Port Tobacco River Conservancy
Surface-Water Quality Monitoring
And
Study of Ground-Water

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Final Report

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This EPA Grant Agreement Project Report contains: USGS Statements of Work negotiated with the PTRC and the Charles County government; study data collected by the USGS and PTRC water quality monitoring teams; figures and graphics contained in USGA powerpoint briefing presented to 2008 Maryland State-County Groundwater Symposium, found on the MDE web site; and data files forwarded to the PTRC EPA Grant Agreement Project Manager during the conduct of the Surface-Water and Ground-Water Studies. The data interpretation, Port Tobacco River watershed and Port Tobacco Riviera GIS maps (supported by a Charles County PGM planner), and study conclusions and recommendations presented in this report are those solely of the PTRC's project manager/authorized representative and preparer of this Report.

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- Current Charles County Commissioners for providing matching funds for the Surface-Water Study and the previous Commissioners for initiating and supporting the PTRC water monitoring program since 2003
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PTRC appreciates the cooperation of the many Riviera homeowners during the three year study period and especially to the 10 homeowners who allowed USGS to install ground-water wells on their properties for collecting contaminant samples and water level measurements.

Special recognition and thanks to Connie Dunbar, PTRC founder, for her continued technical and administrative guidance and for writing/publishing the *Household Guide to Protecting our Water Quality – The Septic Connection*, distributed to over 10,000 Charles County homeowners.

We thank Joe Tieger, PTRC Board Chair, for providing his technical expertise on the Surface and Ground-Water studies, to Nancy Smart, PTRC communications specialist, for technical editing, and to Brianna Bowling, PTRC member, for formatting the project report for publication.

The PTRC, County residents and public officials acknowledges the dedication and endless efforts by all our volunteers. Collectively they have contributed thousands of hours of effort each year to achieve our mutual water quality goals on many different projects. All of our volunteers are valued, but we would like to give special recognition to the team leaders of our on-going core water quality programs:

- Sherie and Don Zimmer and their water quality team who have collected water samples at up to 40 river and stream sites bimonthly during the recreational months of June thru Sept/Oct. since 2003
- Terry and Mark Stancliff and their Stream Waders team who collected macroinvertabrates samples at 40 sites in early spring to determine the biological health of watershed streams
- Melanie and Don Upright and their team who count yellow perch egg masses each year during the spawning months of late winter; and Ken Hastings and Phil Angle and team who seine several time a year to identify the different species and number of surviving fish in the river.

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Executive Summary

The Port Tobacco River Conservancy Surface-Water Monitoring and Study of Ground-Water Project was a three year initiative funded through a U.S. Environmental Protection Agency (EPA) Grant Agreement awarded in April 2007. EPA grant and matching funds supported the introduction of advanced techniques by the U.S. Geological Survey (USGS). This added another dimension to the surface-water data collected since 2003 by Port Tobacco River Conservancy (PTRC) volunteers in the river and streams throughout the 47 square mile Port Tobacco River watershed. Project funds also supported a new ground-water study conducted by USGS and PTRC water monitors of a 145 home, river-side development built in the 1950s in Port Tobacco, MD.

In 2003, PTRC established three ongoing water monitoring programs performed by volunteers to characterize the condition of the watershed and to provide input to plans to restore its river and streams. The three programs are: Surface-Water Monitoring to determine the levels and sources of bacteria that might pose a public health concern; Stream Surveys to determine the biological health of the streams, which impacts fish and wildlife; and Fish Surveys to monitoring spawning to conduct fish population seining.

In 2005, David O'Neill, Director of the Chesapeake Bay Trust, requested that US Congressman Steny Hoyer sponsor a Region III FY 2006 STAG (State and Tribal Assistance Grant) project. PTRC decided to obtain expert scientific support from the USGS to build on the data and the pollution source conclusions assembled by PTRC and its partners since 2003. PTRC submitted a grant agreement application to EPA, through the Maryland Department of the Environment (MDE), the designated state sponsor, in February 2007. EPA awarded the grant agreement to PTRC in April 2007. The project included: surface-water quality monitoring and study in the Port Tobacco River and streams throughout the 47 square mile watershed; a ground-water study in a 145 home Port Tobacco Riviera community, which is in a Critical Area, to identify On Site Sewage Disposal System (OSDS) problems and determine cost effective options for restoring homeowners' septic systems; and support implementation of the BRF nitrogen removal retrofit program.

PTRC initiated the Surface-Water Study to validate the sources of bacteria found in 10 tidal and stream sites with the highest levels of bacteria in the Port Tobacco River watershed during its 2003 to 2007 water monitoring program. The Charles County Commissioners entered into a Joint Funding Agreement with the USGS to conduct this study. In October 2007, the USGS and PTRC team collected water samples to determine the presence of organic wastewater compounds (OWC), major ions, nutrients and bacteria. Most of the stream sites had no or insufficient water flow due to the extreme drought conditions in Southern Maryland resulting in limited data to reach acceptable conclusions. Retesting was conducted in 2008 at four of the original 10 sites that produced the highest levels of contaminants.

The predominance of high bacteria levels at most watershed stream sites leads to the conclusion that streams should be avoided for recreation. Bacteria levels in the main river area near and below Fourth Point become diluted and degraded by brackish tidal waters and are acceptable for recreation except after heavy rains. At the four sites retested in 2008, we conclude that the septic systems in the residential community adjacent to PT 38 are a major source of pollution and recommend that the homes be connected to a waste water treatment plant (WWTP). At PT 48, we cannot determine, with the current data, if the adjacent community is the predominant source of bacteria pollution. However, we recommend that the Town of La Plata continue pursuing funds to connect the community located upstream of the PT 48 site, to the La Plata WWTP. PTRC will monitor bacteria levels at both sites after the PT 33 community is connected. At PT 26, the upstream horse and cattle farms are a major source of bacteria pollution. The Charles County Soil Conservation District and the Maryland Cooperative Extension should recommend BMPs (best management practices) and provide assistance with federal and state cost sharing to farm owners for excluding livestock and their waste from entering the streams. At PT 12, tidal site adjacent to the Port Tobacco Riviera, we conclude that septic systems contribute to polluting the Port Tobacco River. The Ground-Water Study data confirms this conclusion and the recommendation to connect to a WWTP.

The Port Tobacco Riviera was selected for this ground-water study for the following reasons: Fixing failing OSDSs (septic systems) presents the best opportunity for restoring the Port Tobacco River Watershed, accordingly to the Charles County WRAS; approximately 50% of the Riviera homes are in the Port Tobacco River Critical Area and approximately 25% of all Riviera homes have experienced septic system failures; benefits to Riviera families are safe water for recreation, healthier water promotes increased fish populations, attention by local, state and federal governments and other grant entities to apply funding, lower future costs to homeowner by preventing expensive repairs, and increased property values.

A Technical Assistance Agreement was established in April 2007 between the USGS and the PTRC for the Evaluation of Ground–Water Quality and Interaction with Surface-Water in the Port Tobacco Riviera Area, Charles County, Maryland. USGS's methodology was to collect ground-water hydrology and water-quality data "to obtain a preliminary evaluation of (1) ground-water-flow directions in the Port Tobacco Riviera area and flowpaths to the Port Tobacco River, (2) contaminant transport from septic systems in the Port Tobacco Riviera area to underlying aquifers and the Port Tobacco River, and (3) geochemical controls and fate of potential major septic system contaminants during transport to the Port Tobacco River."

In April 2007, a National Park Service helicopter was used in a fly-over of the Riviera to obtain thermal infrared imaging (TIR) to locate potential areas of preferential ground-water discharges in the Port Tobacco River. Six ground-water discharges from the Riviera were recorded. In May, USGS sampled porewater sediment in the riverbed at four of the potential river discharges. USGS recorded nitrate, ammonia, specific conductance, pH and temperature levels to determine if the ground-water in the discharges could contain septic waste contamination. USGS's objective was to identify potential contaminated ground-water locations and to follow inland with piezometer

(ground-water wells) transects. Two discharge areas identified from the TIR and the subsequent sampling are in a line with the ends of Ravines 2 and 3 stream channels.

USGA collected sixteen surface-water samples in the ravine streams whose analysis of nitrate, ammonia, specific conductance, pH, and temperature indicated that septic contaminants in ground-water were being discharged into ravines streams and possibly transported to the Port Tobacco River.

Drilling was conducted in July 2007 using a USGS Geoprobe rig to install 26 piezometers with 1.0-ft-long screened intervals were placed in nests at a total of 10 sites on homeowners' properties. Soil sediment cores were obtained to depths of 20 to 40 ft. Ground-water samples were collected from the piezometers immediately after drilling for preliminary analyses of nitrate, ammonia, specific conductance, pH, and temperature. Nitrate and ammonia concentrations were consistent with measurements in the surface-water of the intermittent ravine streams and in the porewater in the seep areas.

Pressure transducers were installed in three piezometers in September to obtain semi-continuous water-level measurements over two weeks for preliminary evaluation of tidal effects on ground-water flow. Levels at two piezometers at site PT-Z1 located adjacent to a river channel bulkhead showed that tides have a more pronounced effect in shallower wells.

Synoptic water-level measurements were made in all 26 piezometers in September to provide data for evaluation of ground-water-flow directions. Surveying was begun in September 2007 to obtain elevations of measuring points on all piezometers and allow ground-water levels to be calculated to a common reference point. Data analysis of sediment cores, piezometer sampling, and water-level measurements were conducted to refine the geology model of the Riviera.

A search of the Health Department septic drain field repair records showed a 26% failure rate over all homes in the Riviera. The records also indicated that the most repairs were installed below the ground-water levels measured in the study. Current regulations require a minimum of a four foot separation between the bottom of the septic fields and the top level of the ground-water.

Due to the severe drought conditions experienced in 2007, contaminant levels were lower than expected as measured in the ground-water wells and in the limited sampling of ravine surface-waters. USGS and PTRC decided to retest in 2008 in anticipation of a normal rain season. Greater emphasis would be put on sampling surface-water and sediment porewater in the ravines' streams.

Drought conditions continued in 2008, but to a lesser degree than in 2007. However, due to the increased numbers of sites strategically sampled in the ravine streams both before and immediately after a storm event, the levels of the nitrates and bacteria contaminants increased significantly over the 2007 sampling levels. The additional sampling sites for testing OWCs, major ions and total organic carbon confirmed the presence of septic waste in the streams that flowed toward the river.

PTRC concludes that most, if not all, Port Tobacco Riviera OSDS (septics systems) are under ground-water. Contaminates from these systems are being transported to the River via below land surface ground-water and by ground-water that seeps into ravine streams and is carried, with or without storm water, over land directly to multiple discharge locations at river's edge. The geology of the Riviera, consisting of layers of pervious and impervious soil formations, high ground-water levels during normal rain conditions, and steep ravines, rapidly transports contaminants to the river.

Two options for restoring/replacing all sewage disposal systems in the Riviera have been considered: replace with BRF nitrogen reduction septic tanks; or connect to an on or off site waste water treatment plant (WWTP). Considering the superior ability of a WWTP to reduce contaminants going into the river and the current and future costs of maintaining an OSDS, PTRC recommends the WWTP option. This option is recommended by the Charles County Health Department.

Storm water management practices of the 1970s and earlier years, designed to move rain water away from homes and properties, continue to prevail in the Riviera. These practices result in some homes, especially in the lowlands, being flooded and even partially destroyed as a result of storm surges. These practices also provide a conduit for contaminant laden storm water to be discharged in the river without being filtered and used to recharge the aquifers. Ravine stream banks are also being eroded, carrying debris, sand, gravel and sediment from upland areas on to roads and properties and into the river. PTRC recommends that the latest county and state storm water management codes, including Environmental Site Design (ESD) be strategically implemented, in areas of greatest impact, with local, state, and federal government funds.

The PTRC EPA project manager and members assist the Charles County Health Department implement the BRF Program by providing education outreach and hands-on lessons learned to interested homeowners. PTRC first obtained Charles County Commissioners' approval to direct County government resources, namely County Planning and Growth Management (PGM) and the Charles County Health Department, to apply for a competitive BRF grant in April 2006. The County received $604K that supported the installation of 35 systems. In the summer of 2007, PTRC assisted the Health Department's Environmental Health Director conduct a MDE BRF Vendors Day to introduce nitrogen removal retrofits to owners of septic systems. PTRC members applied for and received BRF grants to install two of the first nitrogen removal tanks on their river front properties in the Port Tobacco River watershed. These two systems served as a prototype for homeowners to learn the application process and to test the equipment.

The ultimate success of the initial BRF increment belongs to the Environmental Health Director and his staff. The Health Department requested $1.8M for the second increment; $900K was approved due to other demands on BRF program funds. It is expected that 70 systems will be installed with this second funding increment.

Section 1: Introduction

The Port Tobacco River Conservancy Surface-Water Monitoring and Study of Ground-Water Project was a three year initiative funded through a U.S. Environmental Protection Agency (EPA) Grant Agreement awarded in April 2007. EPA grant and matching funds supported the introduction of advanced techniques by the U.S. Geological Survey (USGS). This added another dimension to the surface-water data collected since 2003 by Port Tobacco River Conservancy (PTRC) volunteers in the river and streams throughout the 47 square mile Port Tobacco River watershed. Project funds also supported a new ground-water study conducted by USGS and PTRC water monitors of a 145 home, river-side development built in the 1950s in Port Tobacco, MD. The goal of the surface-water and ground-water studies was to confirm the various sources of pollution and determine the most effective options for restoration. The project pulled together work by the PTRC, USGS, the Charles County Government, the Maryland Department of the Environment (MDE), the Maryland Department of Natural Resources (DNR), the Maryland Department of Health and Mental Hygiene (DHMH), the Charles County Health Department, and local homeowners.

