lillie Monroe-Lord, PhD, RD, LD**
Head, Center for Nutrition, Diet and Health
Cooperative Extension Service
University of the District of Columbia

**Dawanna James, M.S.**
Program Coordinator, Center for Nutrition, Diet and Health
Cooperative Extension Service
University of the District of Columbia


**Date:** May 2005


**Prepared for the DC Water Resources Research Institute**
**Funds provided by USGS through the US Department of Interior**

# District of Columbia Drinking Water Blind Taste Testing Research Project

## Introduction

The largest component of all living matter is water. The human body is approximately 60 to 70% water and 30% solids. However these figures vary with age and sex. Water is essential for many body functions. Water provides an aqueous medium for cellular metabolism, transports materials to and from cells, acts as a solvent, regulates body temperature, maintains the vascular blood volume, aids in the digestion of food, maintains the chemical and physical constancy of the intracellular and extracellular fluids, and aids in the excretion of waste from the body. Body water balance is essential for good health. Water imbalances may lead to overload or dehydration. Water distribution in the adult body consists of: 30% extracellular fluid (6% plasma, 24% tissue space) and 70% intracellular fluid. A human being deprived of water (fluid) cannot live for long. Without water (fluid) the skin becomes dry and cracks, temperatures soars to burning heights, the mind deteriorates, and cells shrivel.

The question consumers are most often faced with is "Is your water safe? Consumers use many different filtering processes to affect water taste and make the water safe for use such as: shower filters, water filters, water purifiers, water distillers, water ionizer, water coolers, counter top ultra violet water sterilizer system, counter top water distiller, counter top true ionized water ionizer, refrigerator ice and water filters, whole house water treatment system, and whole house water filtration. One of the important elements affecting water taste is the amount of chlorine added to the water supply.

An average, healthy person should take in approximately 2600 milliliters of fluid per day to meet the body's water requirements. A standard calculation for water requirements is 30 milliliters per kilogram of body weight. In order to calculate body weight in kilograms, divide the individual's body weight by 2.2. This research project sought to gather information on consumers' preferences and consumption of drinking water; specifically, District's tap water.

## Goal and Objectives

The overall goal of this project was to determine consumers' preferences and level of consumption of water; specifically, District of Columbia tap drinking water and to make recommendations for increase consumption by individuals who live and work in the District of Columbia.

## Objectives

1) To conduct drinking water Blind Taste Testing to a cross-sectional sample of 100 individuals who live and /or work in the District of Columbia .

2) To determine consumers' preferences for the different types of drinking water: DC tap water, spring water, distilled water, and mineral water.

3) To determine the types of drinking water being consumed by individuals who live and/or work in the District of Columbia.

4) To determine factors related to the selection of drinking water by individuals who live and/or work in the District of Columbia.

5) To develop recommendations for the increased consumption of the District of Columbia tap drinking water.

## Methods and Procedures

### Objective 1

To conduct drinking water blind taste testing to a cross-sectional sample of 100 individuals who live and/or work in the District of Columbia.

Two hundred fourteen (214) individuals who live and/or working in the District of Columbia participated in the study. Each participant was required to read and sign the Informed Consent Form. The participant was required to be willing to taste each of the four samples of water and complete all documents needed by the project. The participant ranked each sample based upon preference order of $1^{st}$ choice, $2^{nd}$ choice, $3^{rd}$ choice, and $4^{th}$ choice with $1^{st}$ being the most favorable and $4^{th}$ being the least favorable. The participants were identified through work sites, churches, health clubs, and community based organizations and agencies. A double blind number unknown to the participant and researcher identified each sample of water. The participant received and completed the survey instrument prior to participating in the taste testing of the water samples. Educational materials on water were provided to each participant. The materials included: District of Columbia Drinking Water Blind Taste Testing Research Project brochure, Are You Drinking Too Much Sugar Informational Sheet, What are your Water Options? Why Drink Water? Myth or Fact about Water, Prices of Water by Brand Name,

### Objective 2

To determine consumers' preferences for the different types of drinking water: Dc tap water, spring water, distilled water, and mineral water.

A short data collection instrument was developed and administered to project participants as part of the taste testing session. The instrument included some open-ended questions in order to solicit additional detailed information. A copy of the data collection instrument is included in the Appendixes as Appendix D.

**Objective 3**
To determine the types of drinking water being consumed by individuals who live and/or work in the District of Columbia.

Questions were developed and included on the data collection instrument to collect the information.

**Objective 4**
To determine factors related to the selection of drinking water by individuals who live and /or work in the District of Columbia.

Questions were developed and included on the data collection instrument to collect the information.

**Objective 5**
To develop recommendation for the increase consumption of the District of Columbia tap drinking water.

Upon completion of the analysis and interpretation of the data, recommendations will be included in the final report. No recommendations are included in this preliminary final report.

**Facilities**

The facilities used for the collection and analysis of data included the Center for Nutrition, Diet and Health located in Building 52, B-O4; New Commandment Baptist Church, Miles Memorial CME Church, Greater Mount Calvary Holy Church, Shiloh Baptist Church, Coalition for the Homeless, Gold's Gym, and UDC Fire Bird Inn.

**Findings**

**DEMOGRAPHICS**

**Table 1:** Shows program participants by geographical location, frequency and percentage

| LOCATION | FREQUENCY | PERCENTAGE |
|---|---|---|
| **District of Columbia** | **122** | **66.70** |
| **Maryland** | **43** | **23.50** |
| **Northern Virginia** | **6** | **3.20** |
| **Outside of the DC Metro Area** | **12** | **6.60** |
| **TOTAL** | **183** | **100.00** |

Table 1 shows the distribution of program participants who live or work in the District of Columbia metropolitan area; which includes the District of Columbia, Maryland, Northern Virginia (66.70%, 23.50% and 3.20%) and those from other states outside of the metropolitan area (6.60%). The majority of the participants who consented to mailing addresses on the study survey showed they were from the District of Columbia. Chart 1 shows an illustration of the program.

**Chart 1:** Illustration of geographical distribution of program participants

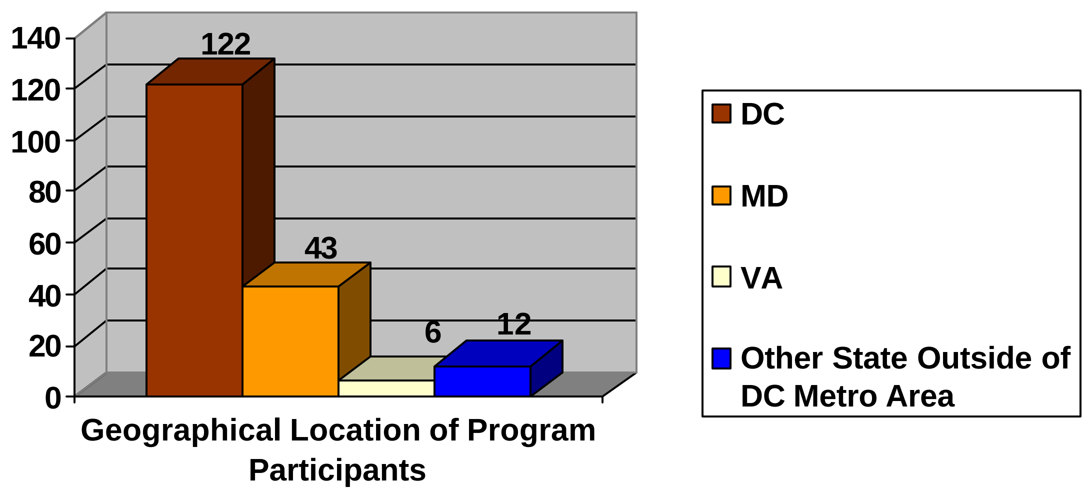


**Table 2:** Shows age ranges of program participants by years, frequency and percentage

| AGE IN YEARS | FREQUENCY | PERCENTAGE |
|---|---|---|
| ≤10 | 04 | 1.87 |
| 11-20 | 23 | 10.75 |
| 21-30 | 48 | 22.43 |
| 31-40 | 23 | 10.75 |
| 41-50 | 43 | 20.09 |
| 51-60 | 22 | 10.28 |
| 61-70 | 10 | 4.67 |
| 71-80 | 03 | 1.40 |
| 81-90 | 01 | .47 |
| No Response | 37 | 17.29 |
| TOTAL | 214 | 100.00 |

Table 2 shows the ages of the program participants. The mean age of participants who reported their age was 27 years of age with a range of 10 to 90 years of age. Sixty-five or 30.37% ranged in age from 41-60 years, and 14 or 6.54% were in the range of 61-90 years of age. Chart 2 shows an illustration of the range of the number of participants within a ten-year span.

**Chart 2:** Illustration of participant ages

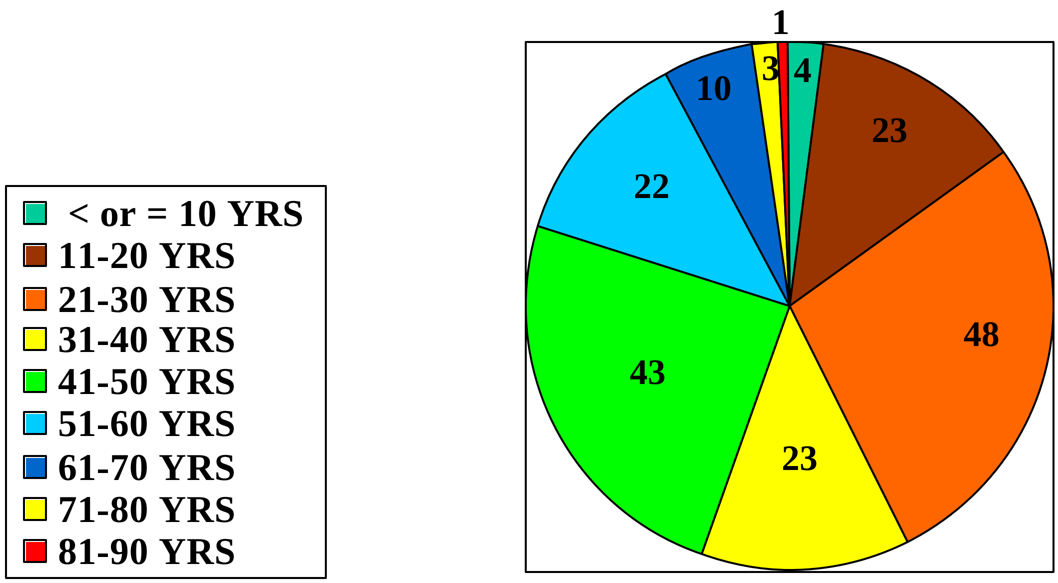



**Table 3:** Shows consumers' preferences for the different types of drinking water by type with frequency and percentage.

| TYPE | FREQUENCY | PERCENTAGE |
|---|---|---|
| SPRING WATER | 72 | 34.29 |
| TAP WATER | 63 | 30.00 |
| DISTILLED WATER | 57 | 27.14 |
| MINERAL WATER | 18 | 8.57 |
| TOTAL | 210 | 100.00 |

Table 3 shows that seventy two (72) individuals chose spring water as their first choice (34.29%), sixty three (63) individuals chose tap water as their first choice (30%), fifty seven (57) individuals chose distilled water as their first choice and eighteen individuals chose mineral water as their first choice (8.57%) among the four types of drinking water categories that were taste tested. The preferred types that were chosen by the study sample (N=210) showed that spring water was the most preferred drinking water choice, while mineral water was the least preferred drinking water choice.

We can imply as a result of this table that the study participants have a positive preference for District of Columbia tap water. Despite the negative exposure associated with District of Columbia tap water, the study participants ranked the District of Columbia tap water sample as their second most preferred choice. Chart 3 is an illustration of table 3, which shows the range of total participant responses to the four types of drinking water categories in the study.

**Chart 3:** Illustration of consumers' preferences by water type (N=210)

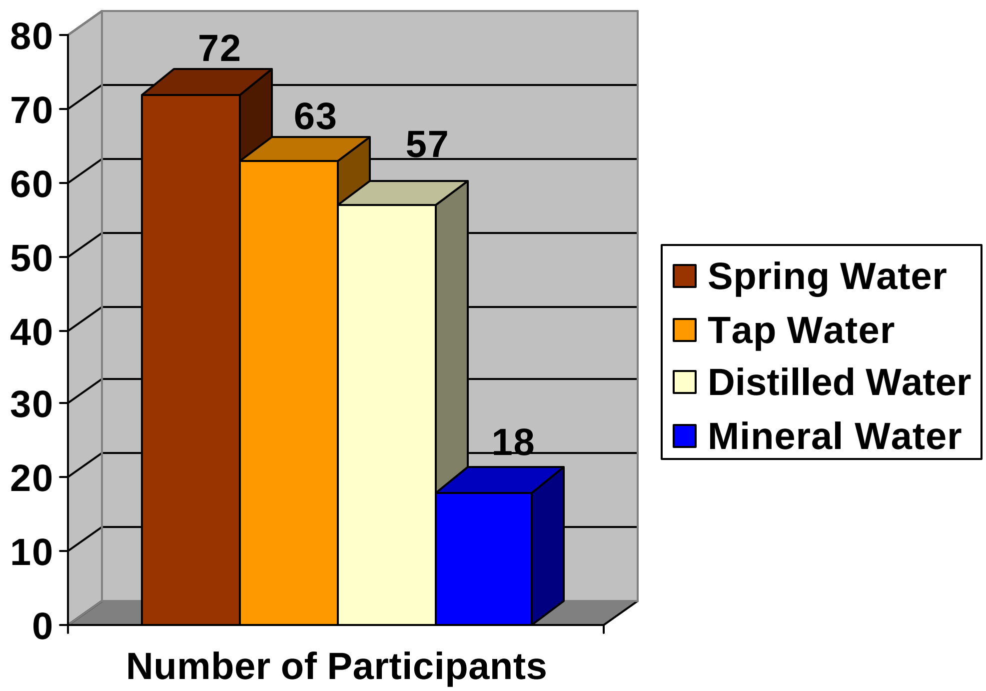


**Table 4:** Shows survey responses to participant sole source of drinking water

| TYPE | FREQUENCY | PERCENTAGE |
|---|---|---|
| TAP WATER | 42 | 20.79 |
| TAP WATER W/ FILTER OR WATER TREATMENT SYSTEM | 32 | 15.84 |
| SPRING WATER | 101 | 50.00 |
| MINERAL WATER | 3 | 1.49 |
| DISTILLED WATER | 9 | 4.46 |
| PURIFIED WATER | 0 | .00 |
| SPARKLING WATER | 1 | .49 |
| OTHER | 4 | 1.98 |
| INCORRECT RESPONSE | 10 | 4.95 |
| TOTAL | 201 | 100.00 |

Table 4 shows the results from the question on the survey that asked participants details on their preferences prior to the taste test showed the following results for survey question number two. The results of the responses from participants on the question that asked, what single type of water source do the participants drink most frequently is shown below. There were 10 persons who did not answer the question correctly, while the majority drank spring water most frequently (101) followed by tap water (42), tap water with a filter system (32), and distilled water (9).

**Chart 4:** Illustration of participant preferences for water source most frequently consumed

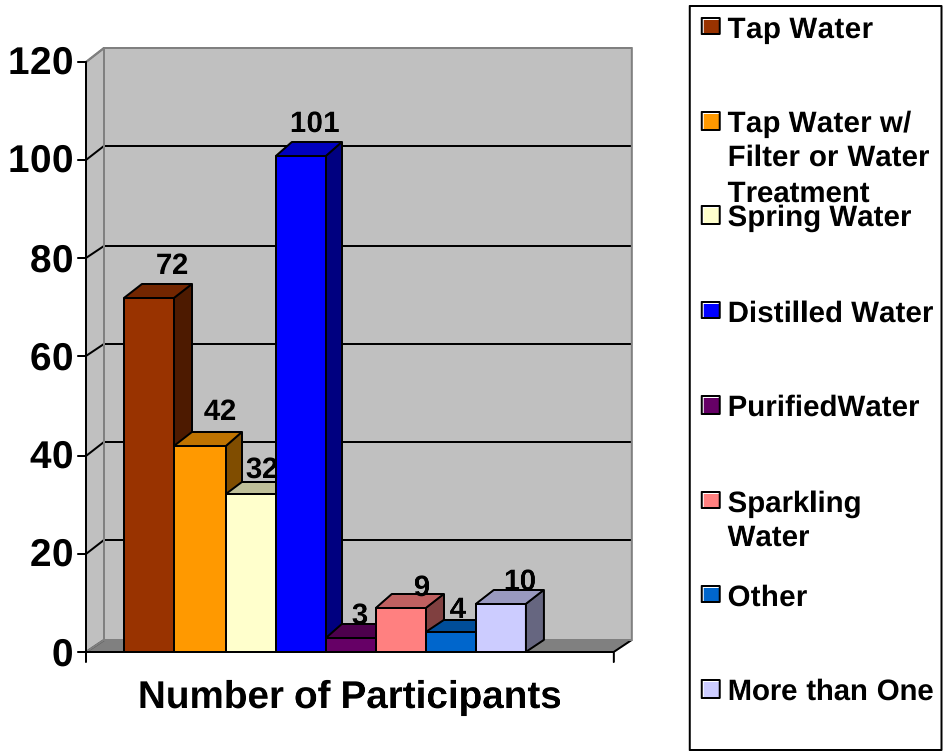



**Table 5** Shows the survey responses for participant intakes of 4 (16 oz.) bottles of water per day

| CATEGORY | TOTAL NUMBER (N) | PERCENTAGE |
|---|---|---|
| YES | 112 | 55.17 |
| NO | 91 | 44.83 |
| TOTAL | 203 | 100.00 |

Table 5 shows the responses to the question on the survey that asked participants details on their preferences prior to the taste test showed the following results for survey question number five. The results of the responses from participants on the question that asked, if the participants drank at least 4 (16 oz.) bottles of water a day? This question gives us a perspective on whether or not the participants drank the recommended intakes of water set by the American Dietetic Association for optimal health and wellness. The majority of the participants who answered this question said yes they did meet the dietary recommendations for fluid intakes (55.17%) and 91 (44.83%) program participants said they did not.

**Chart 5:** Illustration of drinking water intakes of 4 (16 oz.) bottles of water by participant

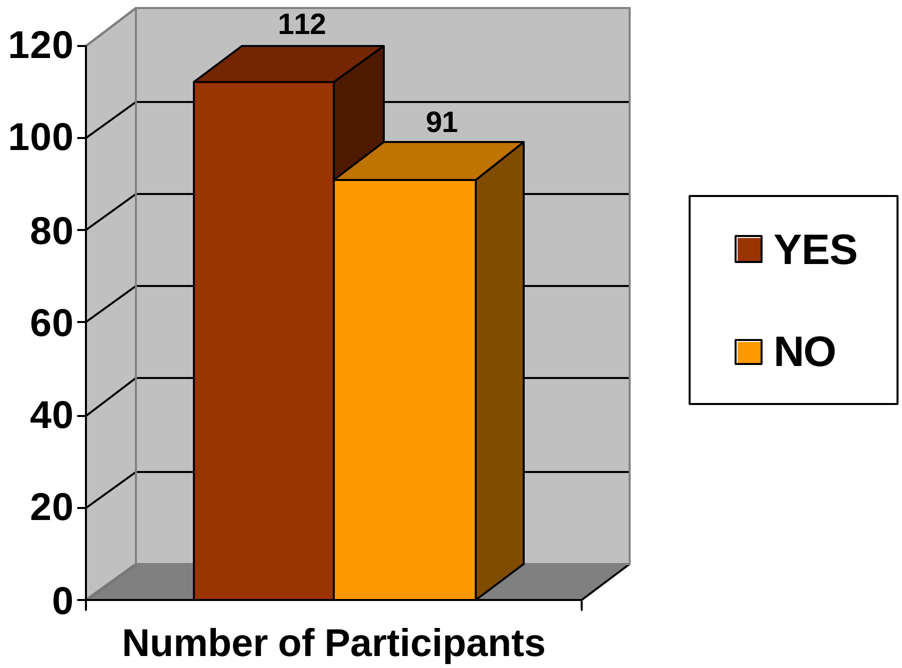
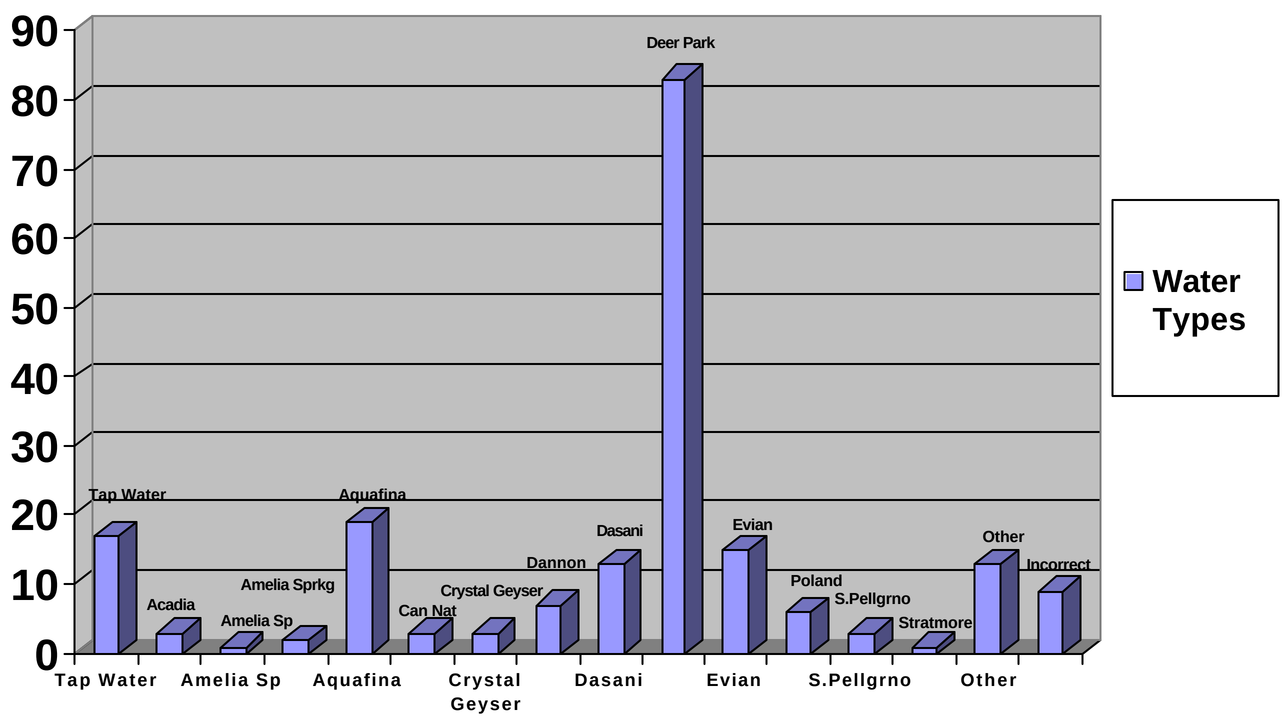


**Table 6:** Shows preferred water types by program participants regardless of usual choices

| TYPE | FREQUENCY | PERCENTAGE |
|---|---|---|
| TAP WATER | 17 | 8.59 |
| ACADIA | 3 | 1.51 |
| AMELIA SPRINGS | 1 | .50 |
| AMELIA SPARKLING WATER | 2 | 1.00 |
| AQUAFINA | 19 | 9.60 |
| CANADIAN NATURALLE | 3 | 1.51 |
| CRYSTAL GEYSER SPRING WATER | 3 | 1.51 |
| DANNON SPRING WATER | 7 | 3.55 |
| DASANI | 13 | 6.57 |
| DEER PARK SPING WATER | 83 | 41.92 |
| EVIAN SPRING WATER | 15 | 7.58 |
| POLAND SPRING WATER | 6 | 3.03 |
| S. PELLEGRINO SPARKLING NATURAL MINERAL WATER | 3 | 1.51 |
| STRATHMORE CARBONATED LOW MINERAL WATER | 1 | .50 |
| OTHER TYPES NOT MENTIONED | 13 | 6.57 |
| INCORRECT RESPONSE (MORE THAN ONE CHOICE MARKED | 9 | 4.55 |
| TOTAL | 198 | 100.00 |

Table 6 shows the responses to the question on the survey that asked participants details on their preferences prior to the taste test showed the following results in Table 6 for survey question number nine. The results of the responses from participants on the question that asked, what single type of water is preferred regardless of actual type of water ordinarily consumed is illustrated in chart 6. This question gives us a perspective on individual preferences for water brands and sources regardless of the circumstances that may influence someone to drink a specific type of water. Influences for selecting water types can be economical, geographical, or convenience. The majority of the participants chose Deer Park Spring Water (41.92%) followed by Aquafina Spring Water (9.60%), Tap Water (8.59%), Evian Spring Water (7.58%), Dasani (6.57%), and another choice not mentioned was equally preferred as the Dasani (6.57%) type. There were nine individuals who did not answer the question correctly (4.55%).

