# Virgin Islands Water Resources Research Institute
# Annual Technical Report
# FY 2003

## Introduction

The Virgin Islands Water Resources Research Institute (VIWRRI) is located at the University of the Virgin Islands, the only institution of higher learning in the Virgin Islands. The University, primarily an undergraduate teaching institution, has campuses on the islands of St. Thomas and St. Croix and a field station on St. John. The VIWRRI is part of the Universitys research and public service sub-component. Since 1973, its integrated program of research, information dissemination and training has been responding to water resources needs in the Virgin Islands. These needs in general evolve from the challenge of providing water of sufficient quantity and quality to a population from varied sources. Included among these are non-conventional ones such as rainfall and desalination. There is also the additional challenge of disposing of the wastewater produced in a setting where maintenance of a pristine environment both for health, ecological and economic reasons is a top priority. The VIWRRI is guided in its activities by an Advisory Board that includes representatives of major stakeholders in the Virgin Islands community. This board insures that the program of the VIWRRI is not only consistent with priorities of the national water institute program but also that issues addressed are of local relevance.

The VIWRRIs program for FY 2003 included a research investigation of the fecal bacteria removal efficiency of stormwater best management practices that are in use in the Virgin Islands. Results of this investigation will have application to resource planning and management in the Virgin Islands and other similar insular tropical areas. An information transfer activity in the FY 2003 program will develop and demonstrate a management procedure applicable to small, mountainous islands trying to preserve the natural environment. Accomplishments on these projects are summarized in this annual report.

## Research Program

# Fecal Coliform Bacteria Removal Efficiency for Stormwater BMPs in the Virgin Islands

## Basic Information

| | |
|---|---|
| **Title:** | Fecal Coliform Bacteria Removal Efficiency for Stormwater BMPs in the Virgin Islands |
| **Project Number:** | 2003VI9B |
| **Start Date:** | 5/1/2003 |
| **End Date:** | 2/28/2004 |
| **Funding Source:** | 104B |
| **Congressional District:** | NA |
| **Research Category:** | Not Applicable |
| **Focus Category:** | Non Point Pollution, Water Quality, Hydrology |
| **Descriptors:** | Fecal Coliform Bacteria, Best Management Practices, BMP, Nonpoint Source Pollution, Bacterial Contamination |
| **Principal Investigators:** | Henry H. Smith, R. Heath Kelsey |

## Publication

1. No publications have resulted to date from this research project.

*Summary Report on*

**Fecal Coliform Bacteria Removal Efficiency for Stormwater
Runoff BMPs in the Virgin Islands**

## Problem and Research Objectives

Fecal pollution from nonpoint sources has been recognized as a major source of water quality impairment in streams, estuaries, and near coastal ocean waters throughout the United States, including the Virgin Islands (DPNR 2003). Fecal pollution is typically indicated by the presence of indicator organisms, including fecal coliform bacteria. Fecal coliform bacteria can originate from human, domestic animal, or wildlife sources, and may present exaggerated problems in tropical areas due to warm temperatures and heavy rainfall (Toranzos 1999).

Best Management Practices (BMPs) used for reducing fecal coliform bacterial contamination of stormwater runoff in the Virgin Islands has included detention ponds, as well as vegetated swales, filter strips, and other engineered structures (DPNR, 2003). Unfortunately, the efficiency of fecal coliform bacteria removal by various BMPs is largely unknown, particularly on local or regional levels. Overall, testing of fecal coliform bacterial removal using BMPs has been limited, and has generally occurred in more temperate areas. Results have shown wide variations in BMP removal efficiency on a regional basis and results from one area may not be applicable to others (Scheuler 2000).

The research objective for this project was to evaluate the performance of detention ponds as BMPs for fecal coliform bacterial pollution reduction under conditions within the Virgin Islands. Performance was evaluated by measuring fecal coliform loading at the inlet to a detention pond and at the outlet during storm events. Loading was calculated by integrating stormwater flow with fecal coliform density. The difference in fecal coliform load in runoff water entering and exiting the pond allowed calculation of the removal efficiency.