1.1 Project Background

PTRC was formed in 2001 by a small group of citizens concerned about the declining health of the River and its watershed. The goal of the PTRC was to return this natural and historic river and watershed to the more pristine conditions experienced prior to the 1950s: having clear and navigable waters; rich in fish and wildlife; and safe for the residents and visitors that use it for recreation.

Working with local and state government and private organizations, PTRC established three ongoing water monitoring programs performed by volunteers to characterize the condition of the watershed and to provide input to plans to restore its river and streams. The three programs are: Surface-Water Monitoring, under the guidance of and technical support from MDE, DHMH and the Charles County Health Department, to determine the levels and sources of bacteria that might pose a public health concern; Stream Surveys under the DNR Stream Wader Program to determine the biological health of the streams, which impacts fish and wildlife; and Fish Surveys (spawning egg counts and fish population seining) supported by the Coastal Conservation Association (CCA). Description of these water monitoring programs and the compilation of the data collected are shown in Appendices B, C and D.

PTRC promoted the MDE Beaches Water Monitoring and Public Notification Program to County government officials. In 2006, the Charles County Commissioners funded and granted responsibility for this program to the Charles County Health Department. Following the water monitoring process established for the Port Tobacco River watershed, the Health Department now monitors water quality at public beaches and provides public notification of health risks at the Nanjemoy Creek, Mattawomen Creek, Neale Sound, Cuckold Creek, and Wicomico River, as well as the Port Tobacco River beach areas.

The results of these monitoring efforts indicated the need and provided the justification to seek grant funding to correct the problems. Since 2001, PTRC's membership has grown to nearly 200 citizens interested in improving their river. Partnerships have been established with over 25 local, state and federal organizations, environmental support groups and grant funders to support our efforts. With the strong support from the PTRC partners, Charles County and the PTRC have received over $2 million in funding and technical support to restore the Port Tobacco River watershed, including:

- $40K 2005 MDE grant to characterize the condition of the watershed and to develop a plan to correct the problems. The County Charles Department of Planning and Growth Management (PGM) applied for this grant based on a request and justification provided by the PTRC. Tens of thousands of dollars in in-kind support have been contributed by MDE, DNR, Charles County Health Department, PGM, and PTRC volunteers in characterizing the watershed. The Center for Watershed Protection (CWP) facilitated the preparation of the Port Tobacco River Watershed Restoration Action Strategy (WRAS) plan approved by the Charles County Commissioners in 2007.

- $35K 2005 National Fish and Wildlife Foundation grant awarded to the PTRC, Southern Maryland Resource Conservation & Development, Inc (SoMd RC&D) and the CWP for watershed planning and OSDS educational outreach. The grant funded a homeowner survey of the Port Tobacco Riviera community that identified problems and citizen willingness to contribute attention and money to fix the community's septic problems. 12,000 *Water Quality/The Septic Connection* brochures were prepared by PTRC and distributed to watershed homeowners, businesses and organizations by PTRC and PGM. Additional, the PTRC web site was updated to provide educational materials to citizens on how they can protect their environment.

- $25K 2006 Chesapeake Bay Trust (CBT) Storm Water Management in the Town of La Plata grant was awarded to the PTRC and CWP partnership. The County Commissioners and the La Plata Mayor and Town Council supported this grant. Major deliverables included: 25 storm water management project initiatives for inclusion in the WRAS watershed plan; a demonstration rain garden at an elementary school and educational outreach to the students.

- $200K 2006 Congressional funding sponsored by Congressman Hoyer, through an EPA Grant Agreement, to the PTRC to continue its water monitoring and restoration efforts. The grant included: a ground-water study in the 1950's river side community referenced above, known as the Port Tobacco Riviera; a watershed wide surface-water study; and identification of OSDS and other pollution sources restoration options.

- $1.5M 2006 Bay Restoration Fund (BRF) grant to the Charles County Government to upgrade septic systems to best available technology for nitrogen removal in the Port

Tobacco River Watershed. Support and justification for the BRF request resulted from a PTRC and Health Department-sponsored Water Monitoring and Septic System Long Range Strategy Workshop. PTRC obtained County Commissioners' approval for the PGM and the Health Department to submit the Bay Restoration Fund grant application to MDE.

- $111.5K 2008 CBT Targeted Watershed Initiative grant for erosion control and nutrient reduction awarded to PTRC. The grant funded: construction of three fully functional rain gardens at a large high school, educational outreach to students; construction of a swale in a privately owned wetland mitigation bank to divert a major stream that was carrying storm and groundwater containing nutrients from a golf course and stream erosion sediment to the river; and fences and a watering well to remove cattle from a stream.

- $11.5K 2008 DNR Land Owner Incentive Program (LIP) grant for buffer planting and nutrient reduction.

- $112K 2005 to 2008 CBT and the Chesapeake Bay Funders Network (CBFN) grants to PTRC for capacity building that provided PTRC volunteers operational support for water monitoring, restoration projects and advocacy.

The data collected and the knowledge gained from the above watershed assessments and restoration initiatives conducted by PTRC and its partners from 2002 through 2009, have contributed to conclusions contained in this EPA Project Report.

1.2 Project Origin

In 2005, David O'Neill, Director of the Chesapeake Bay Trust, requested that US Congressman Steny Hoyer sponsor a Region III FY 2006 STAG (State and Tribal Assistance Grant) project. The Media Release from Congressman Hoyer announcing the project reads:

> *"In October 2001, high levels of harmful bacteria were found in the Port Tobacco River. Since then, the Port Tobacco River Conservancy has worked with residents, local governments, and various conservation groups to restore and protect the rivers and streams in the watershed. While the Conservancy and its partners have made progress, the River does not meet clean water goals and is in need of special protection of its natural resources. This funding will be used for water quality and restoration projects for the Port Tobacco River and its tributaries…"*

Congressman Hoyer's grant was not solicited by PTRC nor was the scope in the above media release specifically defined. This presented PTRC with an opportunity to recommend projects that might resolve the highest priority pollution problems perceived to exist in the watershed. In consultation with the Charles County PGM and Health Department, PTRC decided to obtain expert scientific support to build on the data and the pollution source conclusions assembled by PTRC and its partners since 2003. PTRC submitted a grant agreement application to EPA, through MDE, the

designated state sponsor, in February 2007. EPA awarded the grant agreement to PTRC in April 2007.

1.3 Project Goal and Objectives

The statement of work that accompanied the grant stated that the goal of the Water Quality and Restoration Project "is to improve the water quality in the Port Tobacco River and its watershed." It went on to define the project's objectives:

- Use advanced monitoring techniques, such as USGS's Organic Wastewater Compound (OWC), to add a dimension to the pollution data collected by the PTRC volunteers – and to validate or change current assumptions as to the source of the pollution
- Present options for restoring OSDS and others pollution sources
- Obtain acceptance by Port Tobacco River watershed homeowners and businesses to implement correction/restoration of environmental problems. Clearly present the needs, benefits and costs of the restoration options
- Obtain support from local, state and federal governments and other grant entities to fund the restoration initiatives.

1.4 Project Scope

The project included: surface-water quality monitoring and study in the Port Tobacco River and streams throughout the 47 square mile watershed; a ground-water study in a 145 home Port Tobacco Riviera community, which is in a Critical Area, to identify OSDS problems and determine cost effective options for restoring homeowners' septic systems; and support implementation of the BRF nitrogen removal retrofit program. The scope of the subprojects, as stated in the grant agreement, is provided below:

"Continue PTRC's surface-water quality monitoring for harmful levels of bacteria". This project will support and improve the on-going monitoring program. Currently the waterways are tested twice a month during the recreation season at approximately 15 river and stream sites. Water sampling will further isolate new sources of pollution and identify restoration action required. Testing will also provide a baseline to gauge the effectiveness of restoration efforts funded by this project and by WRAS initiatives funded by others. The project will fund technical oversight of two or more teams of volunteer samplers, the dissemination of information to the County Health Department for public health risk notification and to local and state offices for corrective action. The monitoring data will be updated on the Health Department's and Conservancy's web sites to inform the public. Funds will also be used to replace outdated test instruments on loan from MDE with advanced instruments meeting MDE's upgrade specs. Monitoring results are provided in Appendix B.

Surface-Water Study of the Port Tobacco River watershed using advanced monitoring techniques". The USGS team, using matching funds from Charles County government, will identify the presence

of Organic Wastewater Compounds (OWC) and nutrient pollutants. PTRC volunteers will team with USGS by collecting water samples for the presence of enterococci bacteria. Sampling will be conducted at up to ten locations suspected of producing the pollutants. Study approach, performance and results are given in Section 2.

"Ground-Water Study of a residential community in the Critical Area". The USGS will conduct ground water characterization of the riverside community of Port Tobacco Riviera. This study will identify the geochemical and hydrologic factors that could control the transport and fate of contaminants from residential OSDSs to the Port Tobacco River. PTRC volunteers will team with USGS by collecting water samples for the presence of enterococci bacteria. Study approach, performance and results are given in Section 3.

"Support of the BRF Nutrient Removal Retrofit Program ". PTRC will assist the Charles County Health Department implement the BRF Program by providing education outreach and hands-on lessons learned to interested homeowners. PTRC support is outlined in Section 4.

Section 2: Surface-Water Study

PTRC initiated this surface-water study to validate the sources of bacteria found in river and stream sites with the highest levels of bacteria in the Port Tobacco River watershed during its 2003 to 2007 water monitoring program. The Charles County Commissioners entered into a Joint Funding Agreement with the USGS to conduct this study. The County funds would serve, in part, as a match for the $200,000 EPA grant to PTRC to obtain scientific analyses to support water quality restoration options. County funding to USGS would also cover the cost of a limited number of water samples in the neighboring Nanjemoy River watershed to obtain a comparison with a more rural area of Charles County.

2.1 Statement of Work (SOW)

The Joint Funding Agreement was established between the USGS and the Charles County Government for the "*Reconnaissance of Surface-Water Quality in Charles County, Maryland for Organic Wastewater Compounds, Major Ions, Nutrients and other Water-Quality Parameters* The reconnaissance samples will be collected synoptically during low base flow in October 2006. Kolpin and others (2004) have shown that low base flow is the most opportune time to detect organic wastewater compounds in streams when there is a ground-water source. Approximately 10 samples will be collected in the Port Tobacco River watershed and five samples in the Nanjemoy River watershed. Four additional samples will be used as quality control and will include field blanks and replicates. The use of grab samples rather than the recommended integrated cross-sectional sampling will be consistent with current sample methods used by the Port Tobacco River Conservancy and Charles County. Some modifications by the USGS will likely be necessary for the proposed analytes.

"Whole water will be analyzed for a suite of chemical constituents by the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado. These chemicals will include prescription and non-prescription drugs, fragrances and flavorings, cosmetics, flame retardants, plasticizers, detergents and metabolites, disinfectants, pesticides, and combustion products. A detailed list of analytes in the water schedule will be provided to Charles County ahead of the sampling program (Cahill and others, 2004). Whole water will be analyzed rather than filtered water, because many of the analytes are hydrophobic and thus will be associated with organic carbon in both the particulate and dissolved phases. The analytical method is described in Zaugg and others (in press).

"Dissolved copper will be measured because it is often an indicator of home distribution systems. Total Kjehdahl nitrogen, total and dissolved organic carbons also contribute to wastewater signatures.

"Major ions and nutrients will provide information about overall water chemistry and will help clarify potential sources of water to the streams and tributaries. Information collected in this study will complement the future ground-water study planned for the Port Tobacco Riviera area. USGS databases will be searched for other ground-water- quality data for comparison and future interpretation.

"The USGS will also collect in the field during the water-quality sampling, pH, temperature, specific electrical conductance and alkalinity. This data will be collected using a multi-parameter data sonde that will be deployed in the field during the sampling effort. Alkalinity will be titrated in the field or in the evening. This data will be entered into the USGS databases when returning to the office."

2.2 Performance and Results

2007 Sampling Results The PTRC and USGS teams conducted a field survey to acquaint team members with the locations and to determine the stream's suitability for taking water samples. On 9 October 2007, water samples were taken from three tidal locations to test for the presence of OWCs and enterococci bacteria. Most non-tidal sites had no or insufficient water flow to obtain a sample due to the extreme drought conditions in Southern Maryland. The remaining sites were sampled on 30 October after the area received five inches of rain during the previous week. The OWC results of the 10 Port Tobacco River watershed sites and five Nanjemoy sites are shown in Figure 1 and Appendix D. PTRC and USGS reviewed data from approximately 60 OWC analyses from the Department of Interior USGS Denver Lab, physical properties by USGS field test and bacteria samples by PTRC volunteers and analyses by the DHMH lab. PTRC, USGS and the Charles County PGM concluded that retesting in 2008 was needed when more normal rain conditions were expected.