**Chart 6:** Illustration of types of water participants prefer regardless of usual choices consumed



**Program Photographs:**

**Program Interns:**

Deshawn Williams, DC Summer Youth Program
Washington, D.C.

Paul Brown Jr., Student
St. John's University, New York

Eugene Williams III, Student
University of the District of Columbia

Latasha Peace, Student
Towson State University, Maryland

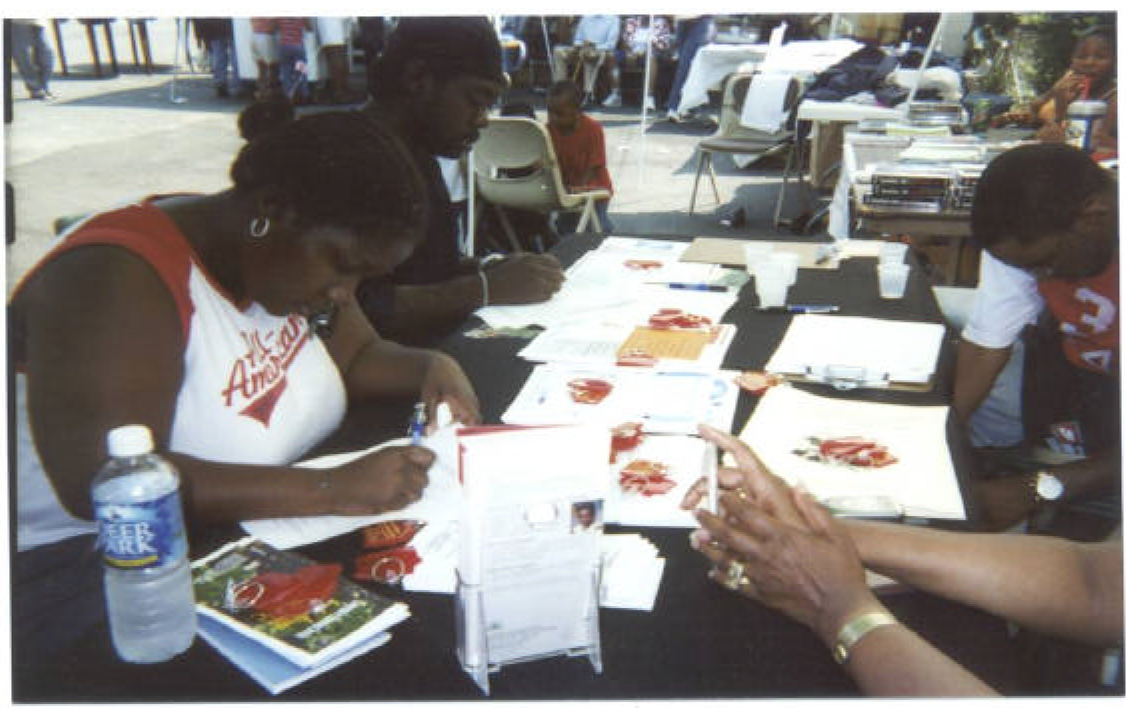
Rebecca Gill, DC Summer Youth Program
Washington, D.C.

Erin Crawford, Student
Morgan State University, Maryland

Amy Busia, Student
University of the District of Columbia


DC Drinking Water Blind Taste Testing Project activity on Saturday August 21, 2004 held at the *Be Healthy for Life Day* at the Greater Mount Calvary Holy Church located at 601 Rhode Island Avenue, NE Washington, DC 20001.

DC Drinking Water Blind Taste Testing Project activity on Saturday August 21, 2004 held at the *Be Healthy for Life Day* provided by the Greater Mount Calvary Holy Church located at 601 Rhode Island Avenue, NE Washington, DC 20001.



DC Drinking Water Blind Taste Testing Project activity on Sunday August 28, 2004 at the *Community Resource Day* provided by the New Commandment Baptist Church located at 925 Park Road NW, Washington, DC 20010.

DC Drinking Water Blind Taste Testing Project activity on Sunday August 28, 2004 at the *Community Resource Day* provided by the New Commandment Baptist Church located at 925 Park Road NW, Washington, DC  20010.

DC Drinking Water Blind Taste Testing Project activity on Sunday August 7, 2004 at the Miles Memorial CME Church located at 510 N Street NW, Washington, DC  20001

# Appendixes

**District of Columbia**
**Drinking Water**
**Blind Taste Testing Project**

**INFORMED CONSENT**

The University of the District of Columbia's Drinking Water Blind Taste Testing Project is designed to determine the comfort level and water intake of the residents and employees of the District of Columbia. You will be asked to taste 4 types of drinking water, rank them in order of preference, and complete a questionnaire. Tap water will be included as one of the taste testing samples. The tap water sample will contain the minimal levels of minerals that are approved by the Washington Sanitation and Sewage Commission (WSSC) and Environmental Protection Agency for all residents of the District of Columbia. You will be randomly assigned an identification number to assure all of your responses will be kept confidential. This experiment will take approximately 5 minutes to complete.

## *Agreement to Participate/Consent*

I have read the above information and have been given sufficient opportunity to ask questions which have been answered to my satisfaction. There will be no costs to me associated with this Blind Taste Testing Project. I am aware that my participation in this taste test is completely voluntary. Based upon this information, I agree to participate in the District of Columbia Drinking Water Blind Taste Testing Project.

I will receive a signed copy of this consent form. If at any time I have questions about this research project, I may call Lillie Monroe-Lord, Ph.D, R.D, L.D, Principal Investigator, Head, of the Center for Nutrition, Diet and Health at the University of the District of Columbia from 9:00 – 5:00p.m. Monday through Friday at 202-274-7115.

___________________________________
Your Name (please print)

___________________________________ __________________
Your Signature (please sign Date

============================================================

The investigator or his/her designee has explained the Blind Taste Testing Project to the participant and has answered any questions.

________________________________________
Investigator's or designee's name (please print)

________________________________________ __________________
Investigator's or designee's signature (please sign) Date

Cooperative Extension Services (CES)
University of the District of Columbia (UDC)

**DISTRICT OF COLUMBIA DRINKING WATER**
**BLIND TASTE TESTING PROJECT**

*This survey will collect information to help determine what types of water sources you or your family consume on a routine basis. Our goal is to help promote recommended intakes of water for healthy living. We appreciate your assistance in completing and returning this form to one of the representatives of our taste test. If you would like more information on the project, please contact: Dr. Lillie Monroe-Lord, Ph.D., Head Center for Nutrition, Diet, and Health or Ms. Dawanna James, Program Coordinator at the University of the District of Columbia – Center for Nutrition, Diet, and Health, 4200 Connecticut Ave. NW, Building 52, Room 322, Washington, DC 20008 or Phone (202) 274-7115 Fax (202) 274-7130.*

**PROFILE**

ID Number ______________________ TELEPHONE ______________________________

ADDRESS ________________________________________________________

CITY ______________________ STATE ____________ ZIP CODE ________________

AGE_____________________________________

1. What drinking water type (brand) do you drink most frequently? **Circle One**
   A. Evian (Spring Water)
   B. Poland Spring (Spring Water)
   C. Aquafina (Spring Water)
   D. Deer Park (Spring Water)
   E. Dannon (Spring Water)
   F. Amelia Springs (Spring Water)
   G. Crystal Geyser (Alpine Spring Water)
   H. Perrier (Sparkling Water)
   I. Amelia Sparkling (Sparkling Water)
   J. Canadian Naturalle (Spring Water)
   K. Acadia (Distilled)
   L. Strathmore (Carbonated Low Mineral Water)
   M. Tap Water W/ Filter or Filtration System 9Brita or other brand)
   N. Over the Counter (Giant, Safeway, CVS, etc.)
   O. Other (write in brand name)______________________________

2. What type of water source do you drink most frequently? **Circle One**
   A. Tap Water
   B. Tap Water w/ Filter or Water Treatment System (Brita System)
   C. Spring Water (Evian, Poland Spring, Aquafina, Deer Park, Over the counter brand)
   D. Mineral Water (S. Pellegrino)
   E. Distilled Water (Over the Counter or other brand)
   F. Purified Water (Dasani)
   G. Sparkling Water (Amelia Sparkling, Perrier)
   H. Other (write in brand name) __________________________________

3. How many 8 oz (1 glass) glasses of water do you drink in one day (24 hours)? **Circle One**

| | |
|---|---|
| A. One | E. Five |
| B. Two | F. Six |
| C. Three | G. Seven |
| D. Four | H. Eight or More |

4. What quantity of drinking water do you purchase most frequently? **Circle One**
   - A. 8 oz. at a time
   - B. 16 oz. at a time
   - C. 20 oz. at a time
   - D. 24 oz. at time
   - E. 1 liter at a time
   - F. 1 gallon at a time
   - G. 2 or more gallons at a time
   - H. I do not purchase drinking water, I drink Tap

5. Do you drink at least 4 (16 oz.) bottles of water a day? **Check One**

   Yes____ No____

6. Do you find water to be a refreshing drinking beverage? **Check One**

   Yes____ No____

7. Have you in the past few months drank water from a DC Water Fountain or other DC Tap Water Source? **Check One**

   Yes____ No____

8. Which of the following stores is the store you most frequently buy your water
   - A. Giant Food Stores
   - B. Safeway
   - C. CVS
   - D. Walmart
   - E. Target
   - F. Cosco
   - G. Sams Club
   - H. Local corner store
   - I. Other (write in name):______________________

In cooperation with the U.S. Department of Agriculture and the District of Columbia Government, Cooperative Extension Service and Agricultural Experiment Station programs and employment opportunities are available to all people regardless of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, marital status or family status.

# District of Columbia
# Drinking Water
# Blind Taste Testing Project

## Which type of water would you prefer to drink?

**ID Number: _______**

## Please check one:

- ❑ Tap Water
- ❑ Acadia
- ❑ Amelia Springs
- ❑ Amelia Sparkling Water
- ❑ Aquafina
- ❑ Canadian Naturelle Spring Water
- ❑ Crystal Geyser Spring Water
- ❑ Dannon Spring Water
- ❑ Dasani Spring Water
- ❑ Deer Park Spring Water
- ❑ Evian Spring Water
- ❑ Poland Spring Water
- ❑ S. Pellegrino Sparkling Natural Mineral Water
- ❑ Strathmore Carbonated Low Mineral Water
- ❑ Other________________________________

This program is funded from a Department of Interior / USGS grant through the DC Water Resources Research Institute

# District of Columbia
# Drinking Water
# Blind Taste Testing Project

## What type of drinking water do you prefer to drink?

**ID NUMBER: ___________________**

**RANK IN ORDER:**

**1st ____________________________**

**2nd ____________________________**

**3rd ____________________________**

**4th ____________________________**

**OPTIONS:**

**A1-A8 = Red**

**B3 = Orange**

**C1 = Green**

**D1-D2 = Blue**

This program is funded from a Department of Interior / USGS grant through the DC Water Resources Research Institute

***In cooperation with the U.S. Department of Agriculture and District of Columbia Government, Cooperative Extension Service and Agricultural Experiment Station programs and employment opportunities are available to all people regardless of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, marital status or family status.***

# Myth or Fact?

***Myth: You do not have to drink as much water in the winter months as in the summer months.***

**Fact:** The human body requires water all year long. The requirement is greater during the summer because people perspire more due to humidity and higher temperatures. The fluid lost must be replaced to maintain proper hydration. At least 70% of our body is water[1]; therefore, it is essential that we consume enough water for proper bodily functions.

***Myth: You can consume eight glasses of any beverage to fulfill the fluid intake requirement.***

**Fact:** This statement contains some truth. However, other beverages like coffee, tea, and fruit juices contain calories and additives that may contribute to weight gain if consumed in excess[1]. Water does not contain any calories or carbohydrates. It contains very little sodium, depending on the source. If you do not like the taste of water, try mixing it with other beverages. For example, try drinking half a glass of water mixed with half a glass of juice[1]. You could also try a hint of le mon in your water to provide it with flavor.

***Myth: Water only helps us get rid of wastes.***

**Fact:** The organs that benefit most from our adequate water consumption are the kidneys. Water allows the kidneys to filter out waste products that are later excreted into the urine. If we do not consume the proper amount of water, our kidneys are unable to do their job adequately and they must recruit help from the liver. The liver compensates for the kidneys and has to compromise the breakdown of fats. This process diminishes the amount of fat your body is about to burn during the course of the day. Therefore, water is also essential in weight loss. (Also see handout, "Why Drink Water")

***Myth: You will know when your body needs water because you will feel thirsty.***

**Fact:** Sometimes, thirst may be confused with hunger. We may think we are hungry when we are actually thirsty. The older we are the less reliable our thirst gauge becomes[2]. We may lose considerable amounts of water before we even feel thirsty. Therefore, it is important to consume water throughout the day whether we are thirsty or not to remain hydrated. After drinking coffee or tea (diuretics), our bodies begin losing water and it must be replaced to maintain a balance. To drink more water throughout the day, try keeping a water bottle handy[3]. **Warning signs of dehydration are excessive thirst, fatigue, headache, dry mouth, little or no urination, muscle weakness, dizziness, and lightheadedness[3].**

***Myth: During exercise, water only replaces the fluid lost.***

**Fact:** Water does not contribute to energy like carbohydrates, proteins and fats, but it does aid in the transformation of energy[4]. Water carries nutrients to the areas they are needed in the body. Water is also essential to building muscle. The electrolytes naturally found in water are needed to conduct a nerve impulse to the muscle for contraction. Without an adequate amount of water, it is harder to control and increase muscle mass[4]. Water also cushions and lubricates the joints. During exercise, the joints are being taxed. With enough water, stress on the joints decreases.

**Sources:**

1. www.mhcs.health.nsw.gov.au/health-public-affairs/mhcs/publication/3055.html
2. www.mayoclinic.com
3. www.nutrition.about.com/od/hydrationwater
4. www.building-muscle101.com/drinking-water-for-health.html

# District of Columbia
# Drinking Water
# Blind Taste Testing Project

**Prices of water in Giant Food Stores:**

| **Brand Name** | **Type of Water** | **Cost per 8oz** | **Cost per Bottle** |
|---|---|---|---|
| Strathmore | Carbonated Low Mineral Water | 50.7 oz = $1.79<br>8 oz = $0.28 | $1.12 per qt |
| Acadia | Distilled | 6pk 16oz = $2.59<br>8oz = $0.22 | $0.817 per qt |
| Poland Spring | Spring Water | 6pk 9oz = $2.99<br>8oz = $0.44 | 24oz = $0.69<br>$0.937 per qt |
| Canadian Naturelle | Spring Water | 12pk 16.9oz = $4.99<br>8oz = $0.20 | $0.937 per qt |
| Dasani | Purified Water Non-Carbonated | 24oz = $1.09<br>8oz = $0.36 | 20 oz bottle = $1.09 |
| Dannon | Spring Water | 24pk 16.9oz = $7.99<br>8oz = $0.16 | $0.634 per qt |
| Amelia Springs | Spring Water | 6pk 16.9oz = $3.99<br>8 oz = $0.32 | $1.25 per qt |
| Evian | Spring Water | 6pk 11.2oz = $4.59<br>8oz = $0.55 | $2.19 per qt |
| Aquafina | Spring Water | 6pk 16.9oz = $3.29<br>8 oz = $0.28 | 20oz = $0.99 |
| Deer Park | Spring Water | 24pk 16.9oz = $7.59<br>8oz = $0.15 | 24oz sport pack = $1.09 |
| Crystal Geyser | Alpine Spring Water | 28pk 8oz = $7.99<br>8oz = $0.29 | $1.14 per qt |
| S.Pellegrino | Sparkling Natural Mineral Water | 25.3 oz = $1.89<br>8oz = $0.60 | $2.39 per qt |
| Amelia Sparkling | Sparkling Water | 4pk 12oz = $1.69<br>8oz = $0.14 | $1.25 per qt |
| Perrier | Sparkling Mineral Water | 4pk 11oz= $2.99<br>8oz = $0.54 | $2.17 per qt |
| Poland Spring Sparkling | Sparkling Water | 33.8 oz = $1.29<br>8oz = $0.30 | $1.22 per qt |
| Acadia | Distilled | | $0.229 per qt |

***Formula 1:*** *Total Cost /Size of the pack = N*
*Oz of one container/8 oz =* $N_2$
$N/N_2$ *= Price per 8 oz*

***Formula 2:*** *Oz of the container/ 8 oz = N*
*Total Cost/ N = Price per 8 oz*

## District of Columbia
## Drinking Water
## Blind Taste Testing Project

**Prices of water in CVS:**

| Brand Name | Type of Water | Cost per 8oz | Cost per Bottle |
|---|---|---|---|
| Aquafina | Spring Water | 6pk-16.9 oz = $2.89<br>8oz = $0.23 | 20oz = $1.19 |
| Dasani | Purified Water<br>Non-Carbonated | 12pk-12oz = $4.99<br>8oz = $0.28 | 20oz = $1.19 |
| Evian | Spring Water | 8 oz.= .56 | 16.9oz = $1.19 |
| CVS Brand<br>Gold Emblem | Natural Spring Water | 8 oz = .42 | 16.9oz = $0.89 |
| Penta $H_20$ – Ultra Premium Purified Drinking Water | Purified<br>Drinking Water | 8 oz = .85 | 16.9oz = $1.79 |
| Poland Spring | Spring Water | 8 oz = .56 | 16.9oz = $1.19 |

***Formula 1:*** *Total Cost /Size of the pack = N*
*Oz of one container/8 oz =* $N_2$
$N/N_2$ *= Price per 8 oz*

***Formula 2:*** *Oz of the container/ 8 oz = N*
*Total Cost/ N = Price per 8 oz*

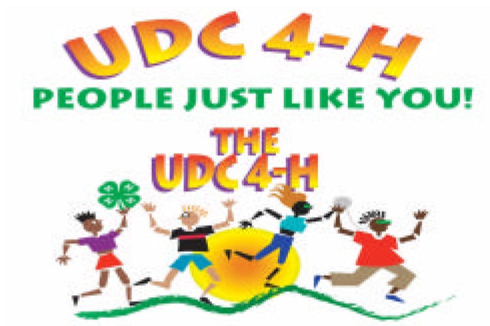
# DC H2O: Whats On Tap?

## Basic Information

| | |
|---|---|
| **Title:** | DC H2O: Whats On Tap? |
| **Project Number:** | 2004DC59B |
| **Start Date:** | 3/1/2004 |
| **End Date:** | 2/28/2005 |
| **Funding Source:** | 104B |
| **Congressional District:** | Washington DC |
| **Research Category:** | None |
| **Focus Category:** | Water Quality, Water Use, None |
| **Descriptors:** | None |
| **Principal Investigators:** | Rovenia Brock-Riggins, William W. Hare |

## Publication

# DC $H_2O$: What's on Tap?




## Annual Progress Report for FY 2004

**Prepared by:**

Dr. Rovenia Brock-Riggins
4-H/Youth Development Specialist
Cooperative Extension Service
University of the District of Columbia

Aisha Tyehimba, Student Intern
Department of Education
University of the District of Columbia

Cheryl Hayes, Student Intern
Department of Education
University of the District of Columbia

Carland Minor-Bey, Student Intern
University of the District of Columbia

**Date:** May 2005

**Prepared for the DC Water Resources Research Institute**
**Funds provided by USGS through the US Department of Interior**

# DC $H_2O$: What's on Tap?

## Introduction

Recent issues of lead and bacteria contamination in the District's drinking water have become a major concern of the residents and policy-makers. The Water and Sewer Authority, responsible for distributing treated water to DC residents has taken the brunt of the blame and has developed mechanisms to disseminate water quality information to its clients. The Geographic Information System (GIS) is one method of reporting the status of the city's water supply and the progress made by government entities responsible for the safety of said supply. However, the majority of DC residents is not familiar with this new technology and cannot interpret nor understand the results provided. This project will introduce the GIS technology as a water resources management tool to DC 4-H youth, ages 12 to 18. They will learn to collect water samples, input results into GIS using global positioning system (GPS) units, and interpret the data collected. The objective is to train future leaders in the field of water resources management.

## Progress Towards Achieving Objectives

The UDC 4-H/Youth Development program has recently completed literature review for the **DC $H_2O$: WHAT'S ON TAP** project. As part of the project, an eight week curriculum (see appendix) was compiled to provide youth participants with an interactive environmental service-learning experience. The curriculum is project based and is designed particularly to familiarize students with the functionalities of Global Positioning Systems and Geographic Information Systems. The Global Positioning System is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. A Geographic Information System is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. The designated curriculum also addresses the use and purpose of watersheds and the different means of measuring water quality. Project resources have secured a GPS unit and additional resources have already been allocated for GIS software.

Project leaders have initiated the first wave of the recruitment plan and will have the required number of participants selected prior to beginning the second phase of the project. The project will move into its next phase in July and continue through the month of August. Phase II will be incorporated as a part of the 4-H Youth Cyber Camp. And as such, will incorporate the technological aspects of the DC $H_2O$ project into the curriculum of the technology based Cyber Camp activities.

Arrangements have been made with Environmental Systems Service, Ltd. to retrieve samples from the University of the District of Columbia as well as test and analyze said samples. Individual tests and the total testing costs have been prepared including the pick-up and transport of the test samples (see Appendix).

# Appendix A. Curriculum

# LESSON 1 GPS

**GRADE LEVEL:** 6-12

**SUBJECT:** GPS technology

**DESCRIPTION:** Research and explain the origins of GPS, the basics of how it works, its benefits, and apply its function to a real-life scenario

**DURATION:** 90 minutes

**LEARNING OBJECTIVES:** To understand the design, function and use of GPS technology

**LEARNING ACTIVITIES:**

1. Students will define GPS
2. Students will explain GPS's initial design (function)
3. Students will identify the location of the GPS master control station
4. Students will understand the basic concepts of how GPS works
5. Students will utilize technology for research purposes
6. Students will identify a current or future use of GPS as it relates to their life
7. Students will identify a current or future GPS device useful in solving a proposed problem
8. Students will write a narrative with a logical beginning, middle, and end
9. Students will identify some of the possible benefits of GPS

**MATERIALS**

- Computers with Internet access
- Printer (optional)
- Copy of the questions for each group (or a large classroom display)
- Enough scenarios copied, cut, and placed in a container for each student to have one. (There are only six scenarios in all. You will need to copy these or if you prefer you may write your own.)

**PROCEDURE**

*45 minutes*

Discussion: Since many students will have some knowledge of or experience with a GPS device, allow them to discuss and share what they know about this system. This should provide other students with a basic framework regarding GPS.

Describe GPS to students as a constellation of 24 radio-transmitting satellites operated by the department of Defense to determine the precise position of a radio receiver on the ground.

Divide students into groups according to the number of computers available.

Assign each group one of the websites listed as general information sites. Discuss the task of the group. Note: More than one group may have the same site and not all sites have the information needed to answer all the questions. The class discussion at the end of the period will allow students to put all of the information together.