## Methodology

The detention pond studied in this effort is located just south of Weymouth Rhymer Highway, in the upper portion of the Turpentine Run watershed in St. Thomas, U. S. Virgin Islands (Figure 1.). The pond was chosen based on the regional use of detention ponds as BMPs and local advice identifying the Turpentine Run gut as an area of concern for pollutant loading into the Benner Bay and Mangrove Lagoon area receiving waters. Although the pond may or may not have been installed specifically to serve as a BMP for pollution reduction or stormwater retention, it serves to do so. Samples also were obtained at the USGS Gaging Station at Turpentine Run (Figure 1), which has no BMP

installed. Effluent from a wastewater treatment facility located upstream potentially impacts this section of Turpentine Run.
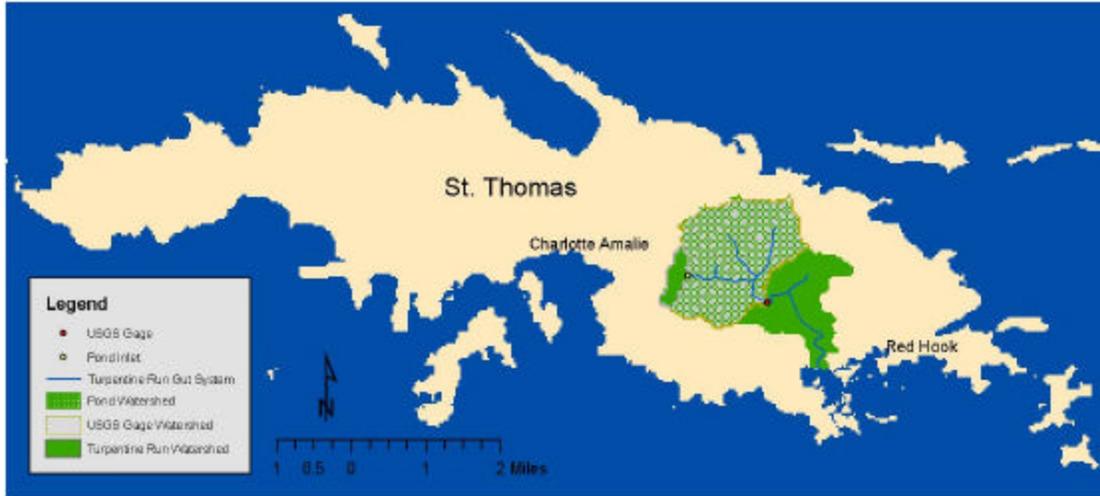


Figure 1.  Location of Study Areas and Associated Watersheds

Sampling events occurred only during times of rainfall and generation of flow into the pond.  Water samples were collected per APHA Methods 9060 A., and 9060 B., for collection of water and wastewater samples (APHA 1998). Bacterial enumeration was performed immediately following sampling, and was accomplished by APHA Method 9222 B, for membrane filtration enumeration of fecal coliform bacteria (APHA 1998). Stormwater velocity measurement occurred concurrently with collection of each water sample.  Stormwater flow was measured with a Marsh-McBirney Flowmate Model 2000 Portable Flowmeter, following guidelines for width integrated flow measurement in streams and piped systems.

**Principal Findings and Significance**

Samples were obtained during rainfall events at the study area locations beginning on 2 November, and ending 13 November 2003.  Data were obtained for fecal coliform concentration, water flow, pH, temperature, and salinity.  Rain events that generated stormwater runoff and flow into the study area pond occurred on November 2, 3, 7, 8, 9, and 13 (Table 1).  In summary, it appears that the pond performs well as a BMP for reducing fecal coliform loading, but the reductions seen are probably a result of the stormwater storage capacity of the pond.  When the storage of the pond was exceeded, the pond did not appear to reduce fecal coliform density, and, in fact, it may have increased (Table 1).   Although the increase observed is not statistically measurable with the single data point, it is possible that fecal coliform concentrations can increase due to sediment re-suspension (Davies et al. 1995, Desmarais et al. 2002).