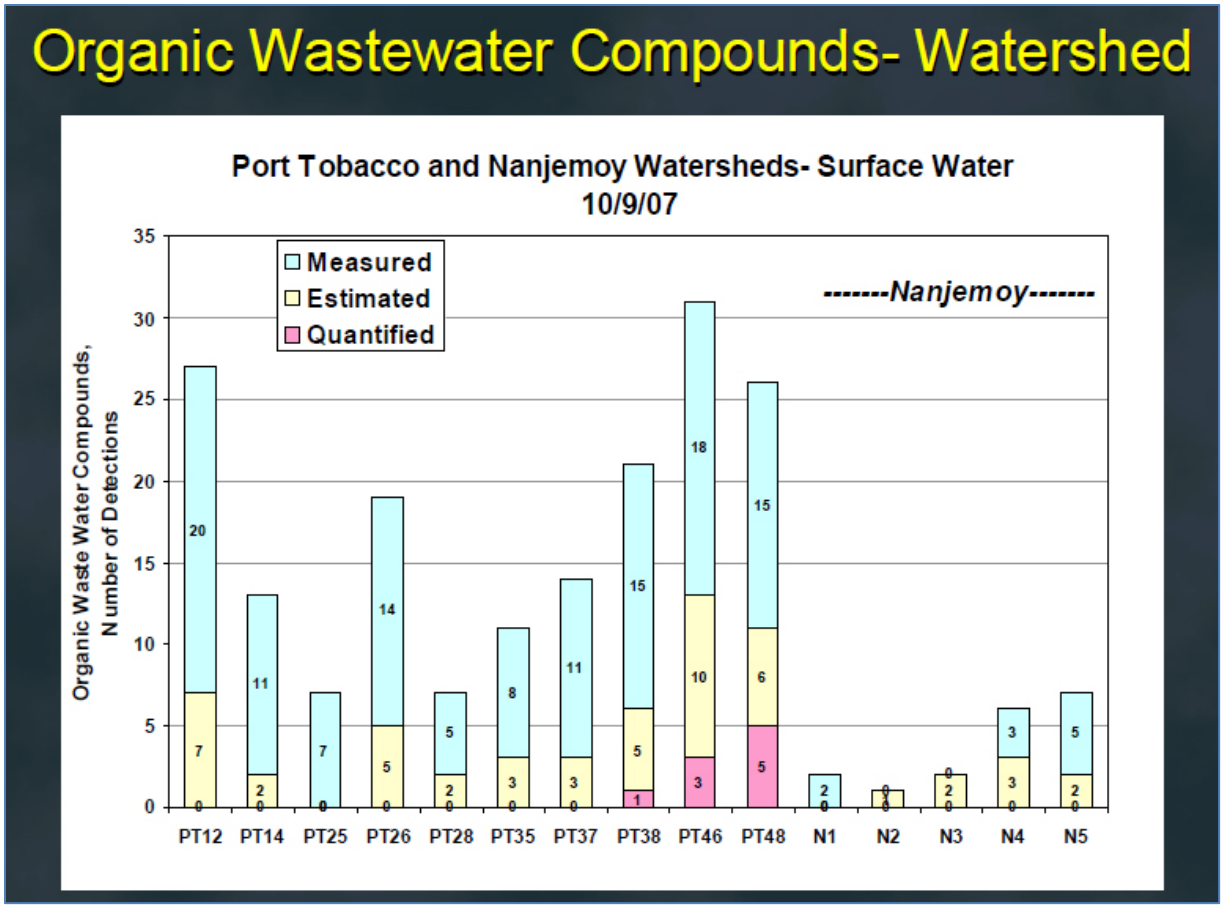


Figure 1: OWCs are used to detect the presence of septic waste.

Surface-Water and Porewater Quality Sampling at Selective Sites in the Port Tobacco River Watershed, Charles County, Maryland **Retesting SOW** "Samples will be collected over two consecutive days during low base flow in June or July 2008. Concurrent surface-water and porewater samples will be collected from five locations in the Port Tobacco River watershed. An equipment blank and duplicate sample will be collected at one of these locations. Surface-water samples also will be collected at one site in the Nanjemoy River watershed that had low detections of OWCs in the 2007 sampling to provide background reference samples. Surface-water collection will be grab samples rather than the recommended integrated cross-sectional sampling to be consistent with current sample methods used by the PTRC and Charles County and the 2007 USGS sampling. Porewater will be collected from shallow temporary piezometers (screen depths of about 2 ft) that will be installed manually in the streambed at the Port Tobacco River watershed sites at least one week prior to sampling.

"All surface-water samples will be analyzed for field parameters, nutrients (nitrate, ammonia, organic nitrogen, phosphorus), Total Organic Carbons (TOC), major ions, OWCs, and enterococci

bacteria. All porewater samples from the piezometers will be analyzed for field parameters, nutrients, TOC, major ions, and bacteria. At one or two of the porewater sites in the Port Tobacco watershed, OWC samples will be collected using passive integrative samplers, which would allow sample collection where sufficient water volumes are difficult to obtain by pumping porewater.

"OWCs only whole water samples or the POCIS will be analyzed by the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado, using the same method as the 2007 samples. Major ions, nutrients, and TOC also will be analyzed by NWQL. Multi-parameter meters will be used to measure pH, temperature, specific electrical conductance, and turbidity in the field during the water-quality sampling. Samples will also be collected for measurement of alkalinity by titration within 24 hours of collection. Field data will be entered into the USGS databases after returning to the office. PTRC will collect the samples for bacteria for analysis by DHMH to remain consistent with 2007 data."

2008 Retesting The major difference between the 2007 and 2008 sampling effort was the addition of porewater (PW) sampling under two methods. At three sites, pipes were pushed into 2 feet of stream sediment and PW samples were extracted. Under a second method, a Polar Organic Chemical Integrative Sampler (POCIS) consisting of a flat wafer-shaped screened container, was buried in the stream sediment at three sites for three weeks to sample the cumulative effect of pollution . The POCIS detected a total of eight pharmaceutical and six pesticide OWCs at these sites. However, due to the continued drought in 2008, the number and levels of OWCs and bacteria samples actually decreased from those recorded in 2007.

2.3 Results, Conclusions and Recommendations

The Port Tobacco River watershed map, shown in Figure 2, summarizes the data results of sites under study in four highlighted text boxes. The map also shows over 40 sites monitored by PTRC volunteers during the 2003 to 2009 recreation seasons (June through September). The Red/Poor, Yellow/Fair and Green/Good circles indicate levels of adherence to the Maryland Code (COMAR) water quality standards.

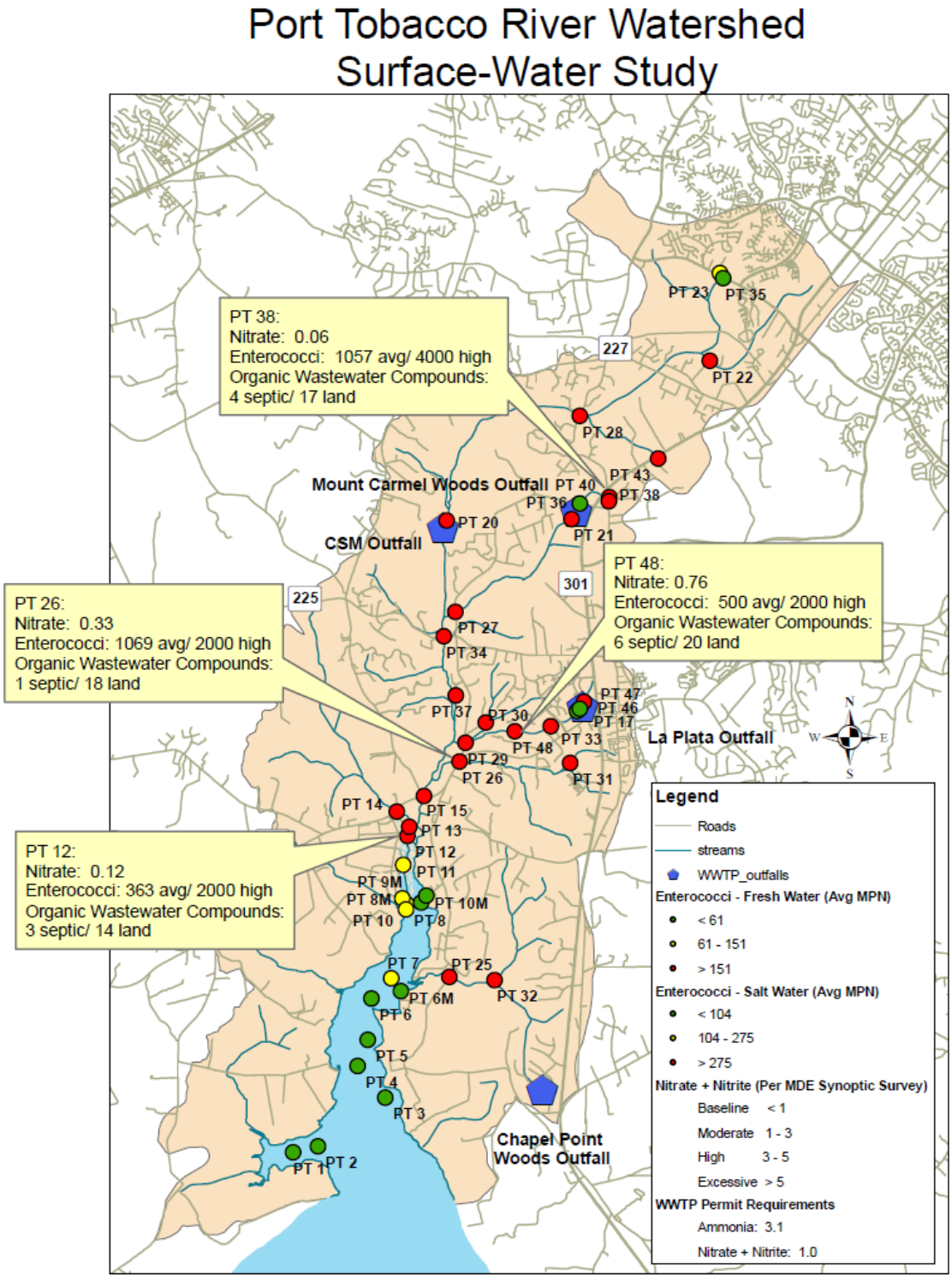


Figure 2: Port Tobacco River Watershed Map – This map prepared by the Charles County Planning Division using MD Property View. Monitoring stations and data from the Port Tobacco River Conservancy, Inc. Roads from Charles County files. March , 2010.

The predominance of red monitoring sites leads to the conclusion that most watershed streams have unacceptable levels of bacteria and should be avoided for recreation. Bacteria levels in the main river area near and below Fourth Point (PT6) become diluted and degraded by brackish tidal waters and are acceptable for recreation except after heavy rains.

Appendix E spreadsheets provide porewater (PW) and surface-water (SW) OWCs detections for 2007 and 2008 sampling results for the Port Tobacco River watershed sites. The spreadsheet also indicates, in the yellow highlights, the OWCs that are normally found in septic systems discharges.

Conclusions and recommendations for four sites in the Surface-Water Study are presented below:

PT 38 - Washington Ave. and Jennie's Run Head Waters. The stream site is located at the entrance of a 1960's residential development on septic systems that have experienced above average number of repairs. The community has high ground-water levels under normal rainfall conditions. This site has the highest recorded bacteria levels, sometimes exceeding 4000 colonies (MPN)/100ml, of any site in the watershed. OWC detection of four septic indicators is slightly less than the six septic OWCs detected downstream from the La Plata waste water treatment plant. Other septic indicators recorded at this site, including TOC and Dissolved Cooper, were moderate. We conclude that septic systems in this community are a major source of pollution and recommend that the Charles County PGM, Health Department and MDE develop plans and funding sources to convert to a waste water treatment plant.

PT 48 – Darley Drive Southwest of the La Plata Outfall. The stream site is adjacent to one side of a 1960's residential development on septic systems. The community is located on a high hill with mostly pervious soils, based on a USDA soil survey, and with no indication of high ground-water (no ground-water measurements taken). The community is southwest of both the La Plata WWTP and a small community, near PT 33, on septic systems. The WWTP fecal coliform levels discharge in the sites stream is seldom over 2 MPNs /100 ml. The average enterococci bacteria level as it passes the PT 33 community is 400MPNs/100ml. OWC level at PT 48 of six septics is compared to five septics discharged from the WWTP. The WWTP's 1 M gal/day discharge of "fresh water" into the PT33 and PT48 stream should have the affect of diluting the bacteria levels recorded downstream. We cannot conclude that the community at PT48 is or is not a source of pollution in the stream. We recommend that the Town of La Plata continue to pursue funding sources to connect the Walnut Hill community at PT33 to the WWTP before further study of the Darley Drive community.

PT 26 – Rt. 6 South of Valley Road (Stream site just southwest of Cattle and Horse Farms). This location has the second highest levels of bacteria recorded in the watershed. The one OWC (normally identified with septic systems) indicates that there is not a strong influence from septic systems. The OWC detected was "Fragrance, stench in feces and coal tar" that could be associated with cattle grazing and horse boarding operations. The land

OWCs, which included liniments, UV absorbing lotions, wood preservatives, pesticides, seed treatments, and herbicides, also indicate the strong presence of the livestock and grain processing operations that are located near the sampling site. The normally high levels of bacteria suggest that there is a strong contaminant source in and feeding the stream. Three miles up-stream, a sewer manhole becomes infiltrated with storm water after heavy rains. However, this problem occurred infrequently during the drought over the two years of testing and is currently being corrected by sewer infrastructure upgrades. The lack of septic OWCs indicates that the bacteria from the manhole were not a significant contributor. We conclude that the source of the bacteria is the livestock operations near and in the stream and recommend Charles County Soil Conservation District and the Maryland Cooperative Extension suggest best management practices (BMP) and provide assistance with federal and state cost sharing to farm owners to exclude livestock and their waste from the streams.