Researching GPS:

Using the site selected, your group's task is to answer as many of the questions as possible. Make sure each person in your group understands and can explain each of your group's answers.

What was the original purpose of GPS?

Where is the master control station located? What is its function?

How does GPS work? (Basics only)

Name three non-military uses of GPS today. Include any details you may find.

What is the fastest growing use of GPS? How will this benefit you?

Allow at least 10 to 15 minutes at the end of your class period for sharing and discussing answers. During this time, encourage each member of the group to share and each group to expand on other group's answers.

*45 minutes*

Student Application:

Review information from the day before. Allow students with new information to share.

Each student will draw one of six scenarios out of a bag. Emphasizing that their solution must utilize some type of GPS device (encourage creativity here), the assignment is to write a narrative using as many details as possible that must include:

**A Beginning**: How the day started.

**A Middle**: What happened?

**An Ending**: Conflict resolution

The identity of the GPS device (current or future) that help resolve the problem.

How the device functioned.

What may have happened without the device? (In the past)

**<u>Scenarios</u>**

1. While driving in an unfamiliar, deserted area, you notice that you are running out of gas…
2. You are on a skiing trip with a group of four friends, when a minor avalanche occurs. You only see one friend….
3. You are going to an out-of-state university to visit friends, when your car catches on fire. You are slightly injured and need immediate help but no one is in sight…
4. You are racing your boat across Lake Erie when your new $60 dollar hat suddenly flies off...
5. You stopped at a local convenience store for a snack. Just as you turn to leave, you see someone riding off on your new motorcycle…
6. You are on your first solo flight and a sudden fog rolls in…

When students have completed their stories, have them share with the class.

Discuss the current and future benefits of GPS as it relates to the students.

**ASSESSMENT** Observations of both individual and team participation in the research phase can form the basis for assessment. The information (quantity and quality) provided in their narratives can be assessed using your state's writing rubric or you and your students may generate your own.

# LESSON 2 Mapping

**GRADE LEVEL** 6-12

**SUBJECT** Geography

**DESCRIPTION** Students will be introduced to maps and mapping terminology.

**DURATION** 2 hours

**LEARNING OBJECTIVES** Students will explore the meaning of longitude and latitude lines. Students will identify the parts of the map and how to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

**MATERIALS**

- computer with Internet access
- Handheld GPS devices
- colored pencils
- white construction paper
- ruler

**PROCEDURE**

1. Guide the students in a map making exercise where they depict the route they take from their home to the school. Make sure representation includes trees, buildings and any other descriptions of their environment.

2. Have students place all five parts of a map accurately on their map (title, grid squares, compass rose, scale and key). Students should compile an accurate and descriptive map title.

3. Instruct the students that grid squares are made up of imaginary lines on a map or a globe called longitude and latitude lines. Show the students the direction of each imaginary line then explain its significance in finding location. Go over warnings, hazards and proper use of GPS.

4. Students should plot a course from home to school using the GPS, then use latitude and longitude information to complete their map.

5. Explain to the students that the compass rose is the part of the map that indicates direction. Have students use the GPS to correct directional arrows on the map.

6. Instruct that a scale is a representation of distance on a map. Have students figure the distance using the GPS from home to school. By looking at different examples of maps have students decide which scale type to use.

7. Tell the students that the key is the part of the map that gives explanations for symbols on the maps. Have students place a key on their maps to explain map symbols

**ASSESSMENT**

The teacher will rate maps on a rubric 1-4, 1 being the highest rating. Students will engage in an open discussion about their experiences using the GPS.

**EXTENSIONS**

Have the students compare and contrast their maps with city and county maps of the same area.

Have students attach a 1-page narrative/descriptive story about their journey "From home to school".

# LESSON 3 GIS/GPS Technology

**GRADE LEVEL** 6-12

**SUBJECT** Science/Technology

**DESCRIPTION** Familiarizes youth with the vocabulary associated with GPS/ GIS and water related concepts and allows students to exercise critical thinking skills and navigate the computer game GISquest.

**DURATION** 30-45 minutes

**LEARNING OBJECTIVES**

1. Recognize related terms and concepts
2. Use and understand terms

**LEARNING ACTIVITIES** Students will take a virtual tour of an area (wetland or desert) and use U.S. GPS and GIS technology.

**MATERIALS**

- Computer with Internet Access
- Windows requirements:
    - Netscape v.4.75+ or Microsoft Internet Explorer v..4+
- Macintosh requirements:
    - Netscape v.6.2
- RealPlayer (download link at www.gisquest.org)- Please note that once you select the link to RealPlayer download site 8 Basic (free version) download link on the left in the middle of the page

**VOCABULARY**

1. **GPS** - Global Positioning System
2. **GIS** - Geographical Information System
3. **ON STAR** - a company that uses GPS to locate your automobile.
4. **Portable (handheld) GPS** - GPS that you can carry in your hand.
5. **Animated Maps** - maps with a lot of pictures that are drawn.
6. **Bird's Eye View Maps** - maps shot from the air.
7. **Topographic Maps** - maps with land features.
8. **Historical Maps** - maps of a city from a long time ago.
9. **Virtual Reality** - 360 Degrees of a full circle also known as a Panorama.

**PROCEDURE**

**Game Plating Options:**

1. Individual play- requires one machine with Internet access.
2. Small group play (2-3 people)- can be accomplished with 2-3 people collectively providing input gathered around one computer with Internet access.
3. Larger group play (more than 3 people)- large-screen projection of computer screen with Internet access with one person entering the information from the groups collective input.

**How the Game Works:**

Participants are given clues to solve 3 simple GIS problems/quests (with one introductory problem). Participants will have to visit 4 GIS-powered Web sites to solve each quest.

Quests with corresponding Web sites;

1. **Introductory Quest**- http://www.lewisandclarkeducationcenter.com – The Lewis and Clark Web site will be used for trail investigation and exploration.
2. **FireQuest**- www.geomac.gov- The GeoMAC (Geospatial Multi-Agency Coordination Group) Web site will be used for wildland fire investigation and inspection.
3. **RoadQuest**- www.geographynetwork.com- Geographic data and solution sharing Web portal. This Web site will be used to solve a routing problem where you will route the presidential limousine from the White House to give a speech at the Washington Center Hospital.
4. **HazardQuest**- http://hud.esri.com/egis/ - HUD (Housing and Urban Development) Web site will be used to learn what environmental hazards lurk in a backyard similar to your own.

Participants can solve each quest using only the clues given (most difficult) or use the detailed set of instructions provided for participants to follow (medium difficulty) or participants may view a video that will walk them through each quest with detailed images (easiest). Once all the Quests have been solved, then the participant(s) will receive a GIS Quest game completion certificate to print out.

# LESSON 4 Wetlands

**GRADE LEVEL** 6- 12

**SUBJECT** Science/Ecology

**DESCRIPTION** In school and at field-based sites, students investigate the characteristics and history of wetlands; the importance of wetlands to the establishment of cooperative living habitats; and the impact of wetlands upon man's lifestyles, available supplies of selective foods, and his built environments.

**DURATION** Five 50-75 minute sessions

**LEARNING OBJECTIVES**

1. Students will conduct research activities in the classroom and at selected field-based sites.
2. Students will interact with wetlands environments.
3. From community resource people, students will learn about the importance of wetlands to the total life space environment of the community/surrounding region.
4. Students will discuss and debate strategies to protect wetlands from man's intrusion and thus their eventual destruction.
5. Students will study the ecosystem of a selected wetlands site.

**LEARNING ACTIVITIES** As a result of conducting this research-oriented investigation, students will understand: the nature and characteristics of wetland environments, the effects of wetland environments upon the overall health of the total life space environment, types of wetlands flora and fauna, and the geographical location of wetlands in the local community/surrounding region.

**MATERIALS**

- magazines (eg: National Geographic , Political magazines)
- atlases, maps, and globes
- computer software (Photo Shop)
- Internet sites
- films, filmstrips, slide/tape presentations, videos, PowerPoint presentations
- overhead transparencies
- community resources (people, places, things, events, processes)
- construction paper, tape/glue, scissors, stapler, thumbtacks, crayons and color markers, paint, butcher paper
- transparency sheets -- to make overhead projector visuals
- 8mm/16mm motion picture cameras
- still photography cameras (35mm)
- video tape equipment

- water, dirt, sand, vegetation, and straw or hay
- a tabletop or piece of plywood

**VOCABULARY**

1. **Cooperative Living Habitat(s)** - Geographical locations within which Man and Nature coexist and mutually prosper from their associations.
2. **Interlocking Dependency** - The inextricable link that exists between Man and Nature on earth.
3. **Life space Environment** - The geographical/physical location in which an individual exists -- at any given moment in time. One's life space environment changes as he/she moves about from one geographical location to another.

**PROCEDURE** A biome is a major community (flora and fauna) located on a specific continental sub-division of the geosphere (solid portion of earth). Biomes are defined by combinations of physiognomy (vegetation structure) and environment. Students investigate wetlands in the classroom, in lab classes, and at field-based sites (whenever possible) -- bogs, marshes, swamps. Community resource guides introduce students to the characteristics of wetlands -- pointing out flora, fauna, the composition of the soil, etc. Data is collected using water sampling kits, graphic media devices (cameras), sketches and maps of the region, observations in logs, etc. Print/non-print materials and resources are used for data gathering purposes.

**ASSESSMENT** Students demonstrate acquired knowledge and research skills by conducting lab studies of water and soil samples from wetlands, creating audiovisual presentations about wetlands sites, writing reflective essays, constructing a tabletop diorama, writing poetry, composing songs, and writing term papers. Students also demonstrate knowledge through discussions concerning the importance of wetlands in the web of life and the impact of wetlands upon the quality of the total life space environment of the community/surrounding region.

# LESSON 5 Ecosystem

**GRADE LEVEL** 6-12

**SUBJECT** Science/Ecology

**DESCRIPTION** Students will become familiar with the terms ecosystem, biotic, and abiotic. They will understand what an ecosystem is and the role of abiotic and biotic factors. Students will create an ecosystem using designated materials.

**DURATION** 1 hour

**LEARNING OBJECTIVES**

1. Students will be able to define the term ecosystem as a working unit made up of organisms interacting with each other and with nonliving factors. More specifically for this lesson, an ecosystem will be a 2-liter bottle filled with sand, gravel, an Elodea plant, water, fish, fish food, and sunlight.
2. Students will be able to discuss ecosystems in their surroundings.
3. Students will be able to create their own ecosystem, with given materials, in a bottle.

**LEARNING ACTIVITIES** Students will gain an understanding of what an ecosystem is and the role that humans play in ecosystems.

**MATERIALS**

- 2-liter bottle
- sand
- aquatic plants (Elodea)
- gravel
- scissors
- ruler
- water
- fish (1 small goldfish or guppy per student)
- fish food
- for the station activity: aquarium, plant with worm, bottle of nail polish, and a moldy sandwich

**VOCABULARY**

1. **Ecosystem** - an ecological community together with its environment, functioning as a unit.
2. **Biotic**- the living parts of an ecosystem.
3. **Abiotic**- the nonliving parts of an ecosystem.

**PROCEDURE**

**Scientific Explanation:**
What is an ecosystem? The biosphere is the part of the Earth that contains all the living things on the planet. Each ecosystem that we study is a part of the biosphere. A system is a group of things that interact with one another. The organisms that make up the living part of an ecosystem are called biotic factors. An organism depends on other biotic factors for food, shelter, protection, and reproduction. Nonliving things that we find in an ecosystem are called abiotic factors. Abiotic factors have an effect on the type and number of organisms living in an ecosystem. Some abiotic factors include soil, water, temperature, and sunlight.

**Focus Phase:**
Have students observe a working aquarium. Have students get into groups of two to think-pair-share about abiotic and biotic elements in the demonstrated ecosystem. Discuss the various elements that may be found in an ecosystem. Brainstorm elements and have students decide if the elements are abiotic or biotic.

**Challenge Phase:**
Have four stations (aquarium, plant with worm, bottle of nail polish, moldy sandwich) set up for students to visit in small groups. As a group, students will decide whether or not each station is an ecosystem. Also have students determine what parts of the system are abiotic or biotic. Have students make predictions about whether or not the station fits the definition of an ecosystem. Have students make further predictions about what each station might need to fit the definition of an ecosystem. One person in the group will record the group's ideas and answers. This information will be shared with the class at a later time.

**Concept Introduction:**
As a class, share the results of the challenge phase. Which stations did students identify as ecosystems? Students should have determined that the aquarium and the plant with worm are ecosystems. The moldy sandwich is part of an ecosystem. The bottle of nail polish is not an ecosystem. Have students share their ideas about what needs to be added to make non-ecosystem stations an ecosystem. For the bottle of nail polish to become an ecosystem, it needs a source of energy, food, water, and a population of "animals" which could maintain life in extreme conditions. The sandwich is part of an ecosystem, but to be an ecosystem of its own, it would require another source of food that could maintain its growth. As a class, brainstorm factors necessary for an ecosystem and list them on the board.
Inform students that they are going to be creating an ecosystem in a 2-liter bottle. They will be given a 2-liter bottle, aquatic sand, gravel, an Elodea plant, water, and eventually,

one fish to add to their ecosystem. Students must first draw an ecosystem and have it approved before they can get their materials and begin construction.

**Concept Application:** After all students have had their plans approved, they may begin building their ecosystem. They will be given all the materials that they will need, except for the fish. Students will have some leniency in the construction of the ecosystem, but because they will be given a live fish to add to their ecosystem, the ecosystem must be safe for the fish. Once students have completed the construction of their ecosystem, students will explain how the fish will be able to survive in this ecosystem, and what they, as students, must provide to ensure the success of the ecosystem (i.e. food, sunlight, oxygen and clean water).

**ASSESSMENT** Students will be assessed on their ability to construct an ecosystem that is a safe and successful environment for a live fish. In their journals, students will be asked to describe the elements that make up their ecosystem. They should also explain the role that they will play in their ecosystem.

# LESSON 6 WATER

**GRADE LEVEL** 6-12

**SUBJECT** Science/Aquatics

**DESCRIPTION** Every day, the average American uses about 50 gallons of water for drinking, bathing, cooking and maintenance. Most people, however, are unaware of the source of their water. In the United States, about 88 percent of the population is supplied by community water supply systems. The other 12 percent is supplied by non-community means, such as campgrounds, resorts, and private wells. Sixty-four percent of public water systems use surface water as their source, the other 36 percent use groundwater from wells. The aesthetic properties of drinking water from these public systems are often affected by the source of the water. Ground water often has a slightly metallic taste, and may contain high amounts of minerals. Surface water, on the other hand, usually has a musty taste and appears cloudy. Treatment techniques aim to produce water that is: safe for human consumption; appealing and good tasting to the consumer; and conforms to applicable State and Federal regulations at the lowest possible cost.

**DURATION** 1 hour

**LEARNING OBJECTIVES** This test should follow a class discussion on the possible sources of water for the community and strengthen student understanding.

**LEARNING ACTIVITIES** This taste test will illustrate the differences between groundwater and surface water, highlight some of the common contaminants in natural water, and encourage student thought on the sources of drinking water.

**MATERIALS**

- 1 gallon of distilled water
- 1 gallon of tap water (identify the source)
- 1 gallon of mineral water (or private well water, if available)
- 1 gallon of filtered tap water
- Cups for the class

**PROCEDURE**

1. Mark a set of 4 cups for each student. Label each cup 1 through 4 and fill them with the different types of water. Make sure that similarly labeled cups contain the same type of water.

2. Indicate on the board the different types of water present in the four cups. Have the students work together in groups to try to identify different tastes, smells, and appearances in the water. Have each group write down their observations on each water sample, and identify which cup has which type of water.

3. After everyone has completed their observations, have the students mark their guesses on the board.

Ask the students what types of impurities they would expect to find in the different types of water, and if their senses confirmed their intuitions. Record these observations on the board.

4. Reveal to the students which samples contained which type of water. Discuss with the students their observations and what other impurities might be found in these waters. Also discuss the source of water for the community. If anyone in the class lives in a location supplied by a private well, ask him/her to describe the water at their home, and how it compares to other water he/she drinks in the community.

**FOLLOW-UP QUESTIONS**

1. What are some possible sources of water in your community?

2. Which type of water tasted best? Why?

3. Which type of water would you consider safer to drink, groundwater from a spring, or surface water from a stream?

# LESSON 7 WATER QUALITY

**GRADE LEVEL** 6-12

**SUBJECT** Science/ Aquatics

**DESCRIPTION** In an effort to develop a system to compare water quality in various parts of the country, over 100 water quality experts were called upon to create a standard Water Quality Index (WQI). The index is basically a mathematical means of calculating a single value from multiple test results. The index result represents the level of water quality in a given water basin, such as a lake, river, or stream.

The WQI, which was developed in the early 1970s, can be used to monitor water quality changes in a particular water supply over time, or can be used to compare the quality of a water supply with other water supplies in the region or from around the world. The results can also be used to determine the healthfulness of a particular stretch of water.

**DURATION** 4 hours

**LEARNING OBJECTIVES** To determine the WQI using the following nine water quality parameters.

The Water Quality Index uses a scale from 0 to 100 to rate the quality of the water, with 100 being the highest possible score. Once the overall WQI score is known, it can be compared against the following scale to determine how healthy the water is on a given day.

| Table I - WQI Quality Scale | |
|---|---|
| 91-100: | Excellent water quality |
| 71-90: | Good water quality |
| 51-70: | Medium or average water quality |
| 26-50: | Fair water quality |
| 0-25: | Poor water quality |

Water supplies with ratings falling in the good or excellent range would able to support a high diversity of aquatic life. In addition, the water would also be suitable for all forms of recreation, including those involving direct contact with the water. Water supplies achieving only an average rating generally have less diversity of aquatic organisms and frequently have increased algae growth.

Water supplies falling into the fair range are only able to support a low diversity of aquatic life and are probably experiencing problems with pollution. Water supplies that fall into the poor category may only be able to support a limited number of aquatic life forms, and it is expected that these waters have abundant quality problems. A water supply with a poor quality rating would not normally be considered acceptable for activities involving direct contact with the water, such as swimming.

**LEARNING ACTIVITIES** After the nine water quality tests are completed and the results recorded, you can calculate the Water Quality Index (WQI) for the section of the water supply you monitored.

To calculate the overall WQI, you must first compute what are known as Q-values for the results you obtained for each of the nine tests and record them on the WQI Worksheet. This section outlines the procedures for computing these values:

1. Locate the chart for the appropriate test parameter (see links below).
2. Locate and mark your test result on the bottom, or horizontal axis, of the chart.
3. Beginning at your mark, draw a vertical line up until it intersects the curve on the chart.
4. From the point where your line intersected with the curve, draw a horizontal line to the left until you reach the vertical axis of the chart.
5. Record the value where this horizontal line intersects the vertical axis of the chart on the form. This would be the Q-value for the test.
6. Repeat each of these steps to find the Q-value for each of the remaining tests results.

You can select each of the following test parameters to view (or print) a copy of the Q-value chart for that parameter.

- Biochemical Oxygen Demand (BOD)
- Dissolved Oxygen
- Fecal Coliform
- Nitrate
- pH
- Temperature Change
- Total Dissolved Solids
- Total Phosphate
- Turbidity

Make sure you record the correct Q-value in the appropriate column next to each test parameter on the WQI Worksheet before you proceed to the next step. After the nine water quality tests are completed and the results recorded, a "Q" value is calculated for each parameter, and the overall WQI for the sampling site is then calculated. It is important to monitor water quality over a period of time in order to detect changes in the water's ecosystem. The Water Quality Index can give an indication of the health of the watershed at various points and can be used to keep track of and analyze changes over time.

### Completing the WQI Calculation

The Q-value for each test should then be multiplied by the weighting factor shown on the Worksheet for each test, and the answer should be recorded in the "Total" column. The weighting factor indicates the importance of each test to overall water quality. For example, the weighting factor for fecal coliform is 0.16, so it is considered more important in evaluating the overall water quality than nitrates, which only has a 0.10 weighting factor.

Finally, add the numbers shown in the Total column to determine the overall Water Quality Index (WQI) for the water source tested. Compare your Index result to the scale shown in Table I to determine the water quality rating for the water supply tested.

### VOCABULARY

1. **Biochemical Oxygen Demand**- a measure of the amount of food for bacteria that is found in water. Bacteria utilize organic matter in their respiration and remove oxygen from the water. The BOD test provides a rough idea of how much biodegradable waste is present in the water. (Biodegradable waste is usually composed of organic wastes, including leaves, grass clippings, and manure).
2. **Dissolved Oxygen**- measures the amount of life-sustaining oxygen dissolved in the water. This is the oxygen that is available to fish, invertebrates, and all other animals living in the water. Most aquatic plants and animals need oxygen to survive; in fact, fish will drown in water when the dissolved oxygen levels get too low. Low levels of dissolved oxygen in water are a sign of possible pollution.
3. **Fecal Coliform**- a form of bacteria found in human and animal waste.
4. **Nitrates**- a measure of the oxidized form of nitrogen and are an essential macronutrient in aquatic environments. Nitrates can be harmful to humans, because our intestines can break nitrates down into nitrites, which affect the ability of red blood cells to carry oxygen. Nitrites can also cause serious illnesses in fish.
5. **pH**- a measure of the acid content of the water. Most forms of aquatic life tend to be very sensitive to pH. Water containing a great deal of organic pollution will normally tend to be somewhat acidic. Water with a pH of 7 is considered neutral. If the pH is below 7, it is classified as acidic, while water

with a pH greater than 7 is said to be alkaline. The pH of tap water in the U.S. is usually between 6.5 and 8.5.

6. **Temperature Change**- the water temperature of a river is very important, as many of the physical, biological, and chemical characteristics of a river are directly affected by temperature. Most waterborne animal and plant life survives within a certain range of water temperatures, and few of them can tolerate extreme changes in this parameter. Using the same thermometer, the water temperature should be checked at the test site and at a similar site one mile upstream. Care should be taken when taking the temperature upstream to ensure that the amount of sunlight and the depth of the river are similar to the original test site.
7. **Total Dissolved Solids**- a measure of the solid materials dissolved in the river water. This includes salts, some organic materials, and a wide range of other things from nutrients to toxic materials. A constant level of minerals in the water is necessary for aquatic life. Concentrations of total dissolved solids that are too high or too low may limit growth and lead to the death of many aquatic life forms.
8. **Total Phosphate**- chemical compounds made from the elements phosphorous and oxygen; they are necessary for plant and animal growth. Phosphates can be present in water in many forms, so total phosphate gives an estimate of the total amount of phosphate potentially available in a given water supply.
9. **Turbidity**- a measure of the dispersion of light in a column of water due to suspended matter. The higher the turbidity, the cloudier the water appears. If water becomes too turbid, it loses the ability to support a wide variety of plants and other aquatic organisms.

**ASSESSMENT**

**National Water Monitoring Day**

Many individuals and volunteer groups from around the country participate in National Water Monitoring Day, which was held last year on October 18, 2002. Participants are requested to sample local rivers and streams for a core set of water quality parameters, including Temperature, pH, Turbidity, Dissolved Oxygen. An inexpensive test kit is available for purchase at www.yearofcleanwater.org for those individuals who do not have access to testing facilities. Those monitoring organizations and government monitors who do have access to regular facilities may use their existing protocols, equipment, and monitoring methods and submit their test results online.

A second water quality monitoring project is coordinated each fall and spring by the Center for Improved Engineering and Science Education (CIESE) in New Jersey. To learn more about the monitoring program, you can visit their website at k12science.ati.stevens-tech.edu/curriculum/waterproj/index.shtml.