Table 1. Fecal Coliform Data

| Location | Date | Time | FCD (cfu/100ml) | Flow (m3/s) | Load (cfu/s) |
|---|---|---|---|---|---|
| Pond Inlet | 11/2/2003 | 14:10 | 28 | 0.000396 | 111 |
| Pond Inlet | 11/2/2003 | 15:10 | 27 | 0.001825 | 493 |
| Pond Inlet | 11/3/2003 | 13:35 | 9 | 0.000531 | 48 |
| Pond Inlet | 11/7/2003 | 08:10 | 162 | 0.00088 | 1427 |
| Pond Inlet | 11/8/2003 | 12:30 | 9 | 0.001056 | 95 |
| Pond Inlet | 11/9/2003 | 09:45 | 81 | 0.003605 | 2923 |
| Pond Inlet | 11/9/2003 | 11:45 | 18 | 0 | 0 |
| Pond Inlet | 11/13/2003 | 10:45 | 27 | 0.01216 | 3286 |
|  |  |  |  |  |  |
| Pond Outlet | 11/2/2003 | 14:16 | 28 | 0 | 0 |
| Pond Outlet | 11/2/2003 | 15:25 | 210 | 0 | 0 |
| Pond Outlet | 11/3/2003 | 13:45 | 36 | 0 | 0 |
| Pond Outlet | 11/7/2003 | 08:32 | 36 | 0 | 0 |
| Pond Outlet | 11/8/2003 | 12:50 | 9 | 0 | 0 |
| Pond Outlet | 11/9/2003 | 10:00 | 72 | 0 | 0 |
| Pond Outlet | 11/9/2003 | 11:59 | 0 | 0 | 0 |
| Pond Outlet | 11/11/2003 | 09:50 | 63 | Flash Flood Conditions | |
| Pond Outlet | 11/13/2003 | 10:14 | 27 | 0.0182 | 4919 |
|  |  |  |  |  |  |
| USGS Gaging Station | 11/2/2003 | 16:40 | 1364 | 0.090614 | 1235642 |
| USGS Gaging Station | 11/3/2003 | 14:15 | 117 | 0.006796 | 7959 |
| USGS Gaging Station | 11/7/2003 | 08:54 | 1273 | 0.036812 | 468514 |
| USGS Gaging Station | 11/8/2003 | 13:12 | 54 | 0.017273 | 9337 |
| USGS Gaging Station | 11/9/2003 | 10:45 | 360 | 0.039644 | 142717 |
| USGS Gaging Station | 11/9/2003 | 12:15 | 270 | 0.028317 | 76455 |
| USGS Gaging Station | 11/11/2003 | 10:35 | 5000 | 8.877317 | 4.44E+08 |
| USGS Gaging Station | 11/12/2003 | 13:37 | 545 | 2.010493 | 10966324 |
| USGS Gaging Station | 11/12/2003 | 13:52 | 455 | 1.529107 | 6950487 |
| USGS Gaging Station | 11/12/2003 | 14:10 | 182 | 1.291246 | 2347720 |
| USGS Gaging Station | 11/13/2003 | 11:15 | 63 | 0.339802 | 214289 |

*cfu = Colony Forming Units    m3 = Cubic Meter   s = Second*

Between November 11 and 14, approximately 11.62 inches of rain were recorded at the University of the Virgin Islands weather station.  This storm event created hazardous conditions at the study area pond site, and sampling there was not possible.  The intensity of the rainfall was unfortunate, in that the pond first experienced outflow beginning in this event.  Outflow from the pond was sampled only once, on November 13, when conditions had temporarily improved.  During the project sampling duration, this was the only occasion that the pond storage capacity was exceeded, and only one data point is available to compare inlet and outlet fecal coliform concentrations during periods of outflow from the pond.  Samples were obtained throughout this period at the USGS Turpentine Run gaging station (Table 1).

It is interesting to note that although over 11.5 inches of precipitation was recorded at the UVI weather station, less than 8 inches was recorded during the same time period at the USGS Turpentine Run gaging station (Table 2).   Additionally, although flow was measured at the USGS Turpentine Run gaging station at each sampling event, visual inspection revealed that little or no flow was often observed at areas farther downstream.  Because pollutant loading from Turpentine Run is of concern to Benner Bay and the

Mangrove Lagoon area receiving waters, it suggests that the relationships between rainfall and stormwater runoff at the Turpentine Run watershed outlet needs to be better understood.  It is also apparent that the spatial variability of rainfall on St. Thomas needs to be evaluated.