PT 12 Tidal Site adjacent to Riviera Place in the Port Tobacco Riviera. The data results and conclusions of this site are an integral part of the Ground-Water Study under Section 3 of this report. We conclude that Riviera septic systems contribute to pollution the Port Tobacco River. Please refer to Section 3 for a full presentation of conclusions.

Section 3: Ground-Water Study

In addition to 145 homes, the Port Tobacco Riviera includes a restaurant, a RV resort and marina, located in Port Tobacco, Maryland in the northern tidal portion of the Port Tobacco River. The Riviera extends from lowland homes with lawns that reach to adjacent bulkheads along the river channels; to midland homes, west of Shirley Blvd., at 30 to 70 ft. elevation and mostly within the Critical Area; and through a heavy forested area of steep slopes and deep ravines to uplands homes up to a 170 ft. elevation and 3500 feet from the river.

The development began in the 1950's with most homes being constructed prior to the 1980's. The homes, restaurant and marina are on individual wells and OSDSs with drain fields; RVs in the RV Resort use a commercial pump out service for their sewage disposal. Since the introduction of more stringent OSDS standards requiring a four foot separation between the bottom of the drain fields and the top of the ground-water, some post 1990 homes have alternative OSDSs employing tanks connected to sand mounds and other advanced systems.

The Port Tobacco Riviera was selected for this ground-water study for the following reasons:

- Fixing failing OSDSs (septic systems) presents the best opportunity for restoring the Port Tobacco River Watershed, accordingly to the Charles County WRAS. The watershed assessment was performed by MDE and the watershed plan was prepared by the CWP under the direction of the Charles County PGM with citizen input including from PTRC. The major anthropogenic (human) pollution source in the immediate Port Tobacco River area was estimated to be from OSDSs: 51% of TN (total nitrogen) and 48% from bacteria

- Approximately 50% of the Riviera homes are in the Port Tobacco River Critical Area and the remaining are in close proximity. Pollutants, especially nitrogen, have a short path through both surface and ground-water to the River. Approximately 25% of the homes have experienced septic system failures

- Benefits to Riviera families (and to surrounding river side communities) to restoring and/or preventing future failing systems are many: safe water for recreation; healthier water promotes increased fish populations; attention by local, state and federal governments and other grant entities to apply funding; lower future costs to homeowner by preventing expensive repairs; and increased property values.

3.1 Statements of Work (SOW)

A Technical Assistance Agreement was established in April 2007 between the USGS and the PTRC for the Evaluation of Ground –Water Quality and Interaction with Surface-Water in the Port Tobacco Riviera Area, Charles County, Maryland. The selection of the USGS to conduct this ground-water study resulted from recommendations from MDE's Water Management Administration and from DNR's Maryland Geological Survey (MGS). Appendix A contains a letter from MGS supporting the selection of the USGS to conduct both the ground-water study funded by federal funds and the

surface-water study funded by the Charles County government. MGS stated that "sampling for organic wastewater compounds (OWC)…have the potential to greatly enhance the evaluation of contaminant sources….the USGS are the recognized experts in this field." MGS also related that results from the USGS studies have the potential to enhance the general knowledge of the shallow ground-water flow systems and ground-water/surface-water interaction in southern Maryland. This area is under a multi-year regional evaluation of the Maryland Coastal Plain aquifer by the MGS supported by MDE.

USGS's methodology given in their statement of work is : "As part of the research, ground-water hydrology and water-quality data will be collected to obtain a preliminary evaluation of (1) ground-water-flow directions in the Port Tobacco Riviera area and flowpaths to the Port Tobacco River, (2) contaminant transport from septic systems in the Port Tobacco Riviera area to underlying aquifers and the Port Tobacco River, and (3) geochemical controls and fate of potential major septic system contaminants during transport to the Port Tobacco River."

According to the statement of work, the study would be conducted and built on the knowledge gained in three phases: Reconnaissance; Phase 1 Direct Push Sampling and Piezometer Installation; and Phase 2 Sampling and Monitoring.

Reconnaissance, Phase 1, and Phase 2 SOW

"Reconnaissance Phase. Ground-water discharge locations in the river adjacent to the Riviera will be identified by aerial, high resolution, thermal infrared imaging with a camera operated from a helicopter. Flyovers will be scheduled in early Spring, at low tide, when the river's surface-water is warmer than the discharge of colder ground-water. PVC pipes will be driven into shallow river sediment at the discharge location to collect water samples to be analyzed in the field for the presence of nitrate, ammonia, and specific conductance to determine if the discharged ground-water is impacted by septic waste.

"Upland areas in the Riviera, from these discharge locations, will be observed during and soon after rain events to determine overland flow or seepage along steep slopes into intermittent stream channels. If flow or seepage is present, samples will be collected and analyzed in the field by USGS for nitrate and specific conductance; PTRC will collect samples at these locations for enterococci bacteria and sent to the DHMH lab for analysis. These analyses may determine possible septic contamination."

"Phase 1 Direct Push Sampling and Piezometer Installation. (For definition purposes for this study, a piezometer is a one-inch diameter PVC pipe of varying length and screens, also referred to as ground water wells; direct push sampling is the collection of water samples from these pipes). Two or three short flowpaths will be established from the shore line, in the vicinity of ground-water discharge identified in the reconnaissance phase, to the uplands. The selection of these paths will consider if there is sufficient flow in the ravine stream beds. Piezometers, including short pipes for sampling ground-water in stream sediment (referred to as porewater), and multilevel ground-water wells permanently installed in nests of two to three pipes, will be used to collect samples for

analysis of nitrate, ammonia, specific conductance, pH, temperature, and bacteria. Passive diffusion samplers may be installed to obtain pore water samples from fine-grained sediments in the Port Tobacco River in line with these flow paths.

"Direct push profiling and piezometer installation will extend to maximum depths of about 10 to 15 ft. Maximum screen lengths of 1-foot generally will be installed in piezometers, except if longer screens are necessary to cover possible water table fluctuations with rainfall. Homeowner wells that could be potentially sampled for deeper aquifer (Aquia) samples in Phase 2 (if funded) will also be identified. Although subsurface transport of bacteria from septic systems is not expected by deeper flowpaths, characterizing the ground-water chemistry from the deep aquifer could be important in evaluating potential mixing of ground water from different source areas during discharge, which would affect contaminant concentrations."

"**Phase 2 Sampling and Monitoring.** Samples should be analyzed for major ions, nitrate and nitrite, ammonia, organic nitrogen, copper, dissolved organic carbon (DOC), enterococci, and redox indicators, including dissolved oxygen, ferrous iron, sulfide, and methane. Major ions and nutrients will provide information about overall water chemistry and will help clarify potential sources of water along the ground-water flowpath. Nutrients and DOC also are major indicators of septic system failure. Dissolved copper will be measured because it is often an indicator of home distribution systems and will also be measured in the proposed USGS surface-water synoptic data collection. Organic wastewater compounds (OWC's) also will be analyzed on whole water samples collected from a few select wells to correlate with proposed USGS surface-water quality work. Whole water will be analyzed rather than filtered water, because many of the analytes are hydrophobic and thus will be associated with organic carbon in both the particulate and dissolved phases. The USGS will also measure pH, temperature, specific electrical conductance and alkalinity in the field during the water-quality sampling."

3.2 Reconnaissance, Phase 1 & Phase 2 (original) Performance

Reconnaissance Phase Performance. In April 2007, a National Park Service helicopter was used in a fly-over of the Riviera to obtain thermal infrared imaging (TIR) to locate potential areas of preferential ground-water discharges in the Port Tobacco River. As shown in Figure 3, six ground-water discharges from the Riviera, and another four, most likely from the land on the east side of the Port Tobacco River, were recorded. As expected from knowledge of the topology and geology of this area, the discharges from the west side of the river lined up with ravines that cross the Riviera.

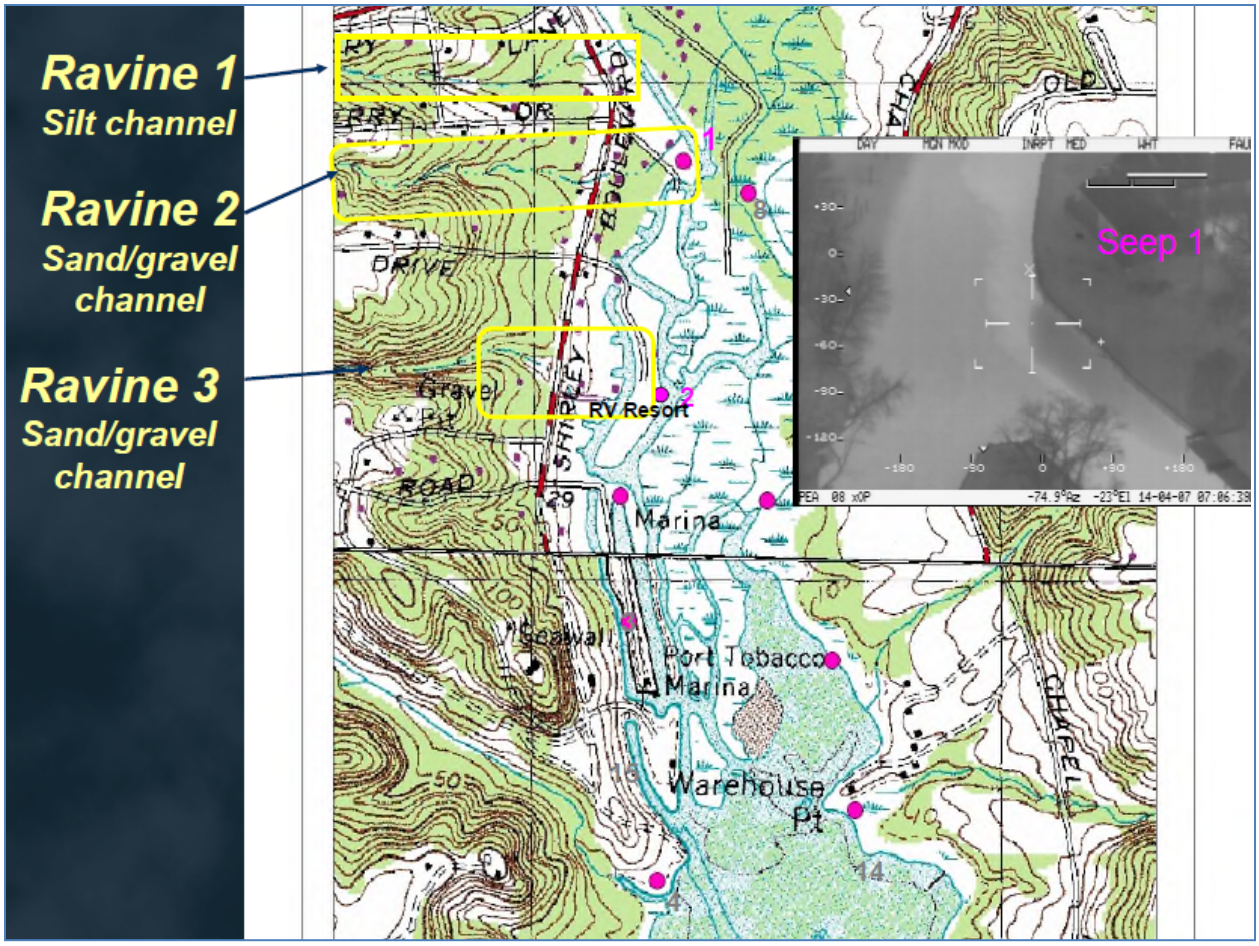


Figure 3: Ground-water discharge in river lines up with ravines

In May, USGS sampled porewater sediment in the riverbed at four of the potential river discharges identified with the TIR near the Port Tobacco Riviera. USGS recorded nitrate, ammonia, specific conductance, pH and temperature levels to determine if the ground-water in the discharges could contain septic waste contamination. USGS's objective was to identify potential contaminated ground-water locations and to follow inland with piezometer transects. Accordingly, the three ravines shown in Figure 3, were selected for the study.

Another objective of the reconnaissance phase was to determine if septic contaminants in the ground-water could discharge to the intermittent streams in the ravines in the Port Tobacco Riviera community and be transported to the Port Tobacco River. Sixteen surface-water samples were collected along three of these streams in May and analyzed for nitrate, ammonia, specific conductance, pH, and temperature. Two discharge areas identified from the TIR and the subsequent sampling are in a line with the ends of Ravines 2 and 3 stream channels.

Phase 1 Direct Push Sampling and Piezometer Installation Performance. The reconnaissance phase data and field observations were evaluated to select locations for two transects for the Phase

1 objective of defining the shallow hydrogeology in the Port Tobacco Riviera community and installing piezometers for ground-water sampling. Seven locations were selected for piezometer installation in Ravine 2 and three locations Ravine 3. The PTRC project manager and the water monitoring team leader obtained permissions from 10 homeowners to drill nests of two to three piezometers on their properties. The response from the community was very positive throughout the project.

Drilling was conducted in July 2007 using a USGS Geoprobe rig in Figure 4. Soil sediment cores were obtained to depths of 20 to 40 ft at a total of 10 sites along the two transects. A total of 26 piezometers with 1.0-ft-long screened intervals were placed in nests at these 10 sites.