# LESSON 8 Surface Water

**GRADE LEVEL** 6-12

**SUBJECT** Ecology, Physical Science, Social Studies, Economics, Government

**DESCRIPTION** Many towns and cities obtain their drinking water from a nearby river, lake or reservoir. The quality of this source water is influenced by the quality of streams flowing into it, the land uses and activities conducted near it, and any air deposition that might occur. Surface source water protection is a 3-step process involving: delineating areas contributing water to a surface water intake, identifying potential contaminant sources that may threaten the water supply, and protecting the supply using a combination of watershed management strategies for specific communities or watersheds. Watershed management strategies incorporate broad concepts such as land use control and/or management practices, and pollution prevention. Specific watershed management strategies may include the following: protection of inland wetlands that serve as filters for pollutants, appropriate forestry management practices, erosion controls, control of adjacent zoning and urbanization, creation of buffer zones along reservoir edges, reservoir access and activity control, and community education. Homeowners, businesses, farmers, and industries may also be encouraged to use pollution prevention and best management practices to prevent surface water contamination.

**DURATION** 4 hours

**MATERIALS**

- student sheets
- bus for field trip

**VOCABULARY**

1. **Best Management Practices (BMPs)-** techniques that are determined to be currently effective, practical means of preventing or reducing pollutants from point or nonpoint sources, in order to protect water quality. BMPs include, but are not limited to structural and nonstructural controls, operation and maintenance procedures, and other practices. Usually, BMPs are applied as a system of practices rather than as a single practice.
2. **Buffer Zone -** an area between the water supply source and the possible contamination sources where no contamination activities are likely to occur.

3. **Pollution Prevention-** preventing the creation of pollutants or reducing the amount created at the source of generation, as well as protecting natural resources through conservation or increased efficiency in the use of energy, water, or other materials.
4. **Source Water Protection-** process that involves delineating areas contributing water to a well or surface water intake; identifying potential contaminant sources that threaten the water supply; and using management strategies to protect the source water from contamination. Source water protection is applied to both surface water and groundwater supply sources.
5. **Watershed-** land area from which water drains to a particular surface water body.
6. **Zonings-** to divide into areas determined by specific restrictions; any section or district in a city restricted by law for a particular use.

## PROCEDURE

1. Discuss Background Information with students.
2. Contact the local drinking water treatment plant and find out the water source in the community.

## LEARNING ACTIVITIES

1. Schedule a visit to the water supply reservoir with a water system representative and ask about source water protection methods that are used, including upstream management methods in the watershed. If a field trip is not possible, have a water system representative visit the class.
2. From local, state, or other sources, define the water supply watershed on a topographic or other map and locate potential pollutant sources. (Use Student Sheet to determine potential pollution problems.)
3. Visit each pollutant source, or location downstream of each one, to determine the type and extent of pollutants to the reservoir. (Students could be assigned this as an out-of-class assignment and report to the class.)
4. Note any pollution prevention or best management practices in place or, where none exist, make notes of recommendations (not just what is needed but how to do what is needed).
5. Make a compilation of all notes from the class into a report on protection of the water supply watershed. Include recommendations as to the location and type of pollution prevention or best management practices used or needed, and other water quality management steps which should be taken.

**EXTENSION**

Have students construct a solar evaporator using the materials you have provided or some they may want to bring. They can follow the directions on the Student Sheet or try their own design. Students should wash hands and dip finger in salt solution and taste. Place solar evaporators in a warm, sunny place for 24 hours. Taste water in beaker (glass) using finger method after washing, and answer questions on Activity Student Sheet. Finally, discuss the findings.

**ASSESSMENT**

Share compiled information or reports with local watershed managers and ask them to comment on the class ideas.

# LESSON 9 Watershed

**GRADE LEVEL** 6-12

**SUBJECT** Ecology

**DESCRIPTION** The land we live on is divided into watersheds. A watershed is a land area whose runoff drains into any river, stream, lake, or ocean. The runoff from small watersheds joins together, and their combined areas become a new, larger watershed. Large watersheds, such as the Anacostia watershed and the Chesapeake Bay watershed, drain into large bodies of water, and cover immense land areas. Despite their differences in size all watersheds share common properties. They all perform the same function of transporting water over the Earth's surface. The watersheds encompass suburban lawns, parking lots and city streets. Water seeps down through the soil to aquifers, which are underground rivers that slowly move water below watersheds to outlet points at springs, rivers, lakes, and oceans.

Many human activities have an effect on watersheds. Construction projects like dams can limit the flow of water; construction of roads and buildings can divert and even increase the flow of water. Agricultural fertilizers can run off of crop fields and inadvertently fertilize harmful microorganisms in rivers and lakes, having an adverse effect on water quality and marine life. The irresponsible disposal of household and industrial chemicals can be harmful because these chemicals travel through the watershed, poisoning life and damaging natural ecosystems.

Watersheds can also have an effect on people. Many communities use rivers and streams as their source of drinking water. Water treatment prepares water for human consumption, but if the water is laden with chemicals and microorganisms, it can be difficult to treat effectively. Floods are one of the major events in a watershed. Homes built on flood plains, low lying areas adjacent to rivers, are susceptible to flooding conditions when heavy precipitation exceeds the watershed's capacity to absorb water. Rivers, streams, and lakes overflow, threaten human lives, and damage or destroy roads, buildings, and flood control measures. Watersheds can also become dry, causing water shortages for those who depend on their lakes and rives for drinking water.

It is clear that people have a close relationship to watersheds. The responsible planning of watershed use and development is important to ensure that the ecosystems sustained by them are not destroyed, and to protect the health and safety of our communities.

**DURATION** 2-4 hours

**LEARNING OBJECTIVES**

1. Understand how the placement of buildings, roads, and parking lots can be important to watershed runoff.
2. Recognize human carelessness in the disposal of harmful contaminants that can have a serious effect on downstream watershed denizens.

**MATERIALS**

- 1 large Tupperware container (about 1.5'W x 3'L x H)
- 2 lbs. of modeling clay
- 3 lbs. of sand (any type of sand will do)
- 2 lbs. of aquarium gravel
- 1 roll of wax paper (or any other impervious, water repellant surface, tin foil, plastic wrap, etc.)
- ¼ cup of cocoa mix, iced tea mix, or other flavored drink mix (to represent chemicals)
- 1 spray bottle or bucket full of water

**PROCEDURE**

1. Wash the aquarium gravel carefully to remove any powdery residue that may add cloudiness to the water. Fill the container to about 2 inches from the bottom with the gravel. Slope the gravel slightly so, that at one end (downslope), the gravel is only about ½ inch deep and, at the other end (upslope), the gravel is about 3 inches deep. This gravel layer will represent the aquifer.
2. Mix the clay and the sand. The consistency of this mix should be gritty, with slightly more clay than sand. This mixture should allow water to run freely over it, but if left standing, the water should slowly permeate the surface. Add this mixture to the container carefully, so as not to disturb the slope of the aquifer already placed. The slopes should be similar, with about 2 inches of sand/clay mix overlying the gravel already placed, and on the downhill end there should be about 3" of gravel left exposed.
3. Carve a channel in the middle of the clay/sand layer, about ½ inch deep and about 1 inch wide. This channel will represent the main river of the watershed. Near the top of the slope, split the channel into two or three separate channels to represent tributaries. You may wish to add other tributaries along the main branch of the "river" to further illustrate other watersheds.
4. With some extra clay/sand mix, build little hills between the tributaries. These hills separate the smaller watersheds, but when looked at as a whole, the entire "river" system is one watershed. You may also wish to add some small model

trees or green felt to represent forests or fields. Buildings can be represented with small blocks of wood.

5. Along the main river, flatten out an area that is about 8 inches. Cut out a piece of wax paper to be about 4 inches by 3 inches in size. Stick this down onto the clay sand mix, sloping slightly towards the river. If necessary, use some clay to hold the edges down. Explain to the students that this wax paper represents the impervious surface of a parking lot.
6. Fill the bottom of the aquarium up to about 2 inches from the bottom with water. The water should fill all of the aquarium gravel "aquifer" area, and should just reach up to the lowest extent of the clay/sand mixture. Explain to students that the aquifer captures and transports water that seeps down through the soil.
7. Using the spray bottle, simulate rain over the flattened soil area and the parking lot. Ask the students to note that the "rain" soaks through the soil, but runs off the parking lot to the river. Ask them what the effect would be if the entire watershed was "paved."
8. Sprinkle some cocoa mix over the sides of one of the smaller watersheds. Tell the students that the cocoa represents pollution. Cause some rain with the spray bottle over one of the unpolluted "watersheds," (*it may be necessary to cause more rain by pouring water). Note that the runoff from the rain is clean. Now, make it rain over the polluted area. Ask the students to note how the pollution travels down through the watershed, contaminating all downstream areas. Discuss with the students why the pollution is a problem, and what can be done to fix the problem.

**ASSESSMENT**

1. What are some possible sources of watershed pollution in your community?
2. What other impervious surfaces besides parking lots can cause excessive runoff in a watershed?
3. What can be done to reduce our impact on watersheds and their environment?
4. Using a map of the area around your house and EPA's "Surf Your Watershed," identify where the runoff from your driveway will end up. Can you track the path of potential pollution to a large body of water (*i.e.,* ocean or bay)?

# LESSON 10 Water Filtration

**GRADE LEVEL** 6-12

**SUBJECT** Science/ Ecology

**DESCRIPTION** Water in lakes, rivers, and swamps often contains impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from surface water sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes: (1) **aeration**; (2) **coagulation**; (3) **sedimentation**; (4) **filtration**; and (5) **disinfection**. Demonstration projects for the first four processes are included below.

**DURATION** 2 hours

**LEARNING OBJECTIVES** To understand the water treatment processes and their importance in ensuring healthful drinking water.

**MATERIALS**

- 5 liters of "swamp water" (or add 2 ½ cups of dirt or mud to 5 liters of water)
- 1 two-liter plastic soft drink bottle with its cap (or cork that fits tightly into the neck)
- 2 two-liter plastic soft drink bottles – 1 with the top removed, 1 with the bottom removed
- 1 one-and-one-half-liter (or larger) beaker (or another soft drink bottle bottom)
- 20 grams of alum (potassium aluminum sulfate – approximately 2 tablespoons)
- fine sand (about 800 ml in volume)
- course sand (about 800 ml in volume)
- small pebbles (about 400 ml in volume)
- 1 large (500 ml or larger) beaker or jar
- 1 coffee filter
- 1 rubber band
- 1 tablespoon
- 1 clock with a second hand (or a stopwatch)

**VOCABULARY**

1. **Aeration-** the addition of air to water. It allows gases trapped in the water to escape and adds oxygen to the water.
2. **Coagulation-** the process by which dirt and other suspended solid particles are chemically "stuck together" into floc so that they can be removed from water.
3. **Sedimentation-** the process that occurs when gravity pulls the particles of floc (clumps of alum and sediment) to the bottom of the cylinder.

**PROCEDURE**

1. Pour about 1.5 liters of the swamp water into a 2-liter bottle. Have students describe the appearance and smell the water.
2. Aeration- Place the cap on the bottle and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cut-off bottles, and then pour the water back and forth between the cut-off bottles 10 times. Ask students to describe any changes that they observe. Pour the aerated water into the bottle with its top cut off.
3. Coagulation- With the tablespoon, add 20 g of alum crystals to the swamp water. Slowly stir the mixture for 5 minutes.
4. Sedimentation- Allow the water to stand undisturbed in the cylinder. Ask students to observe the water at 5 minute intervals for a total of 20 minutes and write their observations with respect to changes in the water's appearance.
5. Construct a filter from the bottle with its bottom cut off as follows:

   a. Attach the coffee filter to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle—the filter will prevent the pebbles from falling out of the neck.
   b. Pour the coarse sand on top of the pebbles.
   c. Pour the fine sand on top of the coarse sand.
   d. Clean the filter by slowly and carefully pouring through 5 liters (or more) of clean tap water. Try not to disturb the top layer of sand as you pour the water.

6. Filtration through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. After a large amount of sediment has settled on the bottom of the bottle of swamp water, carefully—without disturbing the sediment—pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) swamp water back into the collection container. Compare the treated and untreated water. Ask students whether treatment has changed the appearance and smell of the water.

**ADVISE STUDENTS THAT THIS WATER IS UNSAFE TO DRINK!!**

# Appendix B. Water Testing- List and Prices

# Water Testing- List and Prices

**Lab:** Environmental Systems Service, Ltd.
Address: 8321 Leishear Rd
Laurel, MD 20723
Phone: 301.617.9582
Fax: 301.617.3426
URL: Http://www.ess-services.com

**Contact:** Kunle Aladeselu

***Indoor Samples***

| TEST | COST PER SAMPLE | TOTAL PER TEST |
|---|---|---|
| Lead | $20 x 16 | $320 |
| Turbidity | $15 x 16 | $240 |
| pH | $10 x 16 | $160 |
| Choliform | $40 x 16 | $640 |
| **Total Per Sample** | **$85** | |
| **Total Testing Costs** | | **$1360** |

***Public Waterway Samples***

| TEST | COST PER SAMPLE | TOTAL PER TEST |
|---|---|---|
| Lead | $20 x 6 | $120 |
| Copper | $20 x 6 | $120 |
| Chromium | $20 x 6 | $120 |
| Zinc | $20 x 6 | $120 |
| Iron | $20 x 6 | $120 |
| Manganese | $20 x 6 | $120 |
| Metal #7 | $20 x 6 | $120 |
| | | |
| pH | $10 x 6 | $60 |
| Nitrates | $25 x 6 | $150 |
| Turbidity | $15 x 6 | $90 |
| Choliform | $40 x 6 | $240 |
| | | |
| **Total Per Sample** | **$230** | |
| **Total Testing Costs** | | **$1380** |

**$25- pick up per location**

# Identification of PCB and Chlordane sources in the Anacostia RIver Watershed

## Basic Information

| | |
|---|---|
| **Title:** | Identification of PCB and Chlordane sources in the Anacostia RIver Watershed |
| **Project Number:** | 2004DC61B |
| **Start Date:** | 3/1/2004 |
| **End Date:** | 2/28/2005 |
| **Funding Source:** | 104B |
| **Congressional District:** | Washington DC |
| **Research Category:** | None |
| **Focus Category:** | Water Quality, Toxic Substances, Non Point Pollution |
| **Descriptors:** | None |
| **Principal Investigators:** | Harriette Phelps |

## Publication

# Identification of PCB, PAH and Chlordane Source Areas in the Anacostia River Watershed

**Final Report**

**Prepared by:** Dr. Harriette L. Phelps
Department of Biological and Environmental Sciences
University of the District of Columbia

**Date:** May 2005

**Prepared for the DC Water Resources Research Institute**
**Funds provided by USGS through the US Department of Interior**

# Identification of PCB, PAH and Chlordane Source Areas in the Anacostia River Watershed


## ABSTRACT

In 2004 this Anacostia River biomonitoring project used a two-week Asiatic clam (*Corbicula fluminea*) translocation bioaccumulation protocol in an attempt to find the contaminant source areas of its most highly contaminated first-order tributaries. These tributaries were identified from earlier studies as Lower Beaverdam Creek (PCBs), NorthEast Branch (total PAHs and chlordane) and Watts Branch (total PAHs and chlordane). Clams placed at the Lower Beaverdam Creek Landover Metro site had significant accumulation of PCBs and Aroclors, which dropped to reference control levels in clams at the upstream Corporate Drive site above the Landover Metro/ Ardwick-Ardmore Industrial Park/ New Carrolton Metro area. Clams at the NorthEast Branch Odell Road site had high total PAHs which dropped by 50% at the Virginia Manor Road site upstream, above the Beltsville Industrial Center. Clams at the Riverdale East Branch second order stream near the mouth of the Northwest Branch had high pesticides and chlordane not found upstream. Clams at the Watts Branch Upper site had total PAHs not significantly lower than at other Watts Branch sites. Using comparison with data from previous studies it appeared that clam accumulations of high levels of PCBs, Aroclor and PAHs in the Anacostia watershed were associated with industrial park areas in Prince George's County. High bioavailable chlordane was not associated with other contaminants or an identifiable industrial park. Clams at the Fort Foote control site had a significantly greater pesticide (endosulfan I) accumulation than other sites and may have detected an endosulfan I spill in the Potomac River in May 2004. The high endosulfan in clams was lost over their two week translocation period at Anacostia watershed sites.


## Introduction

The heavily contaminated tidal freshwater 10 km Anacostia River estuary stems from the Potomac estuary and is the major water body within the District of Columbia. The poor quality of the Anacostia River estuary has been known for years (Freudberg et al.1989, Cummins et al. 1991) and it is considered one of the three most contaminated locations in the Chesapeake Bay. The Anacostia River runs along the lower third of the District and essentially separates Federal buildings and upscale housing from the poorer and mostly minority communities to the south and west. There is a high incidence of cancer and other diseases in this minority community, where there is also subsistence fishing in the Anacostia in spite of a fishing advisory. Anacostia River estuary catfish have tumors related to high polycyclic hydrocarbon (PAH) levels in sediment (Pinkney e.a. 2000), and high tissue levels of polychlorinated biphenyls (PCBs) and chlordane which can be associated with cancer. Fish that yearly migrate into the Anacostia estuary also have been found contaminated (Velinsky and Cummins 1994). Reference: Phelps, HL. 2005. Identification of PCB, PAH and chlordane source areas in the Anacostia River watershed. DC Water Resources Research Institute, Washington, DC 9p.

The Anacostia River estuary has very little benthic life and shows sediment toxicity to clam larvae (Phelps 1985, Phelps 1993, Phelps 1995). Most studies of Anacostia River contaminants have focused on water and sediments of the estuary portion (Velinsky et al. 1992, Wade et al 1994, Velinsky and Ashley 2001, AWTA 2002). However, contaminants are increasingly recognized as coming from Anacostia tributaries, with many in Maryland (Warner et al.1997, Phelps 2004, Washington Post 2004). UDC's WRRC-sponsored clam biomonitoring studies have developed a rapid two-week protocol using Asiatic clams (*Corbicula fluminea*) translocated from the healthy Potomac to sites in the Anacostia River watershed where they accumulate bioavailable contaminants. These common, non-endangered clams have a high filtration rate, can accumulate toxic contaminants from the water and have been used elsewhere for active freshwater biomonitoring (Dougherty and Cherry 1988, Crawford and Luoma 1993, DeKock and Kramer 1994, Colombo et al 1995). Clam translocation and bioaccumulation has identified one of Anacostia's five first order tributaries as a source of bioavailable polychlorinated biphenyls (PCBs), two as sources of chlordane, and four as sources of polycyclic hydrocarbons (PAHs). This information is essential for DC's Mayor to bring to the attention of counties surrounding the District for remediation efforts to achieve a fishable and swimmable DC Anacostia River.

The most serious contaminants of the Anacostia from the standpoint of human health are the pesticide chlordane and PCBs which are above FDA action levels in Anacostia fish (Velinsky and Cummins 1994). PCBs are known to be toxic and have been banned but residuals come from a variety of sources (Ahlborg et al. 1994, Safe 1994). Chlordane is a termite pesticide harmful to humans and has been banned for over 20 years but is slow to biodegrade and its accumulation in fish tissues is one basis for the 1994 Anacostia fishing advisory. Translocated clams accumulated chlordane in the lower NorthEast Branch and Watts Branch tributaries (Phelps 2000, 2002). High PAH levels in sediment are identified with sediment toxicity and fish tumors (Pinkney et al 2000). PAHs from oils and manufacturing and combustion byproducts are a major contaminant of the Anacostia estuary but are not bioaccumulated by fish so active clam biomonitoring is needed to find sources. The primary objective of this 2004 study was to use active clam biomonitoring to locate the uncontaminated upstream portions of the major Anacostia tributaries contributing PCBs, PAHs, and chlordane (Phelps 2004). The second objective was to continue the involvement and training of UDC undergraduate students in research on DC's Anacostia River.

## **Methodology**

Asiatic clams (*Corbicula fluminea*) were collected from May through September at the healthy nearby Potomac River estuary control site of Fort Foote (MD). Clams collected by along-shore sieving were selected from the same cohort, 20 - 30 mm, and kept cool and dry before 20-30 were placed in mesh shellfish cages at the tributary sites within 24 hours (Table 1).

As clams can accumulate a maximum of contaminants within one to two weeks (Phelps 2004) they were collected after two weeks exposure. The 15 - 30 clams were washed, depurated for 24 hours in three changes of spring water at room temperature and briefly frozen to open shells and extract tissues. The combined frozen tissues were sent to the certified Severn-Trent Laboratory (STL), Burlington, VT for chemical analyses. The STL EPA Priority Pollutant tissue analysis included 21 pesticides, 28 polychlorinated biphenyl (PCB) congenors, 6 Aroclors, 18 polycyclic hydrocarbons (PAHs), and six metals of interest (As, Cd, Cr, Cu, Fe, and Zn), and percent lipid. Results were available within five weeks. The STL analytical variability has been determined as SD = 0.175 (mean) - 1.12 (n = 9) (Phelps 2002). Statistical comparison between sites was by t test and the 95% confidence limits of the mean were calculated as 2.05 SD = 0.36 (mean). Analytical error was considered the most significant since clam tissues were pooled for analysis.

The sites chosen for biomonitoring were located on the Anacostia watershed first order tributaries where previously translocated clams had accumulated high PCBs (Lower Beaverdam Creek), chlordane (NorthEast Branch and Watts Branch), and PAHs (NorthEast Branch and Watts Branch) (Phelps 2003, Phelps 2004). Not all tissue contaminants were examined at each site.

## Results

The GPS site locations and clam translocation dates are in Table 1, listed in order of date. The Riverdale East Branch site clams had to be replaced four times. Translocated clam survival was 97 - 100%.

**Table 1.** Clam site locations listed by translocation date.

| Date placed | Date collected | Site (Code) | UTM GPS Northing | UTM GPS Westing |
|---|---|---|---|---|
| 5/13 | 5/13 | Fort Foote, MD (FF5/04) | 38°46’458” | 077°01’752” |
| 5/13 | 5/27 | Watts Branch Upper, DC (WBU) | 38°58’357” | 076°54’619” |
| | 5/27 | Landover Metro Yard, MD (LMT) | 38°55’932” | 076°53’355” |
| | 5/27 | Riverdale West Branch, MD (RVW) | 38°57’582” | 076°55’557” |
| 6/1 | 6/15 | NorthEast Branch 04, MD (NEB04) | 38°57’621” | 078°55’583” |
| | 6/15 | Odell Road, MD (ODR) | 38°58’375” | 076°55’509” |
| | 6/15 | Virginia Manor Road, MD (VMR) | 39°03’522” | 076°53’909” |
| 7/20 | 8/10 | Corporate Drive, MD (CRD) | 38°56’318” | 076°51’646” |
| 8/28 | 9/9 | Riverdale East Branch, MD (RVE) | 38°57’644” | 076°55’572” |

Contaminants detected in clam tissues were summarized by the total accumulation of each type (tmetals, tPAHs, tPCBs tAroclors and tpesticides), with alpha and beta chlordane additionally summed as tChlr (Table 2). FF control was the average of Fort Foote clams with eight previous Fort Foote samples from 1999 to 2003 (Phelps 2004).