Table 2. Rainfall Data

| Date | Rainfall by Location (in) | |
| | UVI | Gaging Station |
| --- | --- | --- |
| 11/12/2003 | 2.09 | 1.78 |
| 11/13/2003 | 2.67 | 3.29 |
| 11/14/2003 | 4.08 | 2.71 |
| 11/15/2003 | 2.78 | 0.15 |
| Total | 11.62 | 7.93 |

Final project activities will include the installation of a water level indicator at the study area pond.  A Global Water Instrumentation, Inc., Model WL-15 water level indicator has been purchased and will be installed during the week of July 12-16, 2004.  The water level indicator will provide data for the evaluation of pond hydrodynamic properties, watershed response, and evaporation rates.  Data collected will be useful in completing hydrologic analyses begun in October 2003, but which were interrupted by extreme flood conditions in the study area pond.  Although the current project extension period ends as of August 31, 2004, analyses will continue beyond the project end date, and may be incorporated into further funded research efforts.

## **References**

APHA.  1998.  Standard Methods for the Examination of Water and Wastewater.  20th Edition.  American Public Health Association.  Water Pollution Control Federation.  United Book Press, Baltimore Maryland.

Davies, C.M., J.A.H. Long, M. Donald, and N.J. Ashbolt.  1995.  Survival of Fecal Microorganisms in Marine and Freshwater Sediments.  *Applied and Environmental Microbiology 61(5)*: 1888-1896

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Schueler, T. 2000. *Why Stormwater Matters*. In: The practice of watershed protection. Pp365-376. Center for Watershed Protection, Ellicott City, MD.

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# Information Transfer Program

# Coral Bay Watershed: Development of Management Measures for Sediment and Pollution Reduction - Phase II

## Basic Information

| | |
|---:|---|
| **Title:** | Coral Bay Watershed: Development of Management Measures for Sediment and Pollution Reduction - Phase II |
| **Project Number:** | 2003VI11B |
| **Start Date:** | 6/1/2003 |
| **End Date:** | 2/28/2004 |
| **Funding Source:** | 104B |
| **Congressional District:** | NA |
| **Research Category:** | Not Applicable |
| **Focus Category:** | Water Quality, Conservation, Non Point Pollution |
| **Descriptors:** | Watershed Management, Stormwater Management |
| **Principal Investigators:** | Barry Devine |

## Publication

1. No publications have resulted as yet from this project.

*Summary Report on*

**Coral Bay Watershed: Development of Management Measures
for Sediment and Pollution Reduction - Phase II**

## Problem and Objectives

Non-point source pollution of coastal embayments resulting from runoff contamination, sediment deposition and the health hazards caused by dumping of unregulated human waste is a common problem in the Virgin Islands and in most small, mountainous, tropical islands throughout the Caribbean and Pacific regions.

The Coral Bay watershed, St. John, United States Virgin Islands, with the highest population growth rate in the Virgin Islands, is typical of many watersheds throughout the Virgin Islands and the Caribbean, having a large watershed to bay area ratio. Many miles of unpaved roads and inappropriate land uses cause runoff and sedimentation, leading to poor water quality and deterioration of marine resources in waters extending well offshore and into the benthic zone.

A Phase I study within this watershed and the surrounding marine waters, funded by the Non-Point Source Pollution Program at the Department of Planning and Natural Resources, has investigated sediment deposition rate, sediment deposition history and the impact on water quality, fisheries diversity and coral reef health. The proposed study will complete Phase II of this project by developing and demonstrating management procedures applicable to many small, mountainous tropical islands trying to preserve the natural environment.