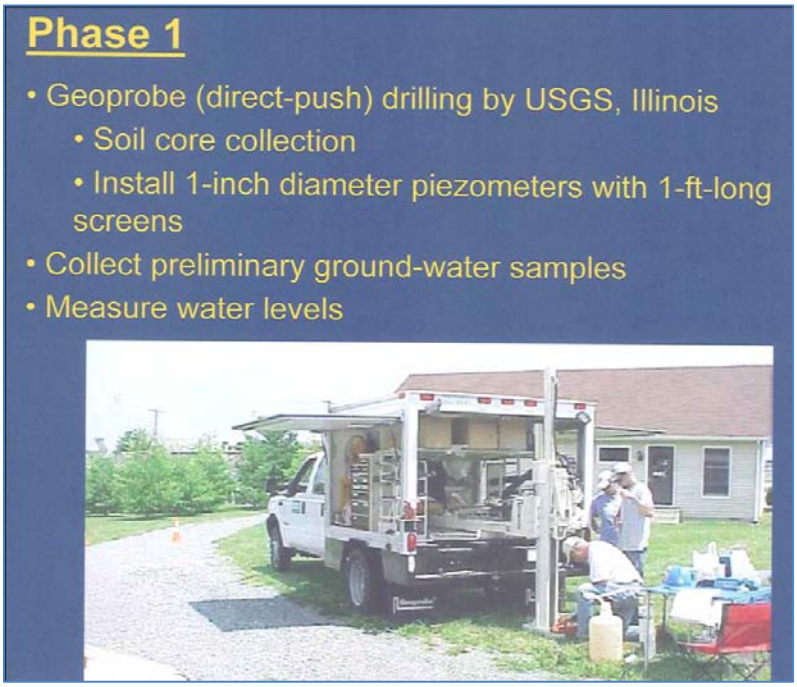


Figure 4: Geoprobe used in Phase 1 drilling

Ground-water samples were collected from the piezometers immediately after drilling for preliminary analyses of nitrate, ammonia, specific conductance, pH, and temperature.

Nitrate and ammonia concentrations were consistent with measurements in the surface-water of the intermittent streams and in the porewater in the seep areas.

Pressure transducers were installed in three piezometers in September to obtain semi-continuous water-level measurements over two weeks for preliminary evaluation of tidal effects on ground-water flow. Figure 5 shows the levels at two piezometers at site PT-Z1 located adjacent to a river channel bulkhead. It shows that tides have a more pronounced effect in shallower wells.

Synoptic water-level measurements were made in all 26 piezometers in September to provide data for evaluation of ground-water-flow directions. Surveying was begun in September 2007 to obtain elevations of measuring points on all piezometers and allow ground-water levels to be calculated to a common reference point. Data analysis of sediment cores, piezometer sampling, and water-level measurements were conducted to refine the geology model of the Riviera.

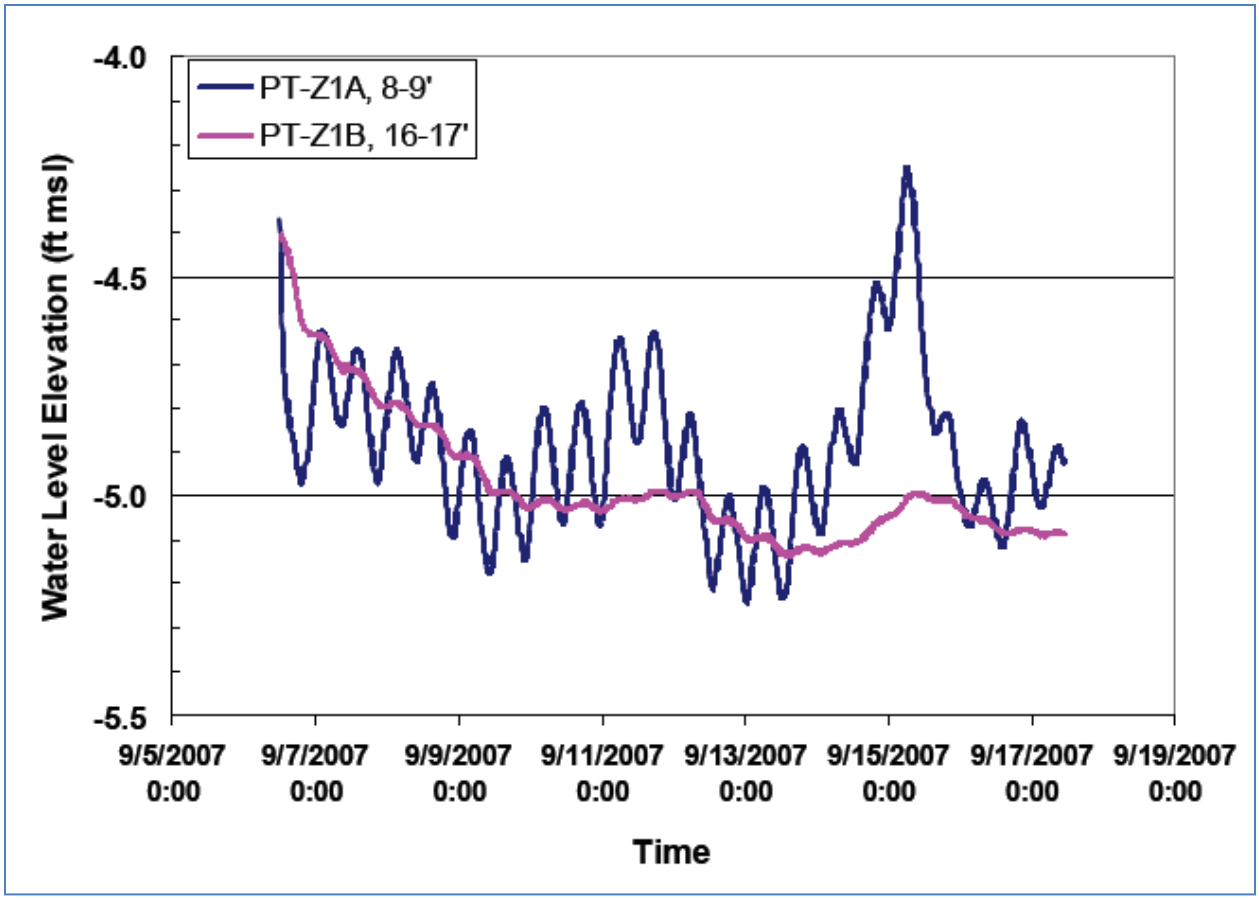


Figure 5: Tides affect ground-water in shallow wells

USGS and PTRC teams collected samples for analyses of nitrates, ammonium, conductance, organic carbon, major ions, OWCs and enterococci from four of the ground-water well nests in late October 2007. The nutrients, major ions and OWCs samples were delivered to the USGS Denver Lab for analysis. Results were provided during the period December 2007 to February 2008. Enterococci samples were processed by the DHMH lab in Baltimore.

USGS provided ground water level recordings from two well sites in Charles County over the past 20 years. Data from 4 County ground water monitoring wells (and USGS wells) showed that ground water levels in 2007 were six feet below normal and the lowest in the 17 years.

The PTRC project manager, with the assistance of a Health Department (HD) sanitarian, reviewed the HD databases for septic drain field failures, repairs and the depth of the fields relative to the level of the ground-water in the uplands, midlands and lowlands. PTRC's project manager met with the HD Environmental Health Director to review the Study's preliminary results and to obtain soil and ground water level data from the Department's experience in issuing permits for and performing inspections of septic system installations.

USGS's Research Hydrologist and Project Leader briefed the PTRC Board of Directors on the Study's progress and preliminary results in December 2007.

3.3 Results

2007 Accomplishments. The ground-water study activities performed by the USGS and PTRC team gained knowledge of the factors that affect the performance of septic systems in the Riviera that did not previously exist, such as:

- Soil sediments core boring samples defined the composition and layers of soils under the land surface that could determine how rain water from storms would either flow downward through soil layers or be limited to flowing out of the ground into the ravine streams. The analysis of the Riviera geology is presented under 2008 Sampling Results

- Pressure transducers installed in ground-water wells provided real time data that river tides infiltrate the ground-water in at least the lowlands soils

- Ground-water monitoring in wells documented the affect of the 2007 drought on each of the 3 altitude levels in the Riviera. Soil composition and layers also influenced the ground-water levels on each level. The 2007 ground-water level data will be combined with the 2008 data and presented in the 2008 Sampling Results section

- A search of the Health Department septic drain field repair records quantified the number of failures and repairs in each of the 3 levels in the Riviera. A summary of the repairs for each section follows:
    - Lowlands - 13 repairs/51 homes = 25% repair rate
    - Midlands - 10 repairs/21 homes – 48% repair rate
    - Highlands – 15 repairs/73 homes = 21% repairs

  The records also indicated that the most repairs were installed below the ground-water levels measured in the study. Current regulations require a minimum of a four foot separation between the bottom of the septic fields and the top level of the ground-water.

2007 Sampling Results. Due to the severe drought conditions experienced in 2007, contaminant levels were lower than expected as measured in the ground-water wells and in the limited sampling of ravine surface-waters:

- In the upland PT-Z8 ground-water well, the ground-water level was recorded near the bottom of the 16.5 ft well, resulting in low detections of OWCs and no recording of enterococci bacteria. Nitrates levels were low-to- moderate and low levels of organic carbon were found.

- Nitrate levels decreased in the streams from the uplands as the surface-water flowed downward into the streambed under the drought conditions and reappeared approaching the PT-Z5 in the midlands. Sampling for bacteria was not conducted in the streams

- Nitrates levels recorded low at the PT-Z1 and PT-Z4 lowlands wells; ammonium levels were high possibly due to the infiltration of tidal waters or transformation from nitrates in the soils; bacteria enterococci levels were very low, possibly due to infiltration of tidal water and cool water temperature (PTRC experience gained from five years of bacteria water surface sampling in watershed streams show that bacteria don't become elevated or appear until the warmer months of June through September)

USGS and PTRC decided to retest in 2008 in anticipation of a normal rain season. Greater emphasis would be put on sampling surface-water and sediment porewater in the ravines' streams.

Phase 2 Evaluation of Water Quality along Intermittent Streams (Ravines) Retest in 2008 - SOW. Twelve surface-water samples will be collected along the intermittent streams in Ravine 1 and Ravine 2 at approximately the same location as sampled in 2007, although one surface-water site will be moved close to piezometer site 5. All these samples will be analyzed for nitrate and ammonia using field colorimetric test kits, and for the field parameters pH, specific conductance, dissolved oxygen, and temperature. PTRC will collect samples for Enterococci bacteria at the same time from these surface-water sites.

In addition, porewater samples will be collected from the streambed at three locations along Ravine 2 (near piezometer sites 5, 6, and 9), and one location along Ravine 1 (adjacent to Shirley Boulevard). Shallow temporary piezometers (screen depths of about 2 to 4 ft) will be installed manually in the streambed for porewater collection at these sites.

The shallow piezometers installed in 2007 at sites 5, 6, and 9 also will be sampled during this event, providing some concurrent shallow ground-water, porewater and surface-water analyses. All porewater and piezometer samples will be analyzed for nitrate, ammonia, ferrous iron, and sulfide using field colorimetric test kits, allowing determination of the redox state of the porewater and potential for denitrification. Field parameters pH, specific conductance, and temperature will also be measured, and bacteria samples will be collected by PTRC.

For two selected porewater, shallow ground-water, and surface-water sampling sites (total of 6 samples), additional samples will be collected for analysis of major ions, organic nitrogen, total organic carbon, and OWCs by the USGS National Water Quality Laboratory (NWQL).

Synoptic water-levels will be obtained from all piezometers installed in 2007 before this ravine sampling event.

Phase 2 Evaluation of Water Quality along Intermittent Streams (Ravines) Retest in 2008 - Performance. Surface-water, porewater and groundwater samples were collected along three

intermittent streams in Ravines 1, 2 and 3 to further evaluate the potential transport of septic-waste contaminants to surface water.

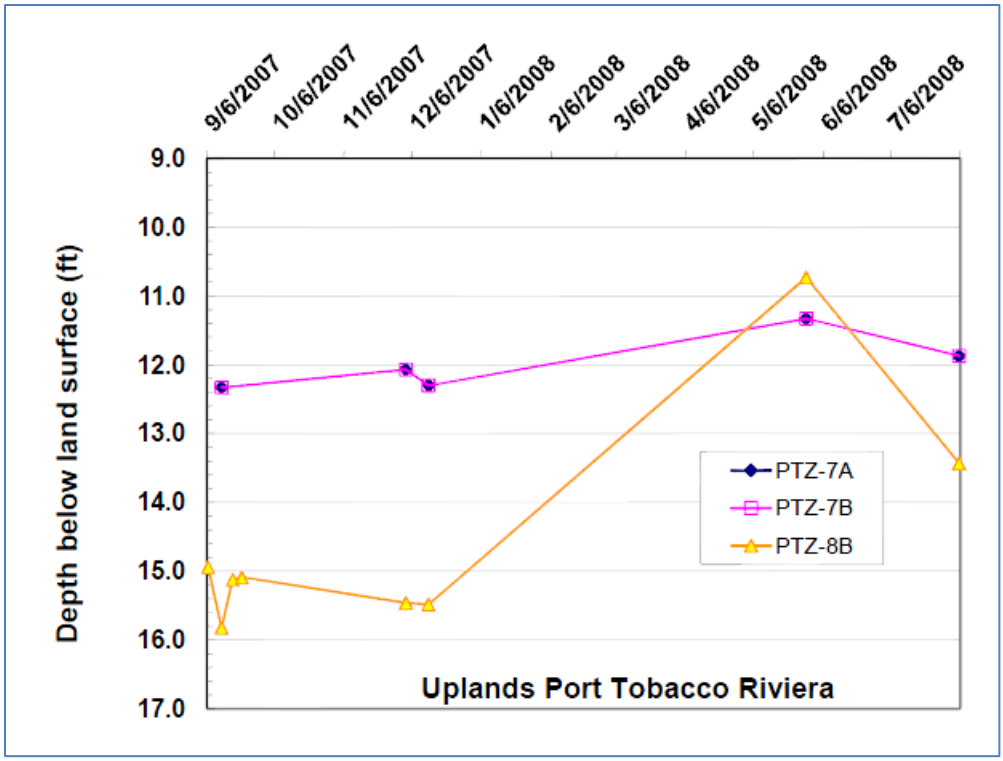
Surface-water samples were collected at nine sites, and seven of these sites were sampled before and after a storm event. Piezometers were installed in the streambed at four of the surface-water sampling sites to obtain porewater samples. Four additional piezometers adjacent to the stream were sampled to obtain samples from the shallow groundwater. All these samples were analyzed for nitrate and ammonia using field colorimetric tests, and for the field parameters pH, specific conductance, dissolved oxygen, and temperature.