**Table 2.** Clam tissue contaminant concentration totals (μg/Kg) at sites by tributary.

| Site | tMetalx.001 | tPAH | tPCB | tArocl. | tPest. | tChlr. |
|---|---|---|---|---|---|---|
| FF Control (average) | 77 | 376 | 93 | 140 | 72 | |
| *Potomac* | | | | | | |
| Fort Foote | 116 | 60 | 76 | 116 | 169* | 38 |
| *Lower Beaverdam Creek* | | | | | | |
| Landover Metro | 24 | --- | 366* | 630* | 97 | 50 |
| Corporate Drive | 70 | 267 | 105 | 120 | 93 | 83* |
| *NorthEast Branch* | | | | | | |
| NorthEast Branch | 69 | 923* | 86 | 149 | 74 | 40 |
| Riverdale West Branch | 21 | | 142 | 62 | 62 | 27 |
| Riverdale East Branch | | --- | --- | --- | 246* | 144* |
| Odell Road | | 2196* | --- | 188 | --- | --- |
| Virginia Manor Rd | 66 | 996* | 72 | 149 | 31 | 19 |
| *Watts Branch* | | | | | | |
| Watts Branch Upper | 23 | 1088* | --- | 120 | 55 | 30 |

* Significantly (95%) greater than FF control

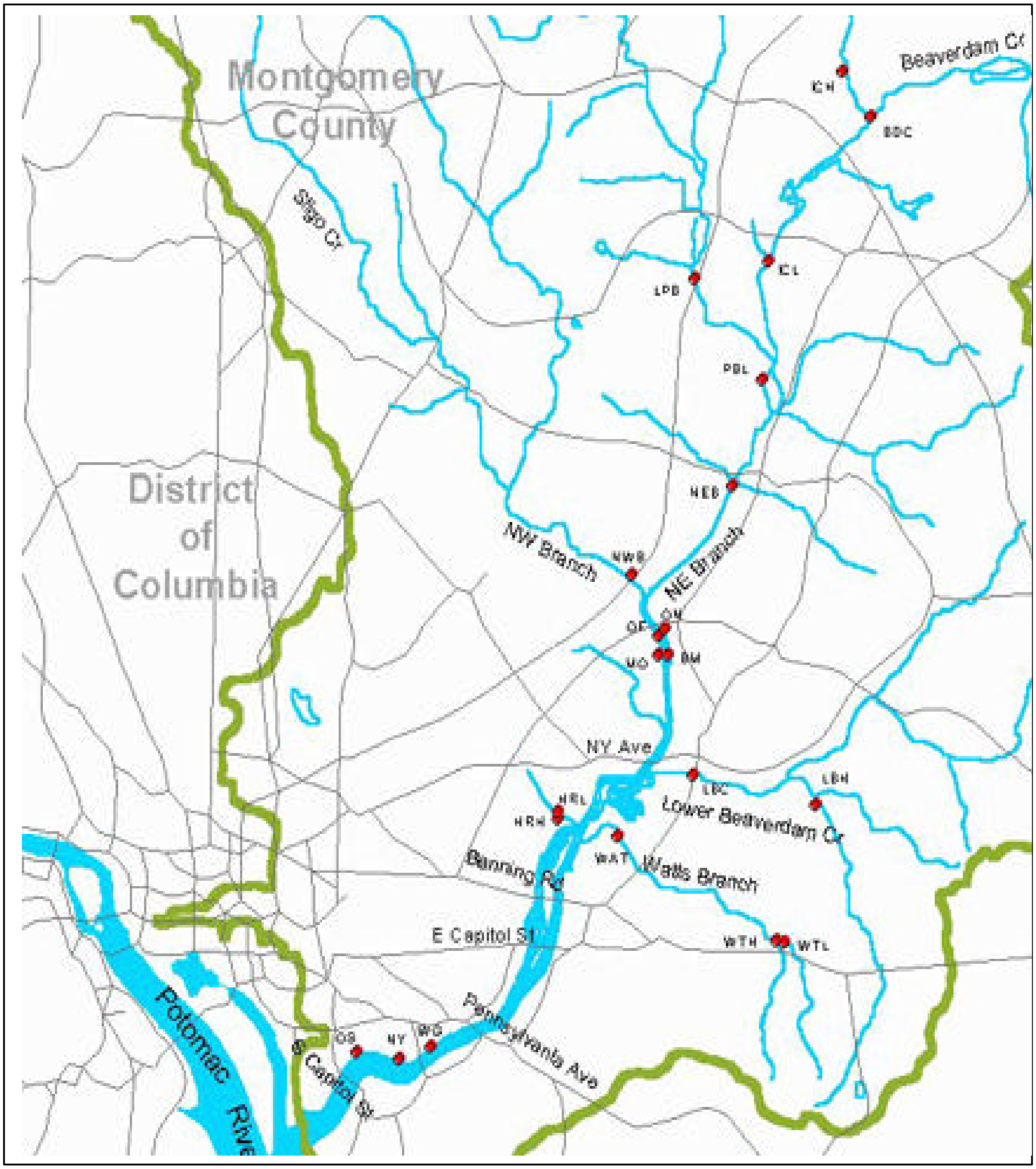



**Figure 1.** The Anacostia River watershed with some sites labeled**.**

The NorthEast Branch tributary clam total PAH and pesticide data was combined with NorthEast Branch first and second order stream data from earlier studies (Phelps 2004) (Fig. 2).

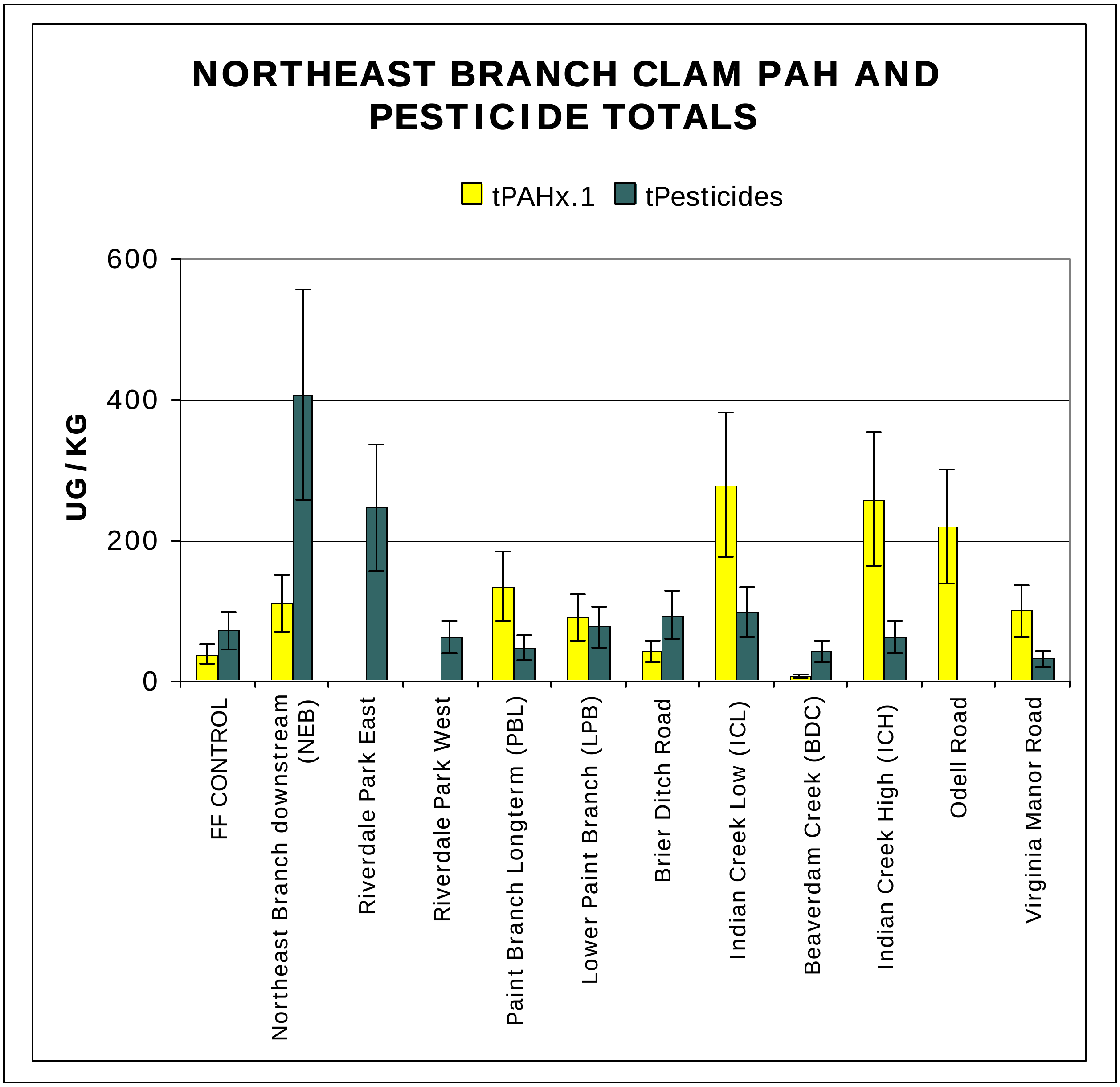



**Figure 2.** NorthEast Branch clam tissue concentrations of total polycyclic hydrocarbons (tPAHx .1) and total pesticides (tPest) at the NorthEast Branch downstream site just above head of tide and at second order stream sites proceeding upstream (Phelps 2004). Error bars show 95% analytical confidence limits. All sites were in Maryland.

The Lower Beaverdam Creek tributary total PCBs and total Aroclors data was combined with earlier data from Lower Beaverdam Creek tributary study sites (Phelps 2003, Phelps 2004) (Fig. 3).

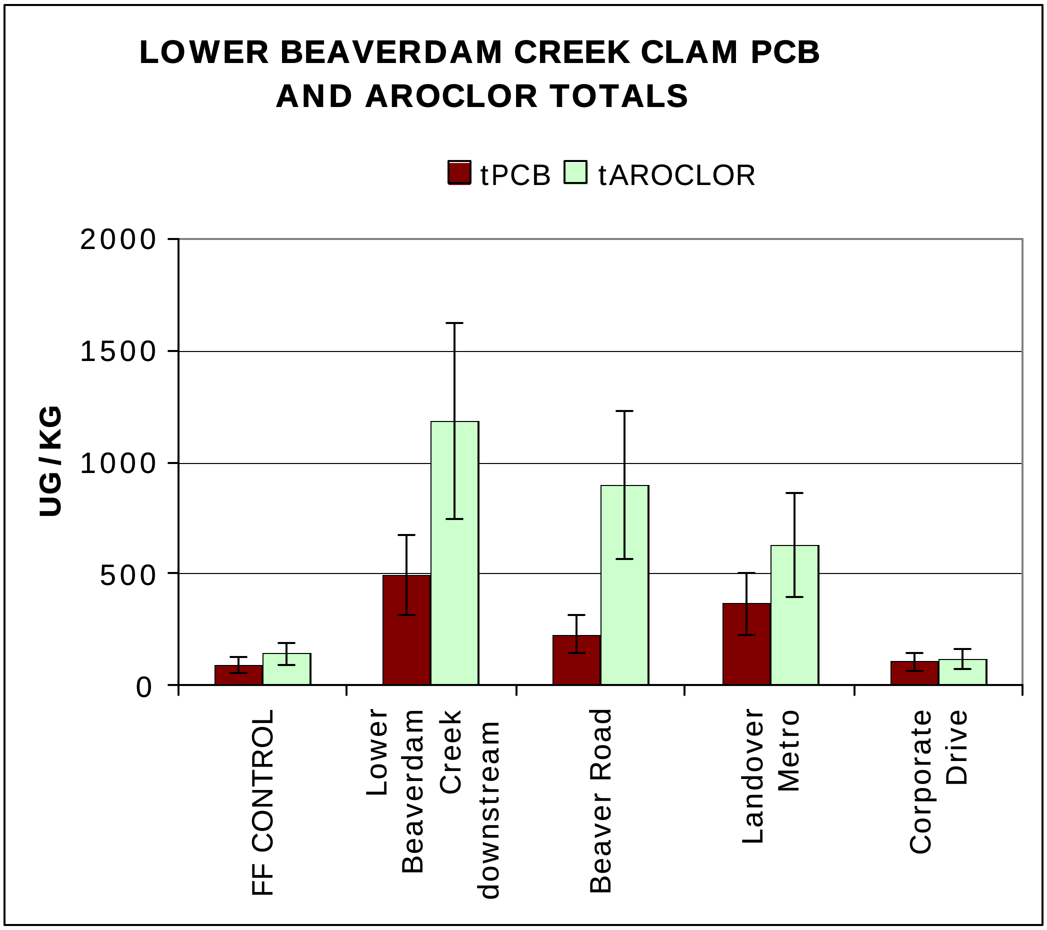



**Figure 3.** Lower Beaverdam Creek clam concentrations of total polychlorinated biphenyls (tPCB) and total Aroclors (tAROCLOR) at sites from just above the head of tide and proceeding upstream. Error bars show 95% analytical confidence limits. The Lower Beaverdam Creek downstream site was in DC and the remaining upstream sites in MD.

To focus on the sources of contaminants they will be considered in connection with data from previous studies.

**METALS:** No clam tissue metal concentrations were significantly greater than the FF control (Table 2). Total metals at Fort Foote were higher than the FFcontrol due to iron, but not significantly greater than average. Metal contamination is not considered a problem in the Anacostia River.

**PAHs:** At all sites the clam tissue total PAH concentrations were significantly increased over the FF control, except at Corporate Drive on Lower Beaverdam Creek (Table 2, Fig 2). High PAHs were also found in 20 of 24 previously studies on Anacostia watershed sites (Phelps 2004). The NorthEast Branch contributes about 45% of Anacostia watershed input with its clams having some of the highest pesticide and PAHs totals (Warner et al 1997, Phelps 2003, Phelps 2004). The present study suggested that clams with the highest accumulations of PAHs were on the NorthEast Branch below industrial parks.

**PCBs:** Total PCBs in clam tissue significantly exceeded FFcontrol at all sites except at Corporate Drive (Table 2, Fig. 3). Total PCBs accumulated by the clams placed at all Lower Beaverdam Creek sites but Corporate Drive exceeded the FDA food action level of 200 µg/Kg. The Landover Metro site is just below and the Corporate Drive site is just above the Landover Metro Station/ Ardwick-Ardmore Industrial Center / New Carrolton/Amtrak Metro area. Future investigations on the watershed sources of PCBs to the Anacostia River should start in this section of Lower Beaverdam Creek. The Corporate Drive site probably represents the highest uncontaminated reach of Lower Beaverdam Creek. Although Lower Beaverdam Creek is only 12% of Anacostia watershed input its watershed has the highest concentration of industrial parks in Prince George’s County (Warner et al 1997).

**AROCLORS:** Aroclors are not measured but are estimated as PCB congenor mixtures that have been developed for specific industrial uses. Total clam Aroclors in this 2004 study significantly exceeded FFcontrol only at the Landover Metro Station site on Lower Beaverdam Creek and included Aroclor 1242 (220 µg/kg) and Aroclor 1254 (110 µg/kg). Overall, total Aroclors in clams dropped significantly going upstream in Lower Beaverdam Creek. Like total PCBs, total Aroclors were at control concentrations in the upstream Corporate Drive site clams.

**PESTICIDES:** Total pesticides in clam tissues significantly exceeded FFcontrol at Fort Foote (discussed below) and at Riverdale East Branch, a small second order stream near the mouth of the NorthEast Branch (Table 2, Fig, 2). Data from previous studies found clams at six other second-order streams of the NorthEast Branch did not have significantly increased total pesticides (Phelps 2004, Fig. 2). The small Riverdale East Branch appears a major pesticide source although it is near no identified industrial park area.

**TOTAL CHLORDANE:** In this 2004 study the total clam chlordane (alpha plus beta) significantly exceeded Fort Foote clams only at the NorthEast Branch second order Riverdale East Branch site (Fig 2). The high clam pesticide at the downstream Northeast Branch site, just below the Riverdale East Branch stream, was 88% chlordane (Phelps 2004). Chlordane is responsible for the fishing advisory and has been associated only with clams placed at the NorthEast Branch and Watts Branch (Phelps 2003). However, follow up studies have not confirmed chlordane accumulation in Watts Branch clams (Phelps 2004).

Fort Foote on the tidal freshwater Potomac River estuary five km below Washington, DC has been the source of *Corbicula* clams for the Anacostia biomonitoring studies. It is considered a good nearby reference area because this part of the Potomac is a major Chesapeake Bay restoration success with the return of submerged aquatic vegetation, benthic populations including clams and development as a top largemouth bass fishing area (Phelps 1994, Orth et al 1996). At least part of the success has been attributed to the water-clearing action of the big Asiatic clam population, which does not survive in the contaminated Anacostia River (Cohen et al 1984, Phelps 1985, Phelps 1993). In the present study the Fort Foote clams had abnormally high total pesticides, of which 65% (110 µg/kg) was endosulfan I. Endosulfan, a toxic pesticide used on crops and other plants, is normally not found in Fort Foote clams (Phelps, unpublished data). The EPA standard for endosulfan in freshwater is 100 µg/l and the Fort Foote clams may have detected a serious endosulfan spill in the Potomac in May. It is interesting to note that those same clams had no detectable Endosulfan I following their two-week deployment at Anacostia watershed sites.

Such apparently isolated incidences of high clam pollutant bioaccumulation, like napthalene in lower Watts Branch clams in 2002 (Phelps 2003), suggest *Corbicula* biomonitoring may be able to detect contaminant spills. Active clam biomonitoring can also indicate long-term freshwater contamination, similar to the International Mussel Watch for salt water (Sericano 2000, Phelps 2002). Much of the water and sediment chemical pollution presently being measured in the Anacostia is not known to be bioavailable (Sunda and Guillard 1976, Tatem 1976, Harrison 1984, AWTA 2002).More clam biomonitoring studies need to be made and followed up in the Anacostia River estuary, which has an excellent watershed to test this protocol for locating the sources of bioavailable pollutants. Active clam biomonitoring using local *Corbicula* also could be used to verify the effectiveness of remediation efforts.

## LITERATURE CITED


AWTA 2002. Anacostia Watershed Toxics Alliance. Charting a Course Toward Restoration: A Contaminated Sediment Management Plan.

Ahlborg, U., G. Becking, L. Birnbaum, A. Brower, H. Derks, M. Feeley, G. Golor, A. Hanberg, J. Larsen, A. Liem, S. Safe, C. Schlatter, F. Waern, M. Younes and E. Yrjanheikki. 1994. Toxicity equivalency factors for dioxin-like PCBs. *Chemosphere* 28(6): 1049-1067.

Cohen, R.R.H., P.V. Dresler, E.J.P. Phillips and R.L. Cory. 1984. The effect of the Asiatic clam, *Corbicula fluminea*, on the phytoplankton of the Potomac River, Maryland. Limn. and Ocean. 29:170-180.

Colombo, J.C., C. Bilos, M. Campanaro, M.J. Rodriguez-Presa and J.A. Catoggio. 1995. Bioaccumulation of polychlorinated biphenyls and chlorinated pesticides by the Asiatic Clam *Corbicula fluminea*: Its use as a sentinel organism in the Rio de La Plata Estuary, Argentina. Env. Sci. and Tech. 29(4):914-927.

Crawford JK and SN Luoma. 1993. Guidelines for studies of contaminants in biological tissues for the National Water Quality Assessment Program. U.S. Geological Survey Open-File Report 92-494.

Cummins JD, JB Stribling and PD Thaler. 1991.1990 MD Anacostia River Basin Study, Part 1. Habitat, Macrobenthic Invertebrate Communities, and Water Quality Assessment. Interstate Commission on the Potomac River Basin Report #91-02. Rockville, MD.

DeKock WC and KJM Kramer. 1994. Active biomonitoring (ABM) by translocation of bivalve molluscs. In: Kramer, KJM (ed.) Biomonitoring of Coastal Waters and Estuaries. CRC Press, Boca Raton, FL.

Dougherty F.S. and DS Cherry. 1988. Tolerance of the Asiatic clam *Corbicula* sp. to lethal levels of toxic stressors - A review. Environ Poll 51:269-313

Freudberg S, Schueler T, Herson L.M. 1989. The state of the Anacostia: 1988 status report. Metropolitan Washington Council of Governments, Washington, DC.

Harrison, G. 1984. A survey of the trace-metal content of *Corbicula fluminea* and associated sediments in the tidal Potomac River. U.S. Geological Survey Open-File Report 84-558.

Orth, RJ, JF Nowak, GF Anderson, DJ Wilcox, JR Whiting and LS Nagey. 1996. Distribution of Submerged Aquatic Vegetation in the Chesapeake Bay and Tributaries and Chincoteague Bay - 1995. USEPA Chesapeake Bay Program Office, Annapolis, MD.

Phelps, H.L.1985. Summer 1984 Survey of Mollusc Populations of the Potomac and Anacostia Rivers near Washington, D.C. D.C. Environmental Services. 67p.

Phelps, H.L. 1993. Sediment toxicity of the Anacostia River estuary Washington, DC. Bull. Environ. Contam. Toxicol. 51:582-587.

Phelps, H.L. 1994. The Asiatic clam (*Corbicula fluminea)* invasion and system-level ecological change in the Potomac River estuary near Washington, DC. Estuaries 17(3):614-621.

Phelps, H.L. 1995. Studies on sediment toxicity in the Anacostia estuary and DC's Kenilworth Marsh. p.183-187. In: Hill and Nelson, eds. Towards a Sustainable Coastal Watershed: The Chesapeake Experiment. 1994 Chesapeake Research Conference. Chesapeake Research Consortium, Inc. Edgewater, MD. 723 p.

Phelps, H.L. 2000. DC's Contaminated Anacostia Estuary Sediments: Bioaccumulation by Asiatic Clams. DC Water Resources Research Center, Washington, DC.

Phelps, HL. 2002. Sources of Bioavailable Toxic Pollutants in the Anacostia. DC Water Resources Research Center, Washington, DC, 13pp

Phelps, HL. 2003. *Corbicula* Biomonitoring in the Anacostia Watershed. Report, DC Water Resources Research Center, Washington, DC. 18p

Phelps, HL. 2004. Sources of Bioavailable Toxic Pollutants in the Anacostia (Part III). DC Water Resources Research Center, Washington, DC, 12pp

Pinkney AE, JC Harshbarger, EB May and MJ Melancon. 2000. Tumor revalence and biomarkers of exposure in Brown Bullheads *(Ameiurus nebulosus*) from the tidal Potomac River watershed. Environ Tox and Chem 20:1196-1205.

Safe S. 1994. Polychlorinated biphenyls (PCBs): Environmental impact: biochemical and toxic responses, and implications for risk assessment. Crit Rev Toxicol 24(2):87-149.

Sericano J. 2000. Mussel watch approach and its applicability to global chemical contamination monitoring programmes. Int J Environ Pollut 13(1):340-350.

Sunda, W. And R.R.L. Guillard. 1976. The relationship between cupric ion activity and the toxicity of copper to phytoplankton. J. Mar. Res. 34:511-529.

Tatem, H.E. 1986. Bioaccumulation of polychlorinated biphenyls and metals from contaminated sediment by freshwater prawns, *Macrobrachium rosenbergii* and clams, *Corbicula fluminea. Arch. Environ Contam. Toxicol.* 15S; 171-183.

Velinsky, DJ, CH Haywood, TL Wade and E Reinharz. 1992. Sediment contamination studies of the Potomac and Anacostia Rivers around the District of Columbia. ICPRB Report #92-2. ICPRB, Rockville, MD.

Velinsky, DJ and JC Cummins. 1994. Distribution of chemical contaminants in wild fish species in the Washington DC area. ICPRB Report #94-1. ICPRB, Rockville, MD

Velinsky, DF and JTF Ashley. 2001. Deposition and Spatial Distribution of Sediment-bound Contaminants in the Anacostia River, District of Columbia: Phase II. Report No. 01-30. Final Report Submitted to the District of Columbia. Patrick Center for Environmental Research, The Academy of Natural Sciences, Philadelphia, PA.

Wade, T.L., D.J. Velinsky, E. Reinharz and C.E. Schlekat. 1994. Tidal river sediments in the Washington, D.C. Area. II. Distribution and sources of organic contaminants. Estuaries 17:304-320.

Warner A, DL. Shepp, K. Corish and J. Galli. 1997. An Existing Source Assessment of Pollutants to the Anacostia Watershed. DCRA, Washington, DC.

Washington Post. 2004. Anacostia River's Dirty Little Secret: Major Water Pollution Begins in Md, Not D.C. 1/29/04.