The primary objective of this project is to use the previously collected data to educate and organize the critical audience of residents, businesses and visitors to non-point source issues affecting water quality in their watershed and to assist them in organizing a watershed residents association with a primary objective of educating and encouraging the larger general population and visitors to use best management practices for water resource protection. The methodology of a watershed focus, where residents have a common identifiable interest in quality of life, has a high impact and transferability within small watershed communities typical of many Caribbean and Pacific locations.

## Methodology

A variety of methodologies will be used to meet the objectives of this project. Several of the objectives are associated with organizing people in the community, developing educational information and providing educational meetings to share this information. Other objectives for this project will require more specific methods to gather information.

Reef Assessment Sampling – This effort will use the coral reef video transect sampling methodology currently in use by U.S. Geological Survey, National Park Service and the University of the Virgin Islands.  Three transect locations previously sampled plus several additional sites at other locations in the bay will provide a representative sampling of coral reef areas in the bay for baseline knowledge of reef health.

Stormwater Chemistry Assessment – The intent is to sample gut water (stormwater runoff) in selected guts within the major portion of the watershed.  Standard and acceptable laboratory techniques will be used to complete a broad analysis of potential contaminants within flowing guts.  This effort will identify possible pollutants originating from land-based sources.

Preliminary Stormwater Management Plan -  A professional engineering firm will be hired to complete the task of evaluating the hydraulic studies of the watershed using the TR55 methodology and physical data supplied by University's Conservation Data Center. After drainage computations are complete, preliminary calculations will determine the stormwater alternatives available to address the sedimentation and runoff problems. The final task will require the contractor to provide stormwater schematics and cost estimates to handle this non-point source pollution.

Watershed Atlas – Using existing Geographic Information Systems (GIS) methodology, all data layers useful for watershed planning will be gathered into a hardcopy and digital atlas of the Coral Bay watershed. This will include data layers for topography, vegetation, marine communities, slope analysis, watershed bounds, National Park bounds, Coral Reef National Monument bounds, Area of Particular Concern (APC) bounds, soils, bathymetry, flood hazard, existing and proposed zoning and land use changes.


**Progress Made**

This project commenced on February 1, 2004. Activities and efforts conducted to date include:

1. Watershed Community Organization- As a result of the Phase I project, a residents association was organized and membership to date is over 150 of 700 residents. Four committees have been formed and all are active in educating, informing and organizing residents. Three presentations have been made on Best Management Practices for watershed residents by the University's Cooperative Extension Service and Conservation Data Center.
2. Watershed Brochure – The final draft of the watershed brochure has been completed. Printing is planned for June 2004.
3. Watershed Atlas – Many of the data layers have been gathered and a preliminary layout has been completed to begin development of the atlas.
4. Preliminary Stormwater Management Plan – A Scope of Work (SOW) has been generated for the plan and the scope has been provided to four engineering firms for bid and task identification.

5. Reef Assessment Sampling – a research dive team has been organized and plans are being made to complete sampling during the June-September period.
6. Stormwater Chemistry – This sampling will be conducted during the wet season from September through December 2004. A local laboratory has been identified to conduct analytical tests for broad spectrum contaminants.
7. Coral Bay Road and Home Maps – The location, size and type of roads in the watershed are critical factors for determining problematic sediment locations. The GIS road and residence data layers have been completed.  These data will be incorporated into the atlas, but the data will also be used to identify problem areas within the watershed for priority restoration.  These maps are also being used as the first Emergency Medical Services locator system, a problem throughout the Territory.

## Presentations

A final version of a community organization brochure and membership application has been prepared for publication in June 2004.

Presentations on this project have been already made to the Coral Bay Community Organization on February 2, 2004 and to the St. John Rotary on February 13, 2004.

Presentations are presently planned for the Cooperative Extension Service's workshop – "Keeping a Healthy Septic System" in March 2004, at the workshop "Visioning – Planning the Future of Coral Bay" offered by Ms. Terri Mars in April 2004, the NOAA/EPA "Land-based Sources of Pollution Conference" on May 17, 2004 and at a workshop titled "Planting for Erosion Control and Drought Tolerance" that will be offered by Ms. Eleanor Gibney in the coming year.

# Student Support

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

# Notable Awards and Achievements

None.

# Publications from Prior Projects