At two of the sampling locations, additional surface-water, porewater, and groundwater samples were collected for laboratory analysis of organic waste-water compounds, major ions, total organic carbon, and nutrients. PTRC also collected samples for enterococci bacteria at the same time from these surface-water, porewater, and groundwater sites.

Water levels were measured before sampling in all the piezometers that were installed in the 2007 phase 1of the study.

2008 Sampling Results. Drought conditions continued in 2008, but to a lesser degree than in 2007. However, due to the increased numbers of sites strategically sampled in the Ravine streams both before and immediately after a storm event, the levels of the nitrates and bacteria contaminants increased significantly over the 2007 sampling levels. The additional sampling sites for testing OWCs, major ions and total organic carbon confirmed the presence of septic waste in the streams that flowed toward the river.

Ground-water levels measured in 2008, shown in Figure 6, rose five feet above 2007 levels in the PT-Z8 upland well and in the PT-Z6 and 9 midland wells after the rain event on 4 June 2008 and then fell quickly. The rain event had no appreciable impact on the PT-Z5 well in the midlands and on the five wells in the lowlands.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7/6/2008
Depth below land surface (ft)
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PTZ-7A
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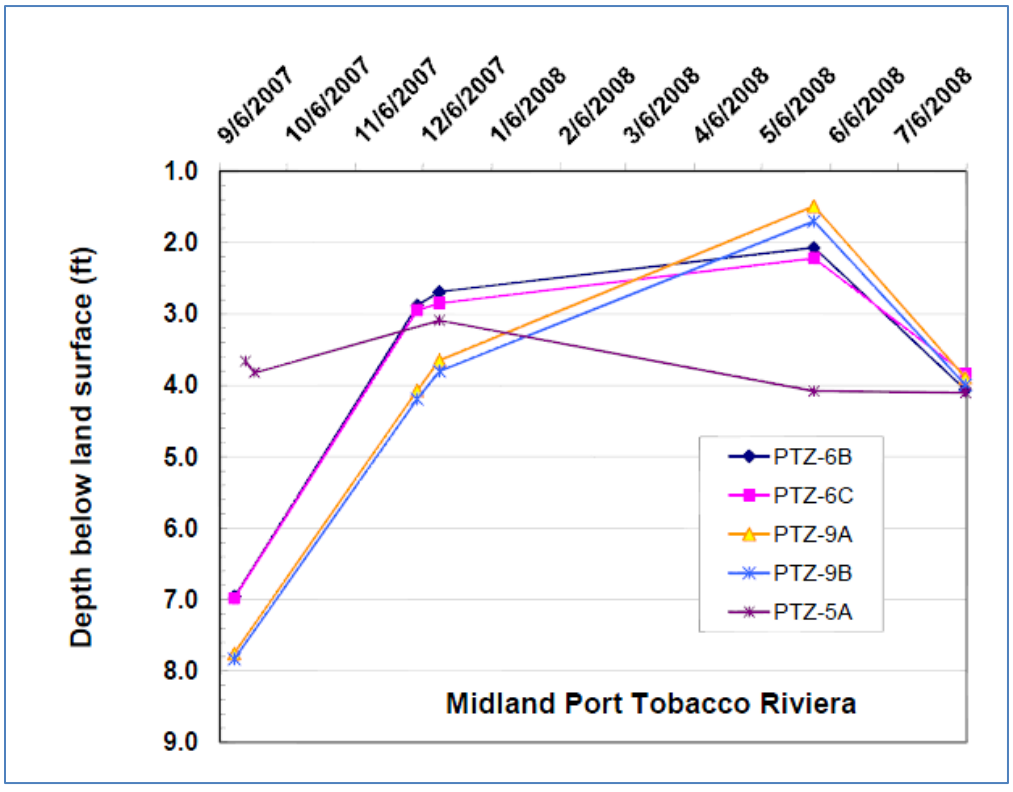
PTZ-8B
Uplands Port Tobacco Riviera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Depth below land surface (ft)
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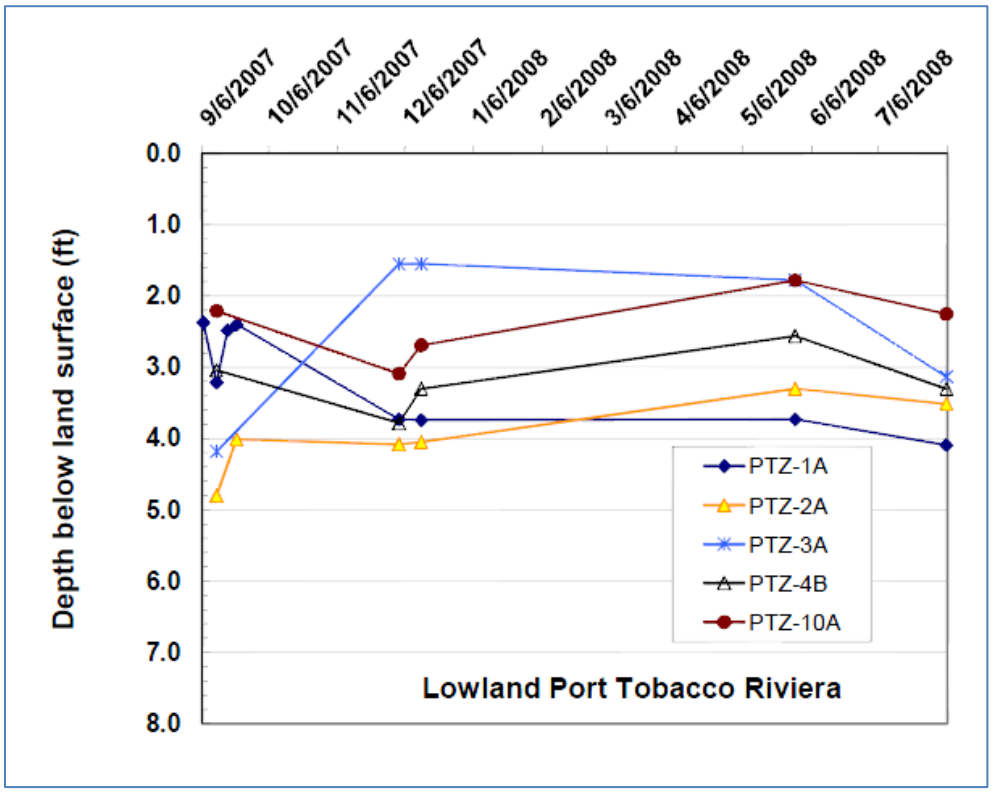


Figure 6: Ground Water Levels are affected by the geology of the Riviera

The varying impact of rain events on the ground-water levels in the uplands, midlands and lowlands during drought and normal rain seasons, can be explained by the ability of the soil layers in the Riviera to restrict or allow storm water to flow downward as ground-water. Analysis of the soil sediment core boring samples, ground-water level measurements and the surveying of Ravine 2 and Ravine 3 by the USGS team provide a geological model of the Riviera based on the combined 2007 and 2008 sampling results. This model is approximated by Figure7 and 8 for Ravines 2 and 3 respectively.

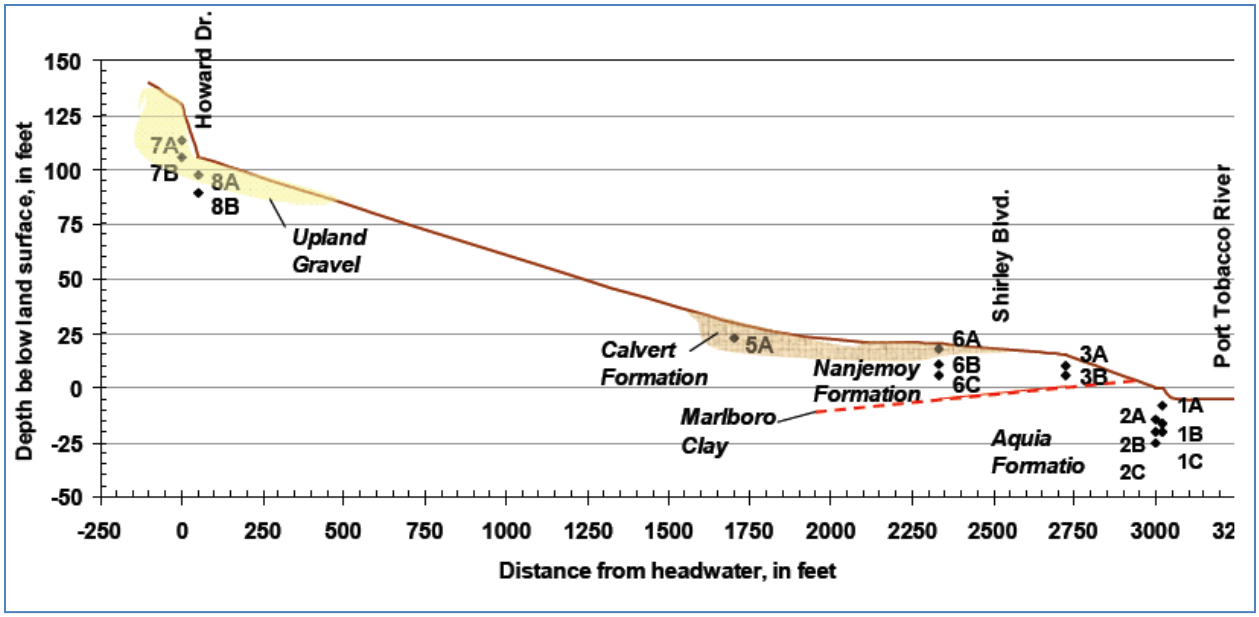


Figure 7: Ravine 2 Profiles

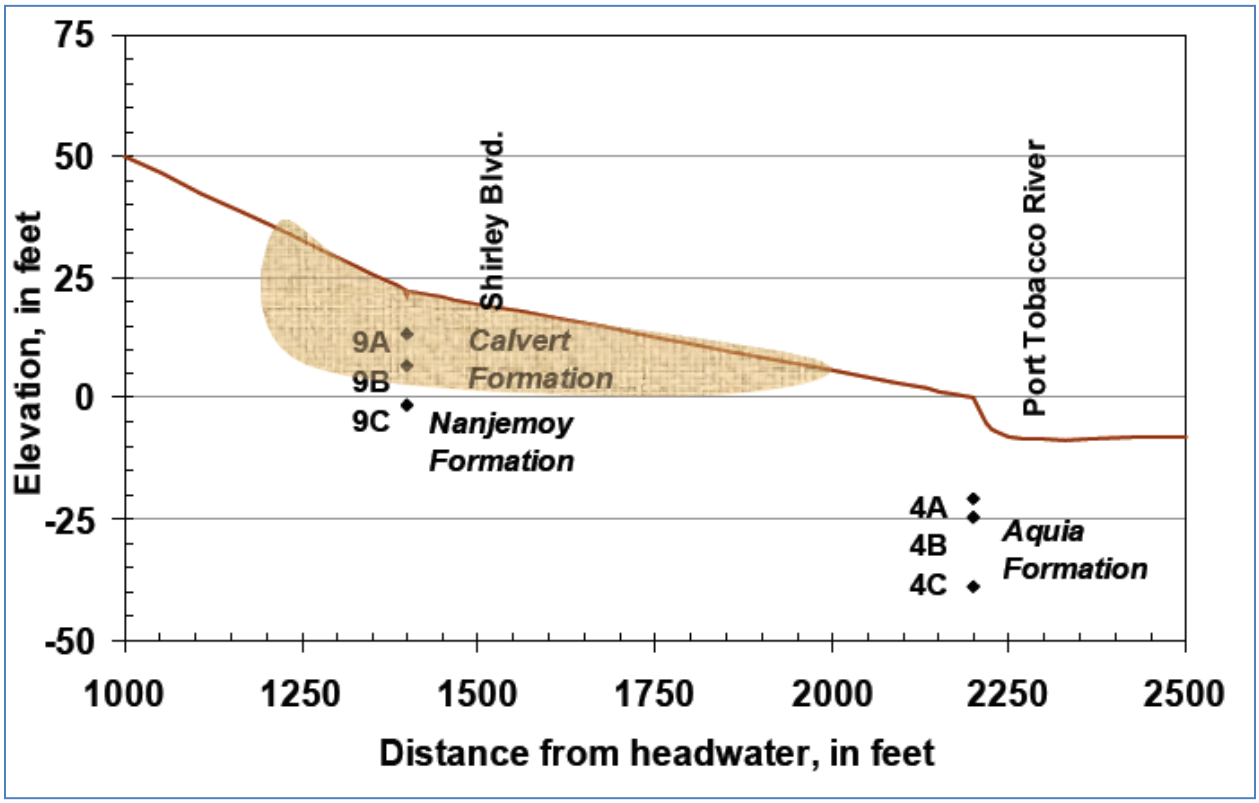


Figure 8: Ravine 3 Profile

In Figure 7, the main contaminant sampling well, PT-Z8 in the Uplands, was drilled/pushed through approximately 16 to 20 feet of Upland Deposits consisting mostly of sand and gravel. Below this level a layer of Calvert Formation soil limits downward flow of ground-water to deeper formations. Water level measurements suggest that during rain events, the resulting ground-water seeps out of the sand and gravel into the Ravine 2 stream very quickly; and that during dry conditions, the ground-water drops to approximately 16 feet below land surface near the bottom of the sand and gravel formation. This assumption was confirmed in 2007 by the low base flow of water in the stream from the uplands to the midlands; and because after the rain event on 4 June, 2008 and the more normal wet seasons in 2009 and 2010, the stream resumed high base flow.