**Students involved with this project were Moina Cook, Danell Sorimade, Dana Buchanan and Earl Greenidge of the Department of Biological and Environmental Sciences of the University of the District of Columbia .**

# Assessment of Soil Erosion at Hillcrest Park Facility and Its Potential Effects on the Quality of DC Water Resources

## Basic Information

| | |
|---|---|
| **Title:** | Assessment of Soil Erosion at Hillcrest Park Facility and Its Potential Effects on the Quality of DC Water Resources |
| **Project Number:** | 2003DC32B |
| **Start Date:** | 3/1/2003 |
| **End Date:** | 2/28/2004 |
| **Funding Source:** | 104B |
| **Congressional District:** | District of Columbia |
| **Research Category:** | None |
| **Focus Category:** | Sediments, Solute Transport, Water Quality |
| **Descriptors:** | None |
| **Principal Investigators:** | Inder J. Bhambri, Ahmet Zeytinci, Philip L. Brach |

## Publication

# Assessment of Soil Erosion at a DC Park Facility
# Spring Valley Park
# NW Washington, DC

## Annual Progress Report for FY 2004


**Prepared by:** **Principal Investigators:**
Inder Bhambri, Ph.D., PE
Philip Brach, Ph.D., PE, FNSPE
Ahmet Zeytinci, Ph.D., PE

**Student Interns:**
Aristides A. Moreno
Ferebory Kourouma
Koji Harada

**Department of Engineering, Architecture and Aerospace Technology**
**University of the District of Columbia**


**Date:** May 2005


**Prepared for the DC Water Resources Research Institute**
**Funded by USGS through the US Department of Interior**

# Table of Contents

## INTRODUCTION

The purpose of this project is to provide a preliminary site inventory and assessment of soil erosion for the Spring Valley Park. This park was one of nine (9) identified by the USDA Natural Resources Conservation Service through the Watershed Protection Division of the DC Department of Health as having severe gully or stream erosion. Due to its location relative to the University and small size it was determined to be an ideal park for the pilot assessment study.

Failure to control erosion caused by the runoff of rain water can lead to environmental problems, both natural and man-made. Awareness of such problems is the beginning of environmental education. But, learning must go beyond awareness. Knowledge of the causes and solutions of problems is an important part of environmental studies. After studying the faults at Spring Valley Park we recommend to take direct action for the repair and protection of the park since the erosion is leaving the roots of the trees hanging on the edges of gullies and causing them to fall into the ravine.

We have found that erosion is a major cause of the deterioration of the quality of the park. “Erosion”, a venerable and time-worn subject, in the history of conservation is still a major ecologic force in the world. Whereas there has been improved control of soil erosion from agricultural lands, in urban areas this has not been the case. Increasing erosion from newly graded land and excavations related to road construction and urban development has compounded the problem in urban areas. All of these changes reduce the capacity of watersheds to absorb heavy rainfall, and they increase the dangers of severe floods.

Studies in the 1950’s indicated that there is more than 300 tons of erosion per square mile per year in the United States, not including wind erosion.

Some erosion is unavoidable, of course, and should be considered part of the natural geologic process. There is no doubt, however, that man's activities, particularly in urban areas have tremendously accelerated erosion.

Spring Valley Park, is getting deeper with time, its gully carries and transports the soil directly to the Potomac River. This not only contributes to the cause of floods but also damages the fauna of the river. Spring Valley Park is an excellent case study that will lead to a "protocol" for the analysis and remediation of erosion in all other parks in the District of Columbia.

**OBJECTIVE**

The objective of this study was to select a single park in Washington, DC and to identify within that park the location of eroded areas, the causes of the soil erosion, and to recommend potential remedial measures to control soil erosion in the park. A single park was selected to serve as model for the investigation of all parks in the District of Columbia for the remediation of soil erosion.

The Spring Valley Park, located at in the 4900 block of Fordham St. NW, was selected for the initial study for the following reasons:

- The proximity of the park to the University.
- The relatively small size of the park.
- The relatively serious nature of the current state of erosion.

These reasons made the park "best" suited for a pilot project that would be accomplished by students and faculty from the University and the resources available.

## METHODOLOGY

**Site investigation:** The park site is visited to establish the general location of the park, the most obvious problem areas and to identify any unique characteristic of the park.

**Data collection:** The boundary and topography of the park are established. Either from existing maps and/or by making a new survey.

**Identification of problem areas:** A carefully visual survey is made of all areas of the park which show evidence of erosion and are indicated on the site plan/ topographic map for further analysis.

**Determination of causes:** Through consideration of a cursory hydrological analysis the most likely cause of the erosion at each site is documented

**Remediation:** Potential means of ameliorating the erosion at each site is presented

## SITE INVESTIGATION

A topographic map of the site is necessary. In that there was not a workable map available, the project team made the initial reconnaissance for the field survey for a topographic map of the park. This enabled the team to determine the position of abutting roads, the creek bed, and the characteristics of the terrain. In addition the areas of erosion that were denied to require remediation were identified and photographed.

## DATA COLLECTION

The field team completed a field survey to draw a topographic map of the park and to locate the boundary of the park relative to the abutting properties.

All the data obtained from the field measurements are listed on an excel spreadsheet in Appendix-A A site plan was prepared using Auto CAD 2005 software

The most common way of indicating relief on a map is using contours. The contour interval selection depends on the diversity of relief in the area being mapped as well as the purpose and scale of the map. For this project it was determined that the contour interval should be 1 foot.

## IDENTIFICATION OF PROBLEM AREAS

Four primary locations were found to have serious erosion and in need of remediation. These are identified as ERN areas (Erosion Remediation Necessary) and are shown on the site plan. Two areas in need of corrective action, but not erosion related were also identified. The overall quality of the park will be improved if both the erosion and ancillary problems are addressed.

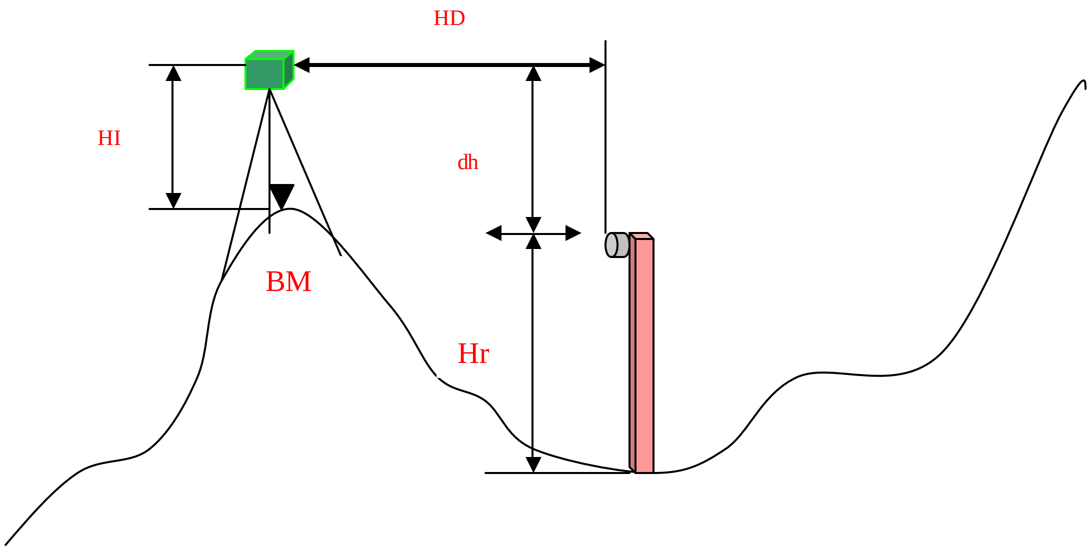
## DETERMINATION OF CAUSES

(Still being prepared)

## REMEDIATION

(Still being prepared)

## Calculations




**HI:** **Instrument height above the ground**

**BM:** **Ground height at the station**

**HD:** **Indicated meteorological corrected horizontal distance**

**Hr:** **Reflector height above ground**

**Dh:** **Height difference between station and target point**

**Using the Listed Data:**

**Data: October 11, 2004**

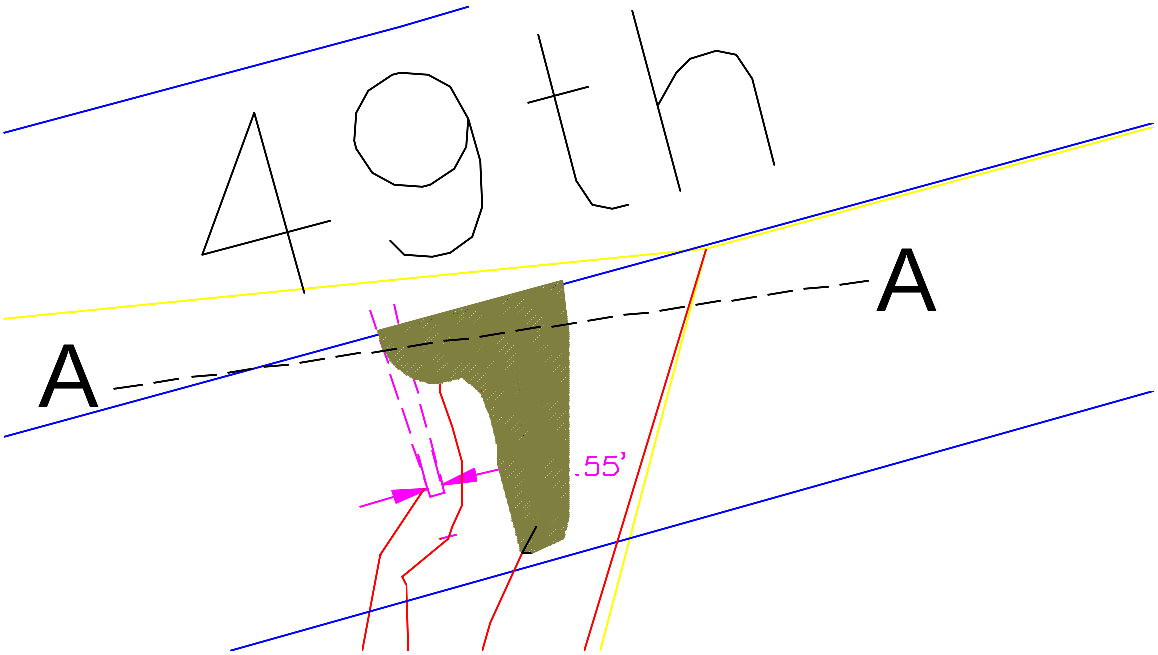
**Time: 12:00(PM)-3:00(PM)**

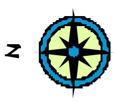
**Measurement of creek at 13$^{th}$ row**

**Creek Elevation=99.27 BM+HI-(dh+Hr)=108.52+4.84-(6.12+7.97)=99.27**

**Results**

**Erosion Remediation Necessary Area 1**
**Location: S. E**
**ERN-AREA #1**

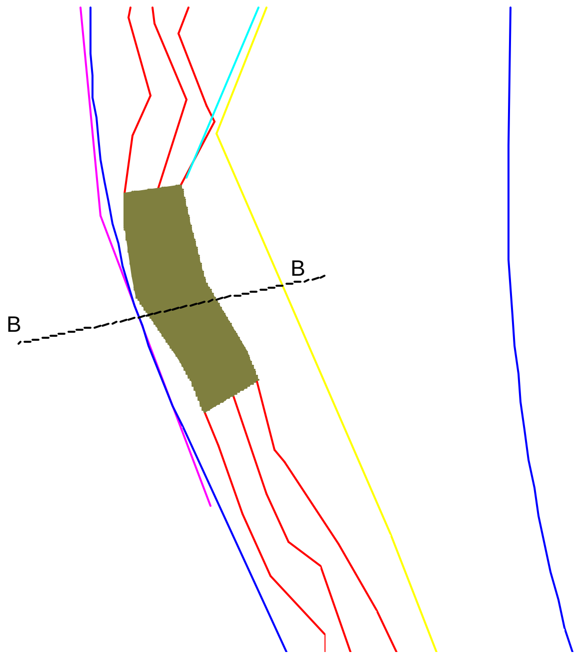


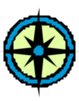



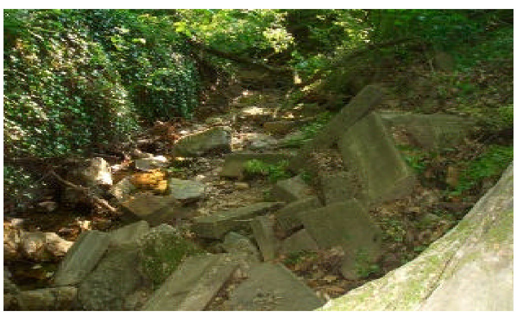

**Picture is taken from the West**

**Picture is taken from the East**

**Erosion Remediation Necessary Area 2**
**Location: N-E**
**ERN-AREA #2**

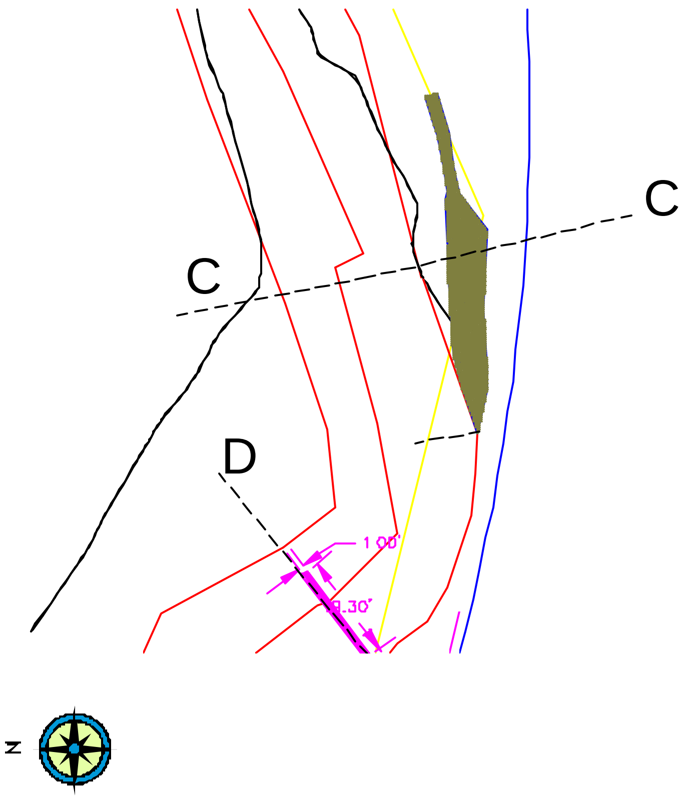



N 

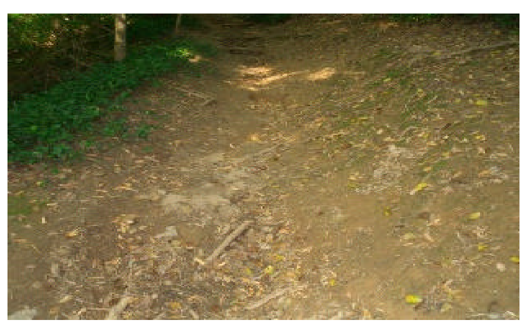


**Picture is taken from the East** **Picture is taken from the East**

**Location: S. W**
**Erosion Remediation Necessary Area 3**
**ERN-AREA #3**

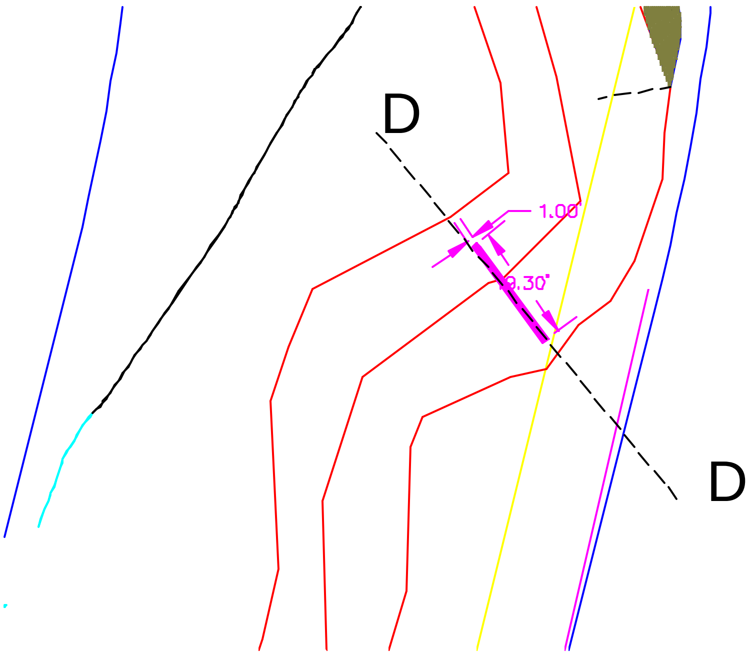


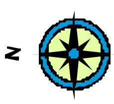

**Picture is taken from the West**



**Picture is taken from the West**

**Location: S. W**
**Erosion Remediation Necessary Area 4**
**AREA #4**

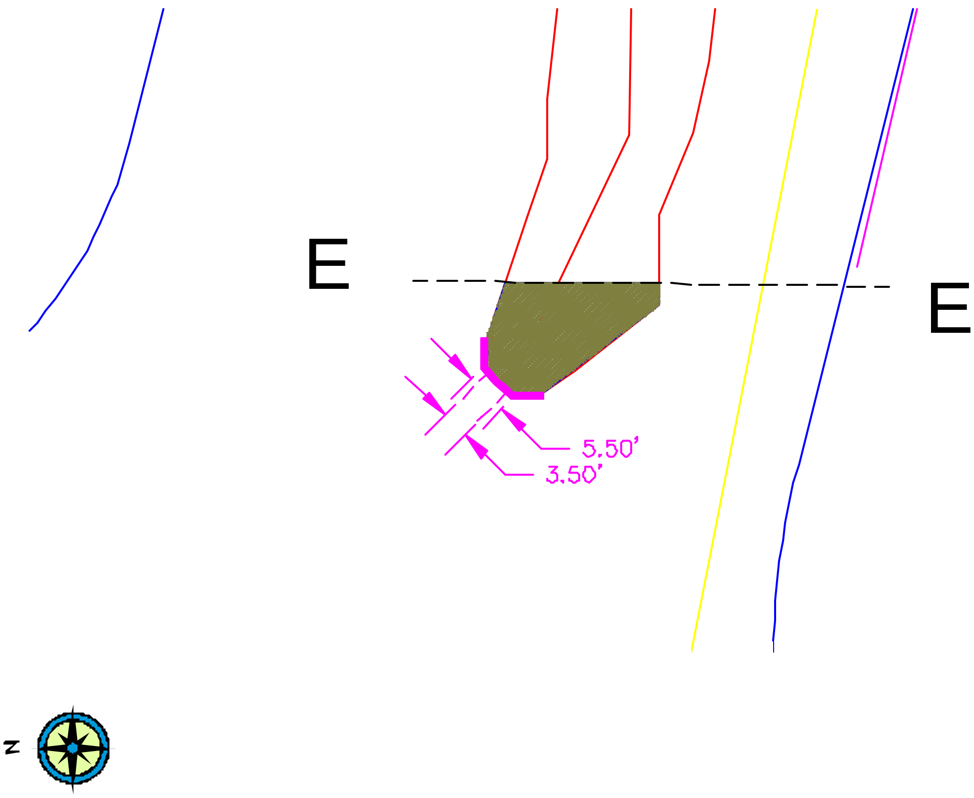



**Picture is taken from the North West**

**Picture is taken from the West**

**Erosion Remediation Necessary Area 5**
**Location: W**
**AREA #5**




**Picture is taken from the West**

**Picture is taken from the East**

## Conclusions

ERN: “Erosion Remediation Necessary”
**ERN AREA (1)**

A drop inlet should be built on the west curb of the sheet at the lowest point w/ the pipe draining to the same location as the pipe draining the east side of the area. (See drawing)

**ERN AREA (2)**

Provide cribbing 100’ as an interim solution to mitigate erosion on the abutting property, a wall of cribbing 100’ long plus 10’ high. Would this be inadequate? An RW will have to be built.

**ERN AREA (3)**

Grade the existing ground to a small open channel 2-3’ w/ surface treatment sufficient treatment with gravel must be used.

**AREA (4) DAM**

There is an existing dam silted up; the silt needs to be clean up and clear away the debris

ANCILLIARY

(1) Rebuild the bridge w/ handrail 4’ wide
(2) w/ a single hand rail
(3) Dam for crossing

**NOT EROSION RELATED**

Park’s service should consider erecting demarcation of park properties, for example “putting a sign”.

**APPENDIX A**

## Data

### Management of Control Line

| At No.2 | Angle | Distance (ft) | Elevation (ft) |
|---|---|---|---|
| No.1 | 0 | 199.91 | 100 |
| No.3 | 182.4352 | 143.84 | 119.82 |

| At No.3 | Angle | Distance (ft) | Elevation (ft) |
|---|---|---|---|
| No.2 | 0 | 143.84 | 108.52 |
| No.4 | 142.3121 | 106.85 | 124.3 |

| At No.4 | Angle | Distance (ft) | Elevation (ft) |
|---|---|---|---|
| No.3 | 0 | 106.85 | 119.82 |
| No.5 | 178.4922 | 128.43 | 126.84 |

| At No.5 | Angle | Distance (ft) | Elevation (ft) |
|---|---|---|---|
| No.4 | 0 | 128.46 | 124.3 |
| No.6 | 183.4545 | 157.65 | 137.97 |

| At No.6 | Angle | Distance (ft) | Elevation (ft) |
|---|---|---|---|
| No.5 | 0 | 157.65 | 126.84 |
| No.7 | 177.3434 | 182.75 | 147.58 |

| At No.7 | Angle | Distance (ft) | Elevation (ft) |
|---|---|---|---|
| No.6 | 0 | 182.74 | 139.97 |
| No.8 | 224.5806 | 137.72 | 155.55 |

| At No.8 | Angle | Distance (ft) | Elevation (ft) |
|---|---|---|---|
| No.7 | 0 | 137.72 | 147.58 |
| No.9 | 173.2417 | 123.03 | 162.5 |

| At No.9 | Angle | Distance (ft) | Elevation (ft) |
|---|---|---|---|
| No.8 | 0 | 123.03 | 155.55 |
| No.10 | 69.2755 | 305.57 | 177.53 |
| No.11 | 239.5422 | 311.56 | 176.89 |

**Management of Points**

| Point Range | Point Number | Description | Note |
|---|---|---|---|
| 1~11 | 11 | Control Line | |
| 12~65 | 54 | Creek Center | |
| 66~106 | 41 | Creek Right | |
| 107~147 | 41 | Creek Left | |
| 148~181 | 34 | 49 Street | |
| 182~194 | 13 | Fordham Street | |
| 196~200 | 5 | Sewer and Water | |
| 205~219 | 15 | Power Pole | |
| 222~349 | 128 | Tree | |
| 350~453 | 104 | Ground | |
| 454~479 | 26 | Fence | |
| 480~800 | 320 | Additional Point | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Elevation Measurements:**
**Location: S.E of Spring Valley Park**
**Date: October 4, 2004 / Time: 10:00(AM)-12:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| AT No.1 | | | | |
| No.2 | 0.0000 | 199.92 | 4.86 | 108.52 |
| Manhole | 190.2644 | 15.90 | 3.04 | 100.03 |
| Creek (water bed) | 184.1548 | 44.36 | -1.44 | 95.55 |
| **BM=** | **100.00** | | | |
| **Hi=** | **4.97** | | | |
| **r=** | **7.98** | | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| AT No.2 | | | | |
| No.1 | 0.0000 | 199.91 | -12.04 | 100.01 |
| Concrete | 16.5744 | 105.11 | -6.59 | 98.80 |
| Creek (water bed) | 16.1426 | 100.92 | -6.12 | 99.27 |
| Creek (water bed) | 17.0105 | 69.56 | -4.66 | 100.73 |
| Creek (water bed) | 27.3305 | 52.00 | -4.11 | 101.28 |
| Creek (water bed) | 49.5100 | 37.58 | -2.89 | 102.50 |
| Creek (water bed) | 100.2743 | 23.82 | -2.13 | 103.26 |
| Creek (water bed) | 133.4755 | 40.09 | -1.42 | 103.97 |
| Creek (water bed) | 151.2928 | 55.33 | -0.44 | 104.95 |
| Creek (water bed) | 172.2559 | 68.33 | 0.79 | 106.18 |
| Creek (water bed) | 174.0920 | 69.19 | 3.36 | 108.75 |
| Creek (water bed) | 181.5717 | 83.58 | 2.75 | 108.14 |
| Creek (water bed) | 177.1931 | 102.65 | 3.49 | 108.88 |
| Creek (water bed) | 172.1255 | 130.23 | 4.51 | 109.90 |
| **BM=** | **108.52** | | | |
| **Hi=** | **4.84** | | | |
| **r=** | **7.97** | | | |