The midland well PT-Z5 located near and approximately 2 to 4 feet above the ravine 2 stream was installed in Calvert Formation soils at a depth of 7.5 feet. Ground-water in the well remained approximately 4 feet below land surface during dry and wet periods, suggesting that the water from the uplands is not contributing to the ground-water levels. However, during heavy rain events, the ground-water in the midland area at PT-Z6 may be contributing to the flooding that occurs near Shirley Blvd. The Ravine 2 stream flows in a culvert under Shirley Blvd. and continues under three additional culverts under home owner driveways until it flows east in a shallow ditch across a lawn to the a river channel.

In Figure 8, PT-Z9 wells near Shirley Blvd. are nearly level with the Ravine 3 stream bed. The two wells were installed at depths of approximately 10 and 15 feet in the Calvert Formation. Recorded ground-water level in the wells was 8 feet in the 2007 sampling period, rose to 1.5 feet below land surface after the rain event in June 2008 and then dropped quickly to 4 feet in August 2008. This area has high stream base flow, suggesting that the ground-water in the wells is affected by the near-by stream. The stream flows in a culvert under Shirley into a deep ditch and then directly to a river channel adjacent to the RV Resort.

A summary of key data and observations collected during the Ground-Water Study is contained on the Riviera topography map in Figure 9.

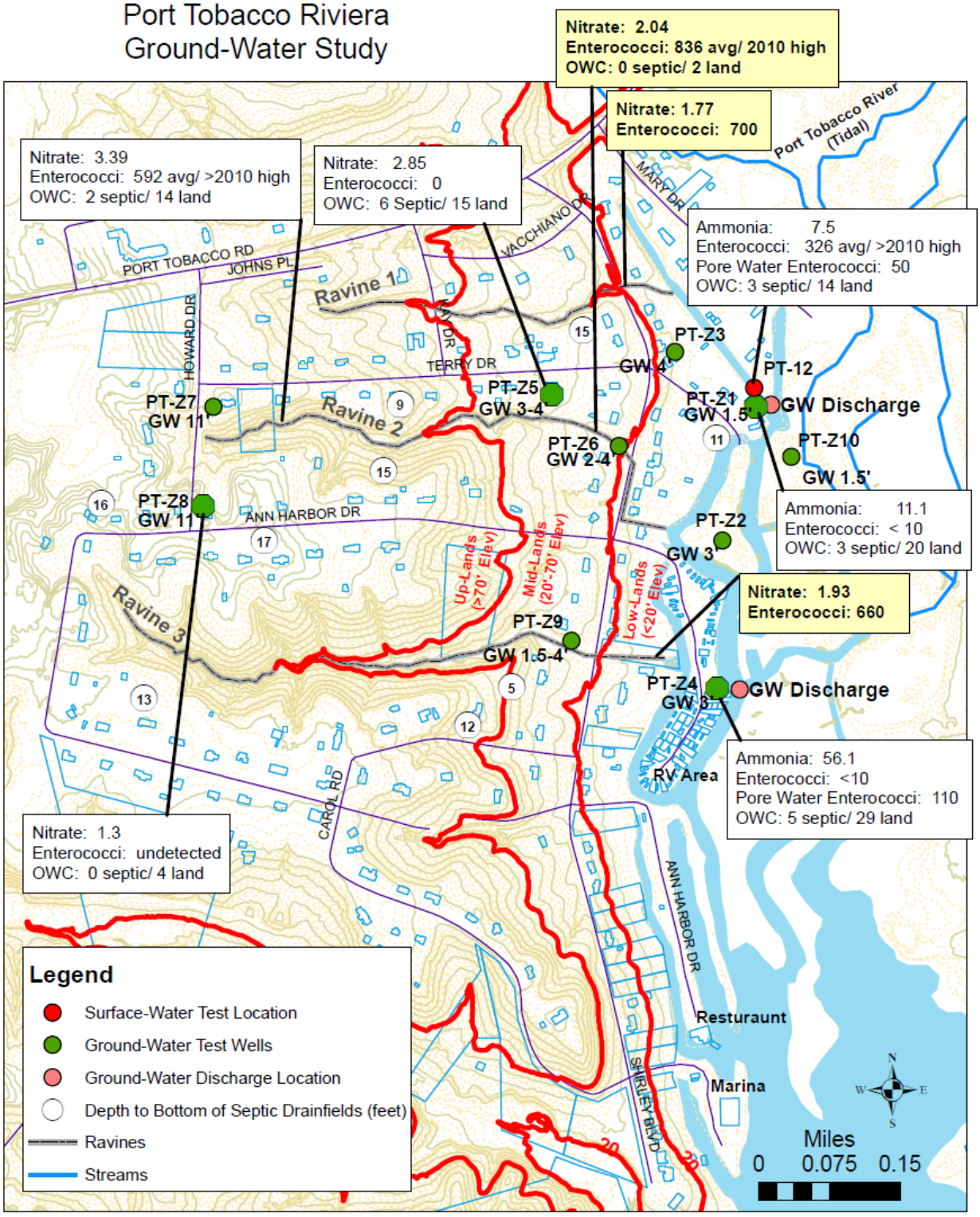


Figure 9: Riviera Topography map shows contaminant levels and flow paths to the river. GIS support provided by Charles County Planning Division, March 2010. Topography, buildings and road centerlines dated 2004. All monitoring data provided by Port Tobacco River Conservancy.

3.4 Conclusions and Recommendations

Most, if not all, Port Tobacco Riviera OSDS (septics systems) are under ground-water. Contaminates from these systems are being transported to the River via below land surface ground-water and by ground-water that seeps into ravine streams and is carried, with or without storm water, over land directly to multiple discharge locations at river's edge. These contaminates include the following:

- Enterococci Bacteria that present a public health risk to residents and visitors that play in the streams, swim in the river and consume the fish (without proper cooking). Bacteria levels are often twenty times the Maryland Code safe levels for recreation standards.

- Nitrates that feeds algae blooms that decay and deplete oxygen that fin and shell fish need for survival

- Ammonium that serve as a lesser fertilizer for algae bloom and can be toxic to fish

- Organic Wastewater Compounds (OWCs) whose impact on humans is not yet known, but is suspected of having hormonal impact on fish breeding

The geology of the Riviera, consisting of layers of pervious and impervious soil formations, high ground-water levels, and steep ravines, rapidly transports contaminants to the river.

Two options for restoring/replacing all OSDS in the Riviera have been considered: replace with BRF nitrogen reduction septic tanks; or connect to an on or off site waste water treatment plant (WWTP).

BRF nitrogen reduction septic tank option: Replace or remove (if space is limited) the current septic tank with a new tank that reduces nitrogen levels by 50% over the current tank, which equates to a nitrogen discharge level of 15 to 20 mg/liter for the new tank. The tank installed, with a five year service contract, would cost roughly $15K funded by the BRF if located in the critical area and if BRF funds were available. Servicing the system after five years would cost the home owner an estimated $300/year. This option would require an UV lamp or other chemical system to reduce the bacteria level to the Maryland standard of 104 colonies/liter at a cost of approximately $2K, which would be borne by the home owner. This option does not repair or replace drain fields which may fail in the future by clogging up and discharging to the land surface or backing up in the dwelling. The cost of drain field repairs/replacement could approach $10K.

Connection to an on-or-off site WWTP: this option would use federal, state, county and/or private financing to cover the cost of the WWTP, which includes sewer lines to street locations where homes are serviced. The WWTP would reduce nitrogen levels to approximately 3 mg/liter, and bacteria levels to under 5 colonies/liter. The WWTP would eliminate the need for drain fields (and future repairs) and the costs of servicing the system. If the WWTP were off site, it would eliminate

the discharge of treated effluent or accidental discharges of partially treated effluent into community streams or river channels. Cost to home owners would be $4K to connect their homes to the sewer lines, and $125 per quarter user fee considering that Riviera homes have their own drinking water wells.

Considering the superior ability of a WWTP to reduce contaminants going into the river and the current and future costs of maintaining an OSDS, PTRC recommends the WWTP option. This option is recommended by the Charles County Health Department.

Storm water management practices of the 1970s and earlier years, designed to move rain water away from homes and properties, continue to prevail in the Riviera. These practices result in some homes, especially in the lowlands, being flooded and even partially destroyed as a result of storm surges. These practices also provide a conduit for contaminant laden storm water to be discharged in the river without being filtered and used to recharge the aquifers. Ravine stream banks are also being eroded, carrying debris, sand, gravel and sediment from upland areas on to roads and properties and into the river. PTRC recommends that the latest county and state storm water management codes, including Environmental Site Design (ESD) be implemented with federal and state funds.

Section 4: Support of the BRF Nitrogen Removal Retrofit Program

The PTRC EPA project manager and members assist the Charles County Health Department implement the BRF Program by providing education outreach and hands-on lessons learned to interested homeowners.

PTRC first obtained Charles County Commissioners' approval to direct County government resources, namely County PGM and the Charles County Health Department, to apply for a competitive BRF grant in April 2006. PTRC furnished much of the justification based on water quality monitoring and Stream Wader results collected by PTRC volunteers in the watershed river and stream sampling in 2003 through 2005, and assisted in developing the scope of the initial program. The County received $604K that support the installation of 35 systems.

In the summer of 2007, PTRC assisted the Health Department's Environmental Health Director plan a MDE BRF Vendors Day to introduce nitrogen removal retrofits to owners of septic systems. PTRC members participated in the Vendors Day on 6 Sept. 2007 by providing a PTRC booth. Graphics and maps displayed the soil conditions and water table levels throughout the watershed that affect performance of traditional OSDSs. Brochures containing a homeowner guide to maintaining their systems and the benefits of the nitrogen removal retrofits were distributed and discussed. PTRC brought together equipment vendors, installers and homeowners into discussions to promote the BRF program and to plan for the purchase and installation of these systems.

PTRC members applied for and received BRF grants to install two of the first nitrogen removal tanks on their river front properties in the Port Tobacco River watershed. One member also installed a UV lamp bacteria reduction system at his own expense. These two systems served as a prototype to learn the application process and to test the equipment. The systems were demonstrated and the program promoted to area residents. Based on lessons learned, the PTRC's EPA grant project manager worked with homeowners, vendors, installers and with MDE and the Environmental Health Director to streamline and clarify the County's application and reimbursement processes to promote acceptance by the homeowners. A BRF article was published in the PTRC 2008 Winter newsletter to watershed residents encouraging their participation.

The ultimate success of the initial BRF increment belongs to the Environmental Health Director and his staff. The Health Department requested $1.8M for the second increment; $900K was approved due to other demands on BRF program funds. It is expected that 70 systems will be installed with this second funding increment.

Appendix A

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Robert L. Ehrlich, Jr., *Governor*
Michael S. Steele, *Lt. Governor*
C. Ronald Franks, *Secretary*

December 4, 2006

Dave Gardiner
Port Tobacco River Conservancy
P.O. Box 464
LaPlata, Maryland 20646

Re: U.S. Geological Survey Proposals: "Reconnaissance of Surface-Water Quality in Charles County, Maryland for Organic Wastewater Compounds, Major Ions, Nutrients and other Water-Quality Parameters," and "Evaluation of Ground-Water Quality and Interactions with Surface Water in the Port Riviera Area, Port Tobacco River Watershed, Charles County, Maryland"

Dear Mr. Gardiner:

The purpose of this letter is to indicate my support for the two referenced U.S. Geological Survey (USGS) proposals. The proposed studies, which will investigate the sources of surface-water contaminants in the Port Tobacco River area, have the potential to enhance our general knowledge of the shallow groundwater flow systems and groundwater/surface water interaction in southern Maryland.

As you know, the USGS and Maryland Geological Survey, with support from the Maryland Department of the Environment, are in the second year of a multi-year regional evaluation of the Maryland Coastal Plain aquifer system. This evaluation is being conducted in response to one of the recommendations by the Advisory Committee on the Management and Protection of the State's Water Resources (2004). Shallow groundwater has been studied extensively on the Delmarva Peninsula, due to the widespread use of the Columbia (surficial) aquifer, and because of its susceptibility to contamination from surface-based sources and septic effluent. However, the shallow groundwater system in Charles County and elsewhere in southern Maryland has received less attention because most groundwater withdrawals are from the deeper, confined aquifers (including the Patapsco, Magothy, and Aquia aquifers), which are protected from surficial contamination by clay layers. We are interested in the shallow systems because of our limited understanding of the relation between the shallow and deep groundwater flow systems, and how withdrawals in pumping centers affect recharge in the areas where the same aquifers are closer to the surface.