## Elevation Measurements:

**Location: N.E of Spring Valley Park**
**Date: October 7, 2004 / Time: 10:00(AM)-12:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| AT No.3 | Angle | Distance(ft) | dh(ft) | |
| No.2 | 0.0000 | 143.83 | -14.86 | 108.55 |
| Creek (water bed) | 58.1600 | 23.13 | -6.7 | 110.05 |
| Creek (water bed) | 111.4830 | 44.97 | -5.5 | 111.25 |
| **BM=** | **119.82** | | | |
| **Hi=** | **4.90** | | | |
| **R=** | **7.97** | | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| At No.4 | | | | |
| No.3 | 0.0000 | 106.85 | -8.28 | 119.83 |
| Creek (water bed) | 33.0059 | 46.92 | -8.97 | 112.48 |
| Creek (water bed) | 66.3748 | 25.17 | -7.91 | 113.54 |
| Creek (water bed) | 155.4119 | 34.44 | -5.97 | 115.48 |
| Creek (water bed) | 163.3711 | 58.68 | -5.21 | 116.24 |
| Creek (water bed) | 162.5937 | 84.38 | -4.76 | 116.69 |
| **BM=** | **124.30** | | | |
| **Hi=** | **5.12** | | | |
| **r=** | **7.97** | | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| At no.5 | | | | |
| No.4 | 0.0000 | 128.46 | -5.75 | 124.33 |
| Creek (water bed) | 30.3357 | 45.92 | -6.17 | 117.25 |
| Creek (water bed) | 25.2447 | 35.20 | -4.53 | 118.89 |
| Creek (water bed) | 62.0655 | 17.16 | -4.06 | 119.36 |
| Creek (water bed) | 126.3659 | 24.82 | -3.56 | 119.86 |
| Creek (water bed) | 157.2453 | 46.10 | -2.62 | 120.80 |
| Creek (water bed) | 161.1741 | 71.06 | -3.89 | 119.53 |
| Creek (water bed) | 165.1657 | 92.78 | -0.71 | 122.71 |
| Creek (water bed) | 165.3916 | 109.12 | 0.21 | 123.63 |
| **BM=** | **126.84** | | | |
| **Hi=** | **4.55** | | | |
| **r=** | **7.97** | | | |

**Elevation Measurements:**

**Location: N.E of Spring Valley Park**
**Date: October 11, 2004 / Time: 10:00(AM)-12:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| At no.6 | | | | |
| No.5 | 0.0000 | 157.65 | -16.77 | 126.87 |
| Creek (water bed) | 86.4000 | 32.78 | -11.67 | 125.31 |
| Creek (water bed) | 106.5653 | 42.61 | -11.03 | 125.95 |
| Creek (water bed) | 129.1903 | 54.56 | -9.57 | 127.41 |
| **BM=** | **139.97** | | | |
| **Hi=** | **4.98** | | | |
| **r=** | **7.97** | | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| At No.7 | | | | |
| No.6 | 0.0000 | 182.74 | -11.16 | 139.99 |
| Creek (water bed) | 18.0030 | 90.78 | -11.43 | 133.06 |
| Creek (water bed) | 21.5317 | 98.89 | -12.49 | 132.00 |
| Creek (water bed) | 28.1225 | 90.05 | -11.53 | 132.96 |
| Creek (water bed) | 38.2614 | 67.64 | -9.99 | 134.50 |
| Creek (water bed) | 47.5731 | 48.52 | -8.32 | 136.17 |
| Creek (water bed) | 69.1724 | 35.78 | -7.04 | 137.45 |
| Creek (water bed) | 161.0052 | 19.66 | -2.91 | 141.58 |
| Creek (water bed) | 173.4921 | 52.87 | -1.39 | 143.10 |
| Creek (water bed) | 180.3230 | 72.10 | 0.65 | 145.14 |
| **BM=** | **147.58** | | | |
| **Hi=** | **4.88** | | | |
| **r=** | **7.97** | | | |
| | | | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| AT No.8 | | | | |
| No7 | 0.0000 | | | |
| Creek (water bed) | 34.4719 | 77.33 | -6.3 | 146.09 |
| Creek (water bed) | 49.2515 | 45.83 | -5.09 | 147.30 |
| Creek (water bed) | 73.4139 | 27.73 | -3.73 | 148.66 |
| Creek (water bed) | 123.2459 | 32.48 | -1.95 | 150.44 |
| Creek (water bed) | 147.3851 | 44.05 | -2.05 | 150.34 |
| Creek (water bed) | 151.4839 | 53.35 | -1.29 | 151.10 |

| | | | | |
|---|---|---|---|---|
| **BM=** | **155.55** | | | |
| **Hi=** | **4.81** | | | |
| **r=** | **7.97** | | | |
| AT No.9 | | | | |
| **Station** | **Angle** | **Distance(ft)** | **dh(ft)** | |
| No8 | 0.0000 | 123.02 | -10.38 | 155.57 |
| Creek (water bed) | 15.1233 | 63.62 | -7.35 | 151.94 |
| Creek (water bed) | 18.3102 | 55.85 | -6.45 | 152.84 |
| Creek (water bed) | 26.5444 | 46.34 | -5.56 | 153.73 |
| Creek (water bed) | 28.0337 | 46.08 | -4.69 | 154.60 |
| Pipe lowest point) | 26.5024 | 39.91 | -4.14 | 155.15 |
| Creek (water bed) | 43.2931 | 33.90 | -2.19 | 157.10 |
| End of creek | 53.3634 | 31.56 | 1.87 | 161.16 |
| Road edge | 61.2145 | 30.29 | 2.36 | 161.65 |
| Road edge | 62.4622 | 310.44 | 18.11 | 177.40 |
| Road edge | 62.2854 | 293.17 | 16.72 | 176.01 |
| Road edge | 62.1059 | 279.37 | 15.86 | 175.15 |
| Road edge | 61.5545 | 266.70 | 15.05 | 174.34 |
| Road edge | 61.4338 | 253.97 | 14.12 | 173.41 |
| Road edge | 61.3033 | 240.09 | 13.03 | 172.32 |
| Road edge | 61.1700 | 225.95 | 11.85 | 171.14 |
| Road edge | 61.0212 | 211.52 | 10.77 | 170.06 |
| Road edge | 60.4905 | 196.79 | 9.52 | 168.81 |
| Road edge | 60.3912 | 181.68 | 8.47 | 167.76 |
| Road edge | 60.3149 | 166.26 | 7.25 | 166.54 |
| Road edge | 60.1432 | 147.40 | 5.99 | 165.28 |
| Road edge | 60.0251 | 134.58 | 5.28 | 164.57 |
| Road edge | 59.5831 | 120.27 | 4.51 | 163.80 |
| Road edge | 239.1203 | 35.52 | 3.25 | 162.54 |
| Road edge | 239.2117 | 49.33 | 3.73 | 163.02 |
| Road edge | 239.3251 | 131.00 | 8.33 | 167.62 |
| Road edge | 239.3943 | 184.94 | 12.1 | 171.39 |
| Road edge | 239.4546 | 311.81 | 17.08 | 176.37 |
| Road edge(L) | 234.1358 | 310.05 | 17 | 176.29 |
| Road edge(L) | 233.3150 | 279.10 | 16.21 | 175.50 |
| Road edge(L) | 232.3234 | 243.71 | 14.74 | 174.03 |
| Road edge(L) | 225.3430 | 124.87 | 7.86 | 167.15 |
| Road edge(L) | 217.1133 | 83.39 | 5.16 | 164.45 |
| Storm | 110.5857 | 38.98 | 2.33 | 161.62 |

| | | | | |
|---|---|---|---|---|
| Storm | 95.4845 | 51.88 | 2.33 | 161.62 |
| Road edge(L) | 74.1051 | 123.84 | 4.66 | 163.95 |
| Road edge(L) | 71.3947 | 151.37 | 6.29 | 165.58 |
| Road edge(L) | 69.5536 | 186.12 | 8.68 | 167.97 |
| Road edge(L) | 68.5837 | 222.85 | 11.61 | 170.90 |
| Road edge(L) | 68.2548 | 265.84 | 15.13 | 174.42 |
| Road edge(L) | 68.2255 | 306.56 | 17.45 | 176.74 |
| Road edge(L) | 68.2749 | 321.62 | 18.01 | 177.30 |
| **BM=** | **162.50** | | | |
| **Hi=** | **4.76** | | | |
| **r=** | **7.97** | | | |

## Elevation Measurements:

**Location: N.W of Spring Valley Park**
**Date: October 25, 2004 / Time: 12:00(PM)-3:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **At No 8** | | | | **155.55** |
| **No 7** | 00.00.00 | 137.77 | -8.27 | **147.60** |
| Tree 10 in. | 29.24.24 | 75.85 | -6.20 | **149.67** |
| Tree 14 in. | 40.27.57 | 74.40 | -6.45 | **149.42** |
| Tree 30 in. | 58.59.30 | 51.80 | -3.12 | **152.75** |
| Tree 28 in. | 53.19.49 | 105.66 | -0.18 | **155.69** |
| Tree 48 in. | 73.30.59 | 37.11 | -3.32 | **152.55** |
| Tree 28 in. | 80.54.45 | 93.15 | 2.07 | **157.94** |
| Tree 18 in. | 81.48.37 | 103.39 | 3.91 | **159.78** |
| Tree 20 in. | 86.38.30 | 110.00 | 4.8 | **160.67** |
| Tree 26 in. | 113.30.23 | 84.13 | 3.67 | **159.54** |
| Tree 26 in. | 132.25.18 | 57.26 | -0.95 | **154.92** |
| Tree 24 in. | 136.06.48 | 99.08 | 7.1 | **162.97** |
| Tree 16 in. | 138.54.20 | 103.06 | 6.8 | **162.67** |
| Tree 10 in. | 156.57.15 | 17.29 | -1.93 | **153.94** |
| Tree 10 in. | 166.48.10 | 39.60 | -2.49 | **153.38** |
| **No 9** | 173.25.20 | 123.06 | 6.63 | **162.50** |
| Tree 10 in. | 160.01.24 | 87.36 | 0.25 | **156.12** |
| Tree 18 in. | 175.41.43 | 90.51 | 3.42 | **159.29** |
| Tree 24 in. | 196.48.47 | 31.92 | 0.99 | **156.86** |
| Tree 20 in. | 212.43.08 | 53.69 | 2.90 | **158.77** |
| Tree 18 in. | 220.29.45 | 65.50 | 6.53 | **162.40** |
| Tree 30 in. | 267.54.15 | 15.78 | 2.14 | **158.01** |
| Tree 30 in. | 289.37.42 | 29.49 | 5.24 | **161.11** |
| Tree 28 in. | 262.43.12 | 54.56 | 12.31 | **168.18** |
| Tree 24 in. | 340.40.05 | 43.72 | 1.68 | **157.55** |
| Tree 22 in. | 325.56.05 | 54.48 | 5.54 | **161.41** |
| Tree 22 in. | 327.46.24 | 68.70 | 6.46 | **162.33** |
| Tree 16 in. | 298.29.28 | 71.72 | 14.60 | **170.47** |
| Tree 10 in. | 309.25.38 | 95.71 | 13.40 | **169.27** |
| | HI=5.04 Ft | Hr=4.72FT | | |
| STATION | ANGLE( D M S ) | HD | dh | ELEV |
| **At No 6** | | | | **139.97** |
| **No 5** | 00.00.00 | 157.69 | -13.32 | **126.85** |

| | | | | |
|---|---|---|---|---|
| Tree 26 in. | 42.00.39 | 59.12 | -8.47 | **131.7** |
| Tree 26 in. | 45.05.59 | 74.30 | -7.45 | **132.72** |
| Tree 30 in. | 48.55.29 | 76.95 | -6.27 | **133.9** |
| Tree 24 in. | 53.30.57 | 70.82 | -6.47 | **133.7** |
| Tree 22 in. | 73.08.19 | 59.80 | -4.67 | **135.5** |
| Tree 38 in. | 91.13.02 | 57.69 | -3.61 | **136.56** |
| Tree 10 in. | 99.47.15 | 49.86 | -4.51 | **135.66** |
| Tree 10 in. | 125.07.20 | 66.02 | -2.43 | **137.74** |
| Tree 10 in. | 131.52.42 | 75.30 | 0.02 | **140.19** |
| Tree 38 in. | 170.54.33 | 204.28 | 6.11 | **146.28** |
| Tree 38 in. | 173.02.10 | 225.34 | 7.81 | **147.98** |
| **No 7** | 177.32.51 | 182.77 | 7.44 | **147.61** |
| | **HI=4.92Ft** | **Hr=4.72Ft** | | |
| **STATION** | **ANGLE( D M S )** | **HD** | **dh** | **ELEV** |
| **At No 5** | | | | **126.84** |
| **No 4** | 00.00.00 | 128.50 | -2.49 | **124.36** |
| Tree 24 in. | 21.00.19 | 123.09 | -4.33 | **122.52** |
| Tree 30 in. | 28.17.58 | 97.82 | -0.88 | **125.97** |
| Tree 36 in. | 25.24.38 | 86.75 | -1.33 | **125.52** |
| Tree 28 in. | 34.21.58 | 65.89 | 0.95 | **127.8** |
| Tree 10 in. | 14.13.38 | 85.44 | -8.91 | **117.94** |
| Tree 26 in. | 54.06.15 | 42.23 | 2.33 | **129.18** |
| Tree 16 in. | 70.41.46 | 47.06 | 4.35 | **131.2** |
| Tree 32 in. | 90.04.55 | 43.01 | 5.06 | **131.91** |
| Tree 20 in. | 95.48.41 | 26.50 | 0.57 | **127.42** |
| Tree 38 in. | 137.29.13 | 45.21 | 3.79 | **130.64** |
| **Electric Pole** | 136.55.27 | 73.60 | 6.39 | **133.24** |
| **Electric Pole** | 326.01.01 | 73.08 | 2.46 | **129.31** |
| **Electric Pole** | 232.57.24 | 52.09 | 6.45 | **133.3** |
| | **HI=4.73 Ft** | **Hr=4.72 Ft** | | |
| **STATION** | **ANGLE( D M S )** | **HD** | **dh** | **ELEV** |
| **At No 7** | | | | **147.58** |
| **No 6** | 00.00.00 | 182.77 | -7.83 | **139.99** |
| Tree 26 in. | 116.02.15 | 32.07 | -1.98 | **145.84** |
| **Electric Pole** | 171.21.30 | 110.44 | 8.23 | **156.05** |
| **Electric Pole** | 80.23.17 | 58.88 | 0.71 | **148.53** |
| **Existing Nail** | 18.06.35 | 10.90 | -0.68 | **147.14** |
| | **HI=4.96 Ft** | **Hr=4.72 Ft** | | |
| **STATION** | **ANGLE( D M S )** | **HD** | **dh** | **ELEV** |

| | | | | |
|---|---|---|---|---|
| **At No 9** | | | | **162.50** |
| **No 8** | 00.00.00 | 123.06 | -7.26 | **155.56** |
| **Corner Fence** | 270.43.03 | 56.26 | 1.36 | **164.18** |
| **Fence in wood** | 288.25.48 | 55.57 | 1.89 | **164.71** |
| **Fence in wood** | 311.36.34 | 65.55 | 1.01 | **163.83** |
| | **HI=5.04 Ft** | **Hr=4.72 Ft** | | |
| **STATION** | **ANGLE( D M S )** | **HD** | **dh** | **ELEV** |
| **At No 8** | | | | **155.55** |
| **No 9** | 00.00.00 | 123.06 | 6.51 | **162.48** |
| **Electric Pole** | 50.30.09 | 65.59 | 6.35 | **162.32** |
| | **HI=5.14 Ft** | **Hr=4.72 Ft** | | |

## Elevation Measurements:

**Location: S.E of Spring Valley Park**
**Date: December 1, 2004 / Time: 1:00(PM)-3:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **AT No 4** | | | | **124.3** |
| **No 5** | 0 | 128.48 | 2.24 | **126.85** |
| Ground | 19.2029 | 59.88 | 0.63 | **125.24** |
| Ground | 19.4347 | 36.49 | -2.46 | **122.15** |
| Ground | 183.2154 | 13.55 | -0.36 | **124.25** |
| Ground | 146.5201 | 17.94 | 2.03 | **126.64** |
| Ground | 185.5907 | 40.92 | -1.56 | **123.05** |
| Ground | 184.4536 | 54.95 | -1.65 | **122.96** |
| Ground | 181.0302 | 68.95 | -1.99 | **122.62** |
| Ground | 179.2727 | 90.77 | -4.04 | **120.57** |
| **No 3** | 181.1335 | 106.89 | -4.75 | **119.86** |
| Ground | 335.0902 | 83.66 | 2.75 | **127.36** |
| Ground | 329.4050 | 75.22 | 2.07 | **126.68** |
| Ground | 317.2925 | 56.12 | 0.06 | **124.67** |
| Ground | 303.4536 | 50.35 | -1.07 | **123.54** |
| Ground | 287.4123 | 43.7 | -2.5 | **122.11** |
| Ground | 269.0517 | 41.55 | -3.57 | **121.04** |
| Corner fence | 266.2754 | 55.77 | -1.33 | **123.28** |
| Fence | 250.3152 | 66.65 | -1.16 | **123.45** |
| Fence | 239.0729 | 80.92 | -1.27 | **123.34** |
| Corner fence | 231.5629 | 95.18 | -1.97 | **122.64** |
| Ground | 245.2321 | 46.57 | -4.26 | **120.35** |
| Ground | 225.2802 | 62.69 | -5.55 | **119.06** |
| Ground | 217.0640 | 81.00 | -6.58 | **118.03** |
| Ground | 212.5347 | 99.95 | -7.13 | **117.48** |
| | **HI=5.07 FT** | **Hr=4.76 FT** | | |

## Elevation Measurements:

**Location: N.E of Spring Valley Park**
**Date: December 8, 2004 / Time: 12:00(PM)-3:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **AT No 3** | | | | **119.82** |
| **No 4** | 0 | 106.93 | 4.08 | **124.3** |
| Ground | 5.1840 | 26.03 | 1.32 | **121.54** |
| Ground | 339.2328 | 9.32 | -0.99 | **119.23** |
| Ground | 222.3418 | 10.94 | -2.56 | **117.66** |
| Ground | 211.5804 | 20.64 | -3.39 | **116.83** |
| Ground | 210.3858 | 26.57 | -5.01 | **115.21** |
| Ground | 208.1107 | 32.65 | -5.99 | **114.23** |
| Ground | 208.5020 | 40.84 | -5.77 | **114.45** |
| Ground | 208.3936 | 56.73 | -8.01 | **112.21** |
| Ground | 210.3041 | 76.63 | -6.65 | **113.57** |
| Sewer | 219.4120 | 90.36 | -7.93 | **112.29** |
| Ground | 223.4014 | 101.16 | -8.64 | **111.58** |
| Ground | 215.3332 | 101.32 | -9.09 | **111.13** |
| Ground | 219.3435 | 117.43 | -10.04 | **110.18** |
| Ground | 215.5514 | 118.12 | -9.96 | **110.26** |
| Ground | 219.3945 | 133.94 | -11.11 | **109.11** |
| Ground | 215.4250 | 136.67 | -10.97 | **109.25** |
| **No 2** | 217.2558 | 143.93 | -11.65 | **108.57** |
| Ground | 218.4049 | 166.34 | -12.51 | **107.71** |
| Ground | 216.2835 | 166.96 | -12.34 | **107.88** |
| Ground | 218.3045 | 196.66 | -13.93 | **106.29** |
| Ground | 215.3204 | 197.61 | -13.92 | **106.3** |
| Ground | 247.3706 | 96.81 | -5.84 | **114.38** |
| Ground | 243.4008 | 79.28 | -6.57 | **113.65** |
| Ground | 252.2752 | 86.58 | -5.07 | **115.15** |
| Ground | 243.1132 | 66.25 | -6.02 | **114.2** |
| Ground | 258.1214 | 70.72 | -4.78 | **115.44** |
| Ground | 264.3821 | 54.18 | -4.57 | **115.65** |
| Ground | 285.5906 | 51.7 | -3.09 | **117.13** |
| Ground | 308.0155 | 61.63 | -2.32 | **117.9** |
| | **HI=5.16 FT** | **Hr=4.76 FT** | | |

**Elevation Measurements:**

**Location: S.W of Spring Valley Park**

**Date: December 10, 2004 / Time: 12:00(PM)-3:00(PM)**

**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **AT No 2** | | | | **108.52** |
| **No 3** | 0 | 143.93 | 10.57 | **119.85** |
| Ground | 174.0138 | 83.00 | -4.92 | 104.36 |
| Ground | 184.1454 | 88.19 | -4.86 | 104.42 |
| Ground | 186.2933 | 102.49 | -5.73 | 103.55 |
| Ground | 176.2049 | 103.14 | -6.13 | 103.15 |
| Ground | 183.2927 | 125.96 | -7.24 | 102.04 |
| Ground | 175.1822 | 129.12 | -7.45 | 101.83 |
| Ground | 182.0746 | 145.2 | -7.88 | 101.4 |
| Ground | 173.2344 | 142.32 | -7.76 | 101.52 |
| Ground | 171.5849 | 165.48 | -8.26 | 101.02 |
| Ground | 179.4407 | 165.11 | -8.07 | 101.21 |
| Ground | 179.1805 | 195.95 | -8.73 | 100.55 |
| Ground | 172.2730 | 205.47 | -9.43 | 99.85 |
| **No 1** | 177.1659 | **199.06** | -9.27 | **100.01** |
| Ground | 212.5522 | 95.46 | -3.42 | 105.86 |
| Ground | 221.0639 | 79.66 | -2.53 | 106.75 |
| Ground | 240.0309 | 61.53 | -0.79 | 108.49 |
| Ground | 272.5703 | 54.02 | 1.96 | 111.24 |
| Ground | 286.5357 | 57.73 | 3.02 | 112.3 |
| Ground | 301.3921 | 61.62 | 3.94 | 113.22 |
| Ground | 324.5245 | 73.92 | 4.03 | 113.31 |
| Corner fence | 225.2154 | 97.4 | 0.71 | 109.99 |
| Fence | 238.0859 | 84.66 | 3.13 | 112.41 |
| Fence | 268.2534 | 76.62 | 6.85 | 116.13 |
| Corner fence | 287.3357 | 83.54 | 8.18 | 117.46 |
| | **HI=5.52 FT** | **Hr=4.76 FT** | | |

## Elevation Measurements:

**Location: N.W of Spring Valley Park**
**Date: December 13, 2004 / Time: 12:00(PM)-3:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **AT NO 2** | | | | **108.52** |
| **NO 1** | 0 | 199.05 | -6.69 | **100.03** |
| Right of creek | 12.2933 | 56.61 | -0.96 | 105.76 |
| Right of creek | 19.2801 | 40.98 | -0.51 | 106.21 |
| Right of creek | 52.2435 | 19.50 | 0.46 | 107.18 |
| Right of creek | 141.2889 | 20.21 | 1.88 | 108.6 |
| Right of creek | 157.2102 | 42.39 | 3.08 | 109.8 |
| Right of creek | 160.4541 | 46.96 | 4.00 | 110.72 |
| Right of creek | 177.0404 | 53.22 | 5.04 | 111.76 |
| Right of creek | 187.0000 | 64.88 | 6.33 | 113.05 |
| Right of creek | 188.4726 | 86.82 | 5.63 | 112.35 |
| Right of creek | 185.2400 | 105.18 | 7.5 | 114.22 |
| **NO 3** | 182.4327 | 143.72 | 13.09 | **119.81** |
| Left of creek | 26.1847 | 71.66 | -2.46 | 104.26 |
| Left of creek | 42.1027 | 50.52 | -0.65 | 106.07 |
| Left of creek | 64.4430 | 40.00 | 0.85 | 107.57 |
| Left of creek | 114.374 | 37.28 | 2.92 | 109.64 |
| Left of creek | 136.1445 | 58.05 | 5.31 | 112.03 |
| Left of creek | 142.4301 | 64.34 | 5.26 | 111.98 |
| Left of creek | 148.3931 | 71.42 | 5.67 | 112.39 |
| Left of creek | 167.2159 | 78.98 | 5.35 | 112.07 |
| Left of creek | 173.4609 | 86.41 | 5.29 | 112.01 |
| Left of creek | 172.1926 | 100.69 | 7.42 | 114.14 |
| | **HI=5.20 FT** | **Hr=7.00 FT** | | |

## Elevation Measurements:

**Location: S.W of Spring Valley Park**
**Date: December 15, 2004 / Time: 12:00(PM)-3:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **AT NO 3** | | | | **119.82** |
| **NO 2** | 0 | 106.79 | -9.14 | **108.54** |
| Right of creek | 30.2834 | 15.87 | -1.70 | 115.98 |
| Right of creek | 131.3947 | 40.12 | 3.69 | 121.37 |
| Right of creek | 134.5939 | 66.82 | 4.40 | 122.08 |
| Right of creek | 138.8142 | 95.21 | 5.29 | 122.97 |
| Left of creek | 52.1921 | 39.59 | -2.21 | 115.47 |
| Left of creek | 98.5914 | 54.75 | -0.49 | 117.19 |
| Left of creek | 114.5521 | 75.55 | 1.15 | 118.83 |
| Left of creek | 120.2951 | 99.73 | 2.65 | 120.33 |
| | **HI=4.86 FT** | **Hr=7.00 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT NO 4** | | | | **124.30** |
| **NO 3** | 0 | 106.79 | -2.36 | **119.87** |
| Right of creek | 187.3320 | 26.05 | -0.66 | 121.57 |
| Right of creek | 173.5499 | 60.59 | 1.25 | 123.48 |
| Right of creek | 173.4050 | 87.85 | 1.81 | 124.04 |
| Right of creek | 178.2139 | 123.65 | 3.76 | 125.99 |
| Right of creek | 174.5550 | 145.59 | 4.96 | 127.19 |
| Left of creek | 138.1218 | 96.04 | 0.74 | 122.97 |
| Left of creek | 149.1847 | 59.31 | 1.87 | 124.1 |
| Left of creek | 154.2230 | 79.06 | 3.99 | 126.22 |
| Left of creek | 158.5850 | 101.79 | 6.66 | 128.89 |
| Left of creek | 164.1337 | 127.89 | 7.41 | 129.64 |
| | **HI=4.93 FT** | **Hr=7.00 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT NO 5** | | | | **126.84** |
| **NO 4** | 0 | 128.43 | -0.28 | 124.34 |
| Right of creek | 148.094 | 18.40 | 2.33 | 126.95 |
| Right of creek | 167.0442 | 44.27 | 3.44 | 128.06 |
| Right of creek | 166.4813 | 67.14 | 5.67 | 130.29 |
| Right of creek | 175.1641 | 92.12 | 9.31 | 133.93 |
| Left of creek | 121.4707 | 42.42 | 6.82 | 131.44 |

| | | | | |
|---|---|---|---|---|
| Left of creek | 135.6817 | 51.96 | 7.48 | 132.1 |
| | **HI=4.78 FT** | **Hr=7.00 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT NO 6** | | | | **139.97** |
| **NO 5** | 0 | 157.60 | -11.2 | 126.8 |
| Right of creek | 6.2055 | 105.89 | -8.46 | 129.54 |
| Right of creek | 7.5652 | 69.09 | -3.96 | 134.04 |
| Right of creek | 31.4051 | 32.24 | -1.69 | 136.31 |
| Right of creek | 101.0504 | 21.84 | -1.87 | 136.13 |
| Right of creek | 145.3200 | 53.89 | -2.6 | 135.4 |
| Right of creek | 146.5536 | 59.79 | -2.68 | 135.32 |
| Right of creek | 160.1210 | 85.47 | 0.67 | 138.67 |
| Right of creek | 162.2612 | 97.34 | 0.82 | 138.82 |
| Right of creek | 164.3334 | 131.46 | 3.75 | 141.75 |
| Left of creek | 31.1428 | 76.86 | -6.87 | 131.13 |
| Left of creek | 48.3413 | 59.11 | -6.00 | 132 |
| Left of creek | 54.2213 | 50.22 | -6.22 | 131.78 |
| Left of creek | 92.1124 | 53.01 | -2.06 | 135.94 |
| Left of creek | 118.2523 | 63.08 | -0.41 | 137.59 |
| Left of creek | 138.0156 | 80.65 | 2.15 | 140.15 |
| Left of creek | 194.1535 | 93.66 | 3.51 | 141.51 |
| Left of creek | 156.0450 | 152.93 | 6.38 | 144.38 |
| | **HI=5.03 FT** | **Hr=7.00 FT** | | |

## Elevation Measurements:

**Location: S.E of Spring Valley Park**
**Date: December 17, 2004 / Time: 12:00(PM)-3:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **AT NO 7** | | | | **147.58** |
| Right of creek | 39.3205 | 41.09 | -2.29 | 143.22 |
| Right of creek | 58.3946 | 26.74 | -1.12 | 144.39 |
| Right of creek | 192.1752 | 5.44 | 1.73 | 147.24 |
| Right of creek | 184.1843 | 12.87 | 2.17 | 147.68 |
| Right of creek | 181.5651 | 45.30 | 2.09 | 147.6 |
| Left of creek | 71.1124 | 53.07 | 1.52 | 147.03 |
| Left of creek | 80.4849 | 46.58 | 1.09 | 146.6 |
| Left of creek | 111.4407 | 35.36 | 2.09 | 147.6 |
| Left of creek | 142.3851 | 32.10 | 1.64 | 147.15 |
| Left of creek | 166.3137 | 61.48 | 2.99 | 148.5 |
| Left of creek | 178.2729 | 83.67 | 6.84 | 152.35 |
| | **HI=4.93 FT** | **Hr=7.00 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT NO 8** | | | | **155.55** |
| **NO 7** | 0 | 137.68 | -5.97 | 147.58 |
| Right of creek | 38.1726 | 44.77 | -1.94 | 151.61 |
| Right of creek | 67.0323 | 19.98 | -1.08 | 152.47 |
| Right of creek | 155.3006 | 49.39 | -0.47 | 153.08 |
| Right of creek | 163.1300 | 65.31 | 1.84 | 155.39 |
| Right of creek | 165.0448 | 81.06 | 3.70 | 157.25 |
| Right of creek | 163.5826 | 97.78 | 6.81 | 160.36 |
| Left of creek | 58.1744 | 51.08 | -1.12 | 152.43 |
| Left of creek | 78.1310 | 36.60 | -1.64 | 151.91 |
| Left of creek | 148.1448 | 56.00 | -0.01 | 153.54 |
| Left of creek | 154.2103 | 70.88 | 2.26 | 155.81 |
| Left of creek | 157.1213 | 87.37 | 4.57 | 158.12 |
| Left of creek | 156.1530 | $99.80 | 7.88 | 161.43 |
| | **HI=5.00 FT** | **Hr=7.00 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT NO 1** | | | | **100.00** |
| **NO 2** | 0 | 200.06 | 8.38 | 108.53 |
| Electric pole | 3.4745 | 122.69 | 4.77 | 104.92 |

| | | | | |
|---|---|---|---|---|
| Electric pole | 328.5758 | 151.52 | 9.10 | 109.25 |
| Ground | 346.4440 | 101.53 | 3.35 | 103.5 |
| Ground | 331.3310 | 108.89 | 4.21 | 104.36 |
| Tree 3 ft | 323.2621 | 75.75 | 3.14 | 103.29 |
| Tree 3 ft | 334.4657 | 44.89 | 1.49 | 101.64 |
| Ground | 4.0618 | 99.58 | 3.8 | 103.95 |
| Ground | 18.0508 | 55.97 | 0.9 | 101.05 |
| Ground | 75.5657 | 47.90 | -0.1 | 100.05 |
| Sewer | 100.1352 | 159.68 | -2.65 | 97.5 |
| Edge | 100.4248 | 160.03 | -3.09 | 97.06 |
| Sewer | 101.2113 | 150.36 | -2.54 | 97.61 |
| Edge | 102.0733 | 151.19 | -3.21 | 96.94 |
| Edge | 105.5146 | 122.51 | -3.04 | 97.11 |
| Edge | 108.5948 | 67.51 | -1.84 | 98.31 |
| Edge | 108.2741 | 29.2 | -1.09 | 99.06 |
| Manhole water | 104.2323 | 84.04 | -2.13 | 98.02 |
| DCSL | 104.1132 | 95.39 | -1.83 | 98.32 |
| DCSL | 20.2230 | 10.61 | 1.14 | 101.29 |
| Edge | 289.2558 | 64.95 | 2.05 | 102.2 |
| Edge | 268.4257 | 84.30 | 2.41 | 102.56 |
| Edge | 203.3803 | 29.20 | -0.19 | 99.96 |
| Curb | 134.5950 | 67.00 | -2.09 | 98.06 |
| Middle curb | 125.4839 | 98.46 | -3.08 | 97.07 |
| End curb | 119.2959 | 128.02 | -3.40 | 96.75 |
| Curb | 112.4807 | 158.88 | -3.77 | 96.38 |
| Edge | 107.3745 | 183.67 | -4.00 | 96.15 |
| Sewer | 107.1832 | 188.67 | -3.17 | 96.98 |
| Corner | 346.0131 | 103.98 | 2.38 | 102.53 |
| | **HI=4.97 FT** | **Hr=4.82 FT** | | |

## Elevation Measurements:

**Location: S.E of Spring Valley Park**
**Date: December 20, 2004 / Time: 12:00(PM)-3:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **AT NO 2** | | | | **108.52** |
| **NO 1** | 0 | 200.05 | -8.66 | 100.02 |
| Fence corner | 351.3136 | 78.27 | -3.00 | 105.68 |
| Fence | 333.3305 | 29.20 | -0.35 | 108.33 |
| Fence | 208.4418 | 29.33 | 2.90 | 111.58 |
| Electric pole | 194.1922 | 64.65 | 5.19 | 113.87 |
| Fence | 193.0423 | 73.71 | 5.66 | 114.34 |
| Fence | 187.2655 | 103.95 | 7.16 | 115.84 |
| Fence | 185.3931 | 129.68 | 11.17 | 119.85 |
| Corner | 183.1355 | 155.40 | 13.35 | 122.03 |
| No 3 | 182.4326 | 144.00 | 11.12 | 119.8 |
| Electric pole | 116.2842 | 82.70 | 8.51 | 117.19 |
| | **HI=4.93 FT** | **Hr=4.77 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT NO 4** | | | | **124.3** |
| **NO 3** | 0 | 106.99 | -4.40 | 119.84 |
| Electric pole | 318.4120 | 44.13 | 9.36 | 133.60 |
| Fence | 284.0224 | 32.00 | 7.75 | 131.99 |
| Corner fence | 212.2936 | 75.63 | 5.75 | 129.99 |
| Electric pole | 210.4802 | 78.96 | 5.12 | 129.36 |
| Electric pole | 129.2249 | 68.35 | 2.38 | 126.62 |
| No 5 | 178.4904 | 128.68 | 2.59 | 126.83 |
| | **HI=4.71 FT** | **Hr=4.77 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT NO 5** | | | | **126.84** |
| **NO 4** | 0 | 128.62 | -2.37 | 124.32 |
| Electric pole | 232.5137 | 52.77 | 6.74 | 133.43 |
| Electric pole | 136.4706 | 75.43 | 8.42 | 135.11 |
| **NO 6** | 183.4540 | 157.84 | 13.28 | 139.97 |
| | **HI=4.62 FT** | **Hr=4.77 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT NO 6** | | | | **139.97** |
| **NO 5** | 0 | 157.87 | -13.07 | 126.86 |

| | | | | |
|---|---|---|---|---|
| **Electric pole** | 200.2935 | 55.24 | 8.73 | 148.66 |
| **Electric pole** | 225.5128 | 93.85 | 22.24 | 162.17 |
| **Electric pole** | 117.5501 | 74.72 | -0.33 | 139.6 |
| **NO 7** | 177.3423 | 182.94 | 7.67 | 147.6 |
| | **HI=4.73 FT** | **Hr=4.77 FT** | | |

## Elevation Measurements:

**Location: S.E of Spring Valley Park**
**Date: December 21, 2004 / Time: 2:00(PM)-4:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **At No 8** | | | | **155.55** |
| **No 9** | 0 | 123.06 | 6.61 | 162.55 |
| Ground | 0.2630 | 67.47 | -0.37 | 155.57 |
| Ground | 10.2550 | 47.83 | -1.64 | 154.3 |
| Ground | 211.3907 | 11.71 | -1.07 | 154.87 |
| Ground | 135.4308 | 15.31 | 1.34 | 157.28 |
| Ground | 218.3829 | 42.33 | -3.66 | 152.28 |
| Ground | 185.2928 | 41.93 | -1.60 | 154.34 |
| Ground | 210.2448 | 72.38 | -5.35 | 150.59 |
| Ground | 189.5524 | 68.19 | -3.40 | 152.54 |
| Ground | 194.3901 | 93.59 | -5.69 | 150.25 |
| Ground | 187.5505 | 91.18 | -4.13 | 151.81 |
| Ground | 185.2030 | 134.71 | -7.92 | 148.02 |
| Ground | 184.1212 | 153.05 | -9.23 | 146.71 |
| Ground | 264.3841 | 69.22 | -0.92 | 155.02 |
| Ground | 248.0056 | 76.82 | -1.88 | 154.06 |
| Ground | 231.3125 | 91.23 | -2.54 | 153.4 |
| Ground | 211.1352 | 133.41 | -4.88 | 151.06 |
| Ground | 203.3923 | 146.29 | -6.28 | 149.66 |
| Ground | 201.4535 | 157.20 | -7.24 | 148.7 |
| Ground | 191.4714 | 199.32 | -10.22 | 145.72 |
| **No 7** | 186.3503 | 137.78 | -8.31 | 147.63 |
| | **HI=5.14 FT** | **Hr=4.75 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **At No 7** | | | | **147.58** |
| **No 8** | 0 | 137.78 | 7.58 | 155.53 |
| Ground | 139.4356 | 35.46 | -2.86 | 145.09 |
| Ground | 137.5454 | 57.85 | -4.44 | 143.51 |
| Ground | 136.5257 | 82.60 | -6.46 | 141.49 |
| Ground | 137.0855 | 104.84 | -8.43 | 139.52 |
| Ground | 137.4459 | 124.75 | -9.35 | 138.6 |
| Ground | 136.2205 | 177.22 | -8.97 | 138.98 |
| Ground | 136.1534 | 248.51 | -13.15 | 134.8 |

| | | | | |
|---|---|---|---|---|
| Fence | 306.1824 | 109.51 | 7.97 | 155.92 |
| Fence | 293.2413 | 82.30 | 5.42 | 153.37 |
| Fence | 282.4845 | 70.58 | 3.83 | 151.78 |
| Ground | 279.0337 | 51.90 | 2.46 | 150.41 |
| Fence | 244.5238 | 53.34 | 2.09 | 150.04 |
| Fence | 213.5341 | 59.78 | 0.56 | 148.51 |
| Fence | 187.0249 | 78.85 | -1.70 | 146.25 |
| Fence | 173.4354 | 105.07 | -3.03 | 144.92 |
| Fence | 163.3422 | 134.46 | -5.40 | 142.55 |
| Fence | 159.3841 | 155.91 | -7.47 | 140.48 |
| | **HI=5.12 FT** | **Hr=4.75 FT** | | |

## Elevation Measurements:

**Location: N.E of Spring Valley Park**
**Date: January 4, 2005 / Time: 10:00(AM)-12:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **At No 5** | | | | **126.84** |
| **No 6** | 0 | 157.72 | 12.69 | 140.08 |
| Ground | 358.2013 | 92.58 | 7.46 | 134.85 |
| Ground | 0.2857 | 68.61 | 4.83 | 132.22 |
| Ground | 3.3857 | 43.37 | 1.71 | 129.1 |
| Ground | 14.2826 | 19.45 | 0.20 | 127.59 |
| Ground | 55.5250 | 29.66 | 2.01 | 129.4 |
| Ground | 97.4509 | 24.77 | 1.33 | 128.72 |
| Ground | 154.2841 | 34.87 | -1.05 | 126.34 |
| Ground | 154.3629 | 51.74 | -1.19 | 126.2 |
| Ground | 167.1957 | 64.49 | -2.25 | 125.14 |
| Ground | 149.0417 | 68.85 | 0.72 | 128.11 |
| Ground | 174.4010 | 130.38 | -2.79 | 124.6 |
| | **HI=5.30 FT** | **Hr=4.75 FT** | | |

## Elevation Measurements:

**Location: S.E of Spring Valley Park**
**Date: January 11, 2005 / Time: 12:00(PM)-2:00(PM)**
**Surveyors: Kourouma and Harada**

| STATION | ANGLE ( D M S ) | HD | dh | ELEV |
|---|---|---|---|---|
| **AT No 4** | | | | **124.3** |
| **No 3** | 0 | 106.9 | -4.67 | 119.85 |
| Tree 3 ft | 350.0134 | 24.77 | 2.16 | 126.68 |
| Tree 3 ft | 24.1155 | 25.89 | -1.41 | 123.11 |
| Tree 3 ft | 308.2448 | 22.56 | 4.6 | 129.12 |
| Tree 4 ft | 293.0220 | 6.35 | 1.31 | 125.83 |
| Tree 3 ft | 187.4514 | 44.89 | -1.27 | 123.25 |
| Tree 4 ft | 184.3655 | 50.02 | -0.17 | 124.35 |
| Tree 4 ft | 200.1604 | 87.27 | 4.45 | 128.97 |
| **No 5** | 178.4922 | 128.49 | 2.31 | 126.83 |
| | **HI=4.94 FT** | **Hr=4.72 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT No 5** | | | | **126.84** |
| **No 4** | 0 | 128.47 | -2.76 | 124.32 |
| Tree 2.5 ft | 293.4234 | 33.74 | 2.52 | 129.60 |
| Tree 2.5 ft | 284.1719 | 45.74 | 5.24 | 132.32 |
| Tree 2 ft | 274.1550 | 45.85 | 4.76 | 131.84 |
| Tree 1.5 ft | 251.2522 | 54.88 | 6.31 | 133.39 |
| Tree 1 ft | 233.3920 | 61.8 | 8.18 | 135.26 |
| Tree 1 ft | 212.2610 | 54.31 | 5.67 | 132.75 |
| Tree 3 ft | 215.0357 | 68.83 | 9.97 | 137.05 |
| Tree 1 ft | 224.5344 | 71.79 | 10.83 | 137.91 |
| Tree 1ft | 201.1524 | 66.54 | 6.4 | 133.48 |
| Tree 1.5 ft | 197.1902 | 86.72 | 9.81 | 136.89 |
| Tree 2 ft | 187.3414 | 81.65 | 7.3 | 134.38 |
| Tree 1 ft | 168.2022 | 63.28 | 3.58 | 130.66 |
| Tree 4 ft | 178.4856 | 44.07 | 2.57 | 129.65 |
| **No 6** | 183.4535 | 197.72 | 12.93 | **140.01** |
| | **HI=4.96 FT** | **Hr=4.72FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT No 6** | | | | **139.97** |
| **No 5** | 0 | 157.71 | -13.3 | 126.85 |
| Tree 2 ft | 8.0222 | 30.55 | -1.5 | 138.65 |
| Tree 3.5 ft | 22.0432 | 14.32 | -0.72 | 139.43 |
| Tree 2.5 ft | 150.5451 | 22.01 | -1.69 | 138.46 |
| Tree 2.5 ft | 183.5026 | 29.86 | 0.96 | 141.11 |

| | | | | |
|---|---|---|---|---|
| Tree 2.5 ft | 189.3819 | 44.62 | 2.73 | 142.88 |
| Tree 1 ft | 205.4137 | 53.65 | 7.1 | 147.25 |
| Tree 2 ft | 244.5452 | 49.57 | 13.11 | 153.26 |
| Tree 1.5 ft | 235.0458 | 63.16 | 15.43 | 155.58 |
| Tree 1 ft | 298.0634 | 45.12 | 7.44 | 147.59 |
| Tree 1 ft | 286.0242 | 36.58 | 7.57 | 147.72 |
| Tree 1.5 ft | 262.2002 | 13.96 | 2.89 | 143.04 |
| Tree 2 ft | 170.3946 | 106.83 | 2.14 | 142.29 |
| Tree 2 ft | 174.2444 | 129.57 | 4.66 | 144.81 |
| Tree 1.5 ft | 175.3649 | 159.12 | 6.61 | 146.76 |
| Tree 1 ft | 173.1204 | 105.46 | 5.87 | 146.02 |
| Tree 1 ft | 177.5517 | 191.99 | 7.26 | 147.41 |
| | **HI=4.90 FT** | **Hr=4.72 FT** | | |
| **STATION** | **ANGLE ( D M S )** | **HD** | **dh** | **ELEV** |
| **AT No 7** | | | | **147.58** |
| **No 6** | 0 | 182.81 | -7.92 | **140.01** |
| Tree 2 ft | 209.2301 | 78.4 | 3.86 | 151.79 |
| Tree 2.5 ft | 216.3111 | 98.04 | 5.19 | 153.12 |
| Tree 2.5 ft | 222.2642 | 109.03 | 6.83 | 154.76 |
| Tree 1.5 ft | 230.1236 | 71.3 | 6.83 | 154.76 |
| Tree 1.5 ft | 231.2504 | 47.25 | 5.09 | 153.02 |
| Tree 1.5 ft | 239.0610 | 31.35 | 4.07 | 152 |
| Tree 1.5 ft | 245.3542 | 57.5 | 8.27 | 156.2 |
| Tree 1 ft | 259.3916 | 31.46 | 5.77 | 153.7 |
| Tree 1 ft | 266.3947 | 65.26 | 13.71 | 161.64 |
| Tree 1 ft | 279.1928 | 67.28 | 15.29 | 163.22 |
| Tree 1.5 ft | 282.5351 | 39.71 | 8.78 | 156.71 |
| Tree 2 ft | 293.5924 | 14.89 | 1.95 | 149.88 |
| Tree 1 ft | 305.4265 | 20.55 | 2.91 | 150.84 |
| Tree 1 ft | 347.0928 | 42.49 | -0.64 | 147.29 |
| Tree 2 ft | 342.0652 | 52.56 | -0.18 | 147.75 |
| Tree 2 ft | 330.2145 | 62.47 | 1.98 | 149.91 |
| Tree 2 ft | 321.4922 | 50.84 | 6.32 | 154.25 |
| Tree 2 ft | 348.2953 | 75.72 | -2.34 | 145.59 |
| Tree 1.5 ft | 343.0850 | 93.07 | -1.42 | 146.51 |
| | **HI=5.07 FT** | **Hr=4.72FT** | | |

# Information Transfer Program

# Student Support

| Student Support | | | | | |
|---|---|---|---|---|---|
| **Category** | **Section 104 Base Grant** | **Section 104 RCGP Award** | **NIWR-USGS Internship** | **Supplemental Awards** | **Total** |
| **Undergraduate** | 22 | 0 | 1 | 0 | 23 |
| **Masters** | 0 | 0 | 0 | 0 | 0 |
| **Ph.D.** | 0 | 0 | 0 | 0 | 0 |
| **Post-Doc.** | 0 | 0 | 0 | 0 | 0 |
| **Total** | 22 | 0 | 1 | 0 | 23 |

# Notable Awards and Achievements

# Publications from Prior Projects

None