In addition to the investigation of the flow system, the proposed work will evaluate the transformation of nutrients, wastewater compounds, and other constituents as they travel from input areas to discharge into surface waters. Geological materials can be very complex, and an understanding of the geochemical processes can help identify areas that may be most susceptible to surface-water contamination. In recent years, sampling for organic wastewater compounds (OWC's) has made us aware of the increased variety of synthetic organic compounds that are released into the environment. These compounds have the potential to greatly enhance the evaluation of contaminant sources. Laboratory and field collection methods for OWC's are quite exacting and require special techniques; the USGS has been on the forefront of developing the sampling and analytical methodologies for these compounds, and are the recognized experts in this field.

In closing, I fully support these proposals, and feel that they have the potential to greatly increase our understanding of the affected hydrologic systems.

Sincerely,

David W. Bolton
Chief, Hydrology and Hydrogeology Program
Maryland Geological Survey

Cc: James Gerhart, USGS
Emery T. Cleaves, MGS
Douglas J. Yeskis, USGS

Appendix B

Water Monitoring Program Background

In October 2001, a small group of the citizens living on or near the Port Tobacco River formed the PTRC over concerns about the river's declining health due to sewage overflows. In 2002, the PTRC obtained the Charles County Commissioners' financial and technical support to establish a bacteria water quality monitoring program. PTRC established a partnership with MDE in 2003 to assist in structuring this program. MDE SSA's water monitoring team made three trips to Port Tobacco to train our volunteers on water sampling collection procedures and to determine appropriate sampling sites. They furnished a boat with a caption and four team members and loaned PTRC instruments and materials for training and the first rounds of water sampling. They also arranged for the Department of Mental Health and Hygiene (DHMH) laboratory to analyze water samples.

PTRC volunteers collected water samples twice a month over 12 months in 2003 and 2004. Beginning in 2005, samples were collected only the warm recreation months June through September and occasionally in October because experience showed that bacteria levels dropped or were not detected in cold waters. The sites sampled from 2003 through 2009 are shown on Fig. 2 which also includes the results on the Surface-Water Study; enterococci bacteria levels are provided in the attached spreadsheets in this appendix.

Link to 2003 - 2009 Water Monitoring Bacteria Levels spreadsheet

Appendix C

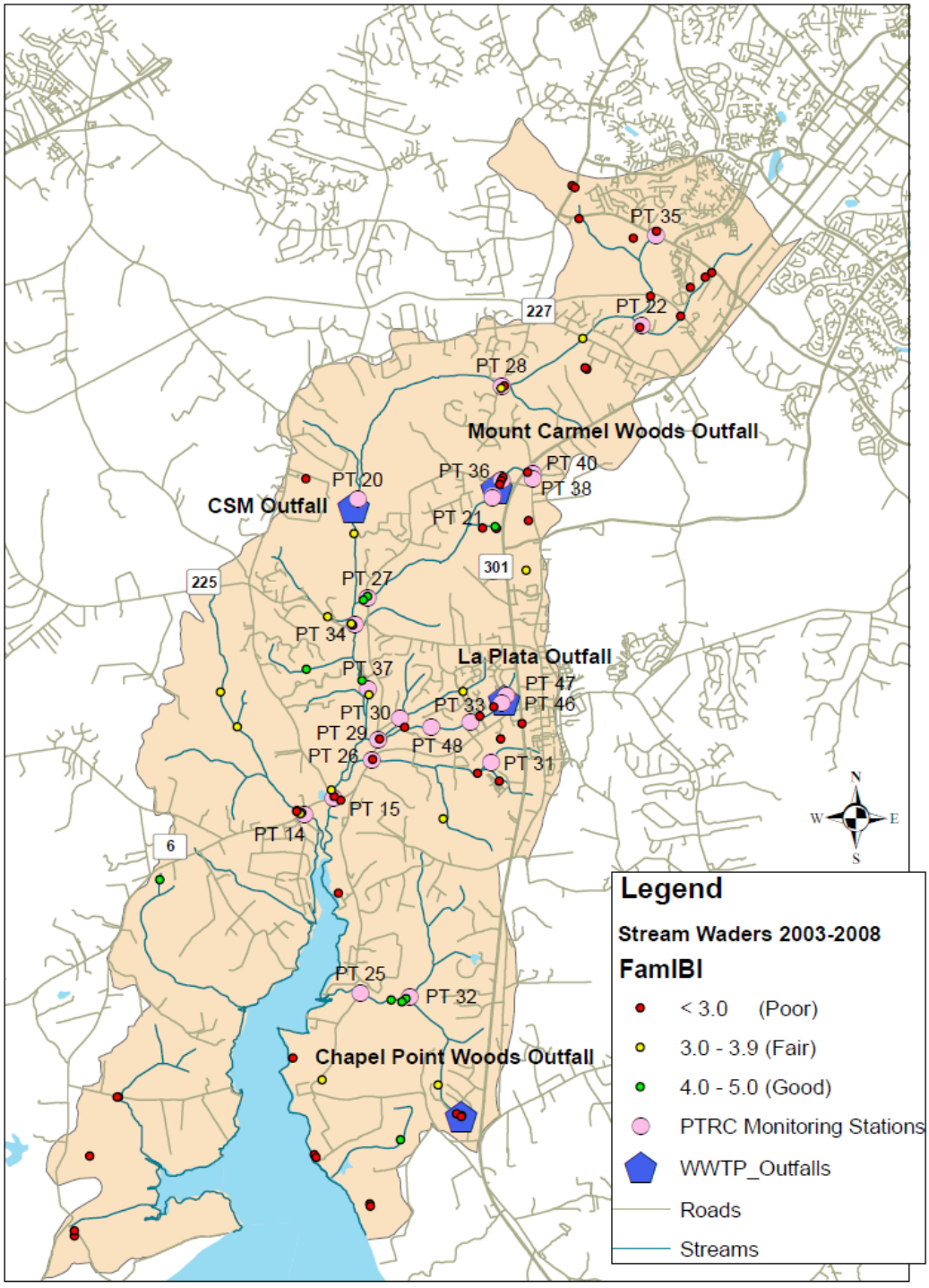
Stream Wader Program Background

PTRC began participating in the DNR Stream Waders Program in 2003 to determine the biological health of the streams that impact fish and wildlife in the Port Tobacco River watershed. The Stream Waders Program supports the statewide Maryland Biological Stream Survey (MBSS) program, which monitors and assesses the chemical, physical and biological quality of small to medium size freshwater streams. Stream Waders volunteers provide local resources to increase the number of streams surveys across the state.

Volunteers from County governments and watershed groups attend DNR training sessions offered each year in February or March. Volunteer group are issued equipment and supplies to collect benthic macroinvertebrates (aquatic insects, crustaceans, snails and other "bugs") in their local streams. Samples are preserved in the field and delivered to DNR benthic taxonomists at the DNR field office in Annapolis for identification and stream ratings. Streams that have more bugs that can tolerate pollution are assigned a poor to fair rating; streams with more bugs that cannot tolerate pollution receive a good to fair rating.

The watershed map in this appendix shows the stream sites and their ratings in red, yellow and green small circles. The map also shows the PTRC water monitor sites in larger pink circles for comparison with bacteria pollution levels shown in Fig.2 in section 2. The DNR Stream Waders Sampling Data 2003-2008 spread sheets, in this appendix, provide the rating scores (Family IBI) for each site.

Port Tobacco River Conservancy, Inc. Monitoring Sites



This map prepared by the Charles County Planning Division using MD Property View. Monitoring stations from the Port Tobacco River Conservancy, Inc. Roads from Charles County. March, 2010.

Stream Waders Sampling Data 2003-2008

SITE YR	Stream Name	Family IBI Score	NORTHING	EASTING
0770-01-2003	Port Tobacco R. UT	4.71	92628.2593	394935.839
0770-02-2003	Port Tobacco R. UT	2.71	88682.0737	394181.8289
0770-03-2003	Port Tobacco R. UT	1.29	86153.7929	393379.8603
0770-04-2003	Port Tobacco R. UT	1.29	87603.5976	393664.3011
0770-05-2003	Port Tobacco R. UT	1.57	87631.8492	397745.2022
0770-07-2003	Port Tobacco R. UT	2.71	86737.5011	398763.3142
0770-08-2003	Port Tobacco R. UT	3.29	88988.4825	397890.9759
0771-01-2003	Wills Br.	1.00	88371.5913	400339.4145
0771-02-2003	Wills Br.	3.86	88895.7382	400000
0771-03-2003	Wills Br.	4.14	90468.3335	399418.2873
0772-01-2003	Wills Br.	4.14	90406.6217	399345.6008
0773-01-2003	Hoghole Run	3.29	93831.4912	397495.8168
0773-02-2003	Hoghole Run	3.57	95402.5606	396342.546
0774-00-2003	Pages Swamp UT	1.29	104412.1887	403981.0824
0774-10-2003	Jennie Run UT	1.86	99009.3914	401065.2572
0774-11-2003	Jennie Run UT	1.29	98269.3433	401138.0536
0774-01-2003	Pages Swamp UT	1.57	105238.2101	402443.4183
0774-12-2003	Jennie Run	2.71	99936.9339	401181.1827
0774-15-2003	Jennie Run	4.43	97714.3619	398643.9341
0774-16-2003	Port Tobacco Cr. UT	3.86	97406.2446	397990.0575
0774-17-2003	Port Tobacco Cr.	1.86	97251.9584	398450.1453
0774-18-2003	Port Tobacco Cr. UT	4.14	96450.5046	397602.357
0774-19-2003	Port Tobacco R.	3.57	95987.6936	398740.5975
0774-20-2003	Port Tobacco R.	3.29	94261.0684	398061.9971
0774-02-2003	Pages Swamp UT	2.14	104639.5198	402569.8489
0774-23-2003	Port Tobacco Cr. UT	3.57	96044.6484	400453.3048
0774-24-2003	Port Tobacco Cr. UT	1.00	95597.4047	400762.6113
0774-25-2003	Port Tobacco Cr. UT	1.29	95401.7434	399394.4936
0774-26-2003	Port Tobacco Cr. UT	1.00	95186.002	398934.231
0774-27-2003	Port Tobacco Cr. UT	1.29	94558.0728	400719.671
0774-28-2003	Port Tobacco Cr. UT	3.86	93736.6776	400096.8978
0774-29-2003	Port Tobacco Cr.	3.00	94815.9354	398813.0538
0774-03-2003	Pages Swamp UT	1.29	103658.2682	404980.5447
0774-04-2003	Pages Swamp	3.00	102668.1752	403676.675
0774-05-2003	Pages Swamp	3.57	102463.1822	402637.8544
0774-06-2003	Pages Swamp	3.86	101562.2948	401145.3549
0774-07-2003	Pages Swamp UT	2.71	101908.1894	402710.6155
0774-08-2003	Port Tobacco Cr. UT	3.00	99914.0956	397597.4653
0774-09-2003	Port Tobacco Cr.	3.29	98917.0006	398474.7
0770-02-2004	Goose Cr. UT	2.71	88682.09138	394157.6545
0770-03-2004	Unknown tributary to Goose Cr.	1.29	86246.74879	393379.8692
0770-05-2004	Port Tobacco R. UT	2.14	87580.42303	397783.3453
0770-07-2004	Port Tobacco R. UT2	1.29	86697.98259	398765.199
0770-08-2004	Port Tobacco R. UT3	4.43	87902.03654	399317.5543
0771-01-2004	Basswood Run	1.29	88322.0016	400422.6597
0772-01-2004	Wills Br.	4.43	90439.08359	399152.9504

Stream Waders Sampling Data 2003-2008

SITE YR	Stream Name	Family IBI Score	NORTHING	EASTING
0773-02-2004	Hoghole Run	5.00	93889.65166	397438.7143
0773-81-2004	Hoghole Run	3.00	93869.6968	397428.1356
0774-10-2004	Jennie Run UT	3.00	99015.50713	400810.7523
0774-11-2004	Jennie Run UT	1.00	98168.60729	401038.6602
0774-01-2004	Pages Swamp UT	1.57	105207.3661	402491.7634
0774-12-2004	Jennie Run	1.29	99884.03028	401152.1839
0774-17-2004	Port Tobacco Cr.	3.57	97282.82201	398425.9159
0774-02-2004	UT to Pages Swamp UT	1.57	104282.7774	403556.6044
0774-24-2004	Port Tobacco Cr. UT	1.29	95771.75823	401017.2977
0774-25-2004	Port Tobacco Cr. UT	1.29	95186.01207	401138.4946
0774-27-2004	Port Tobacco Cr. UT	1.86	94415.09348	401114.3607
0774-28-2004	Pages Swamp Cr.	1.86	103389.1771	404597.5454
0774-03-2004	Pages Swamp Cr.	1.86	103574.2673	404863.5564
0774-07-2004	Pages Swamp UT	1.29	101929.3171	402673.3135
0770-01-2005	Port Tobaco River UT	2.14	89389.52139	397357.8288
0774-21-2005	Jennie Run	1.86	99814.09475	401126.6253
0774-22-2005	Jennie Run UT	4.14	99040.23493	401041.0617
0774-23-2005	Port Tobacco Cr. UT	1.57	102865.1477	404418.1213
0774-06-2005	Port Tobacco Cr. UT	2.43	103234.5698	403871.676
0770-02-2006	Port Tobacco River UT	2.71	92380.19618	398182.6752
0771-03-2006	Wills Br. UT	1.57	88341.45112	400433.9308
0773-01-2006	Hoghole Run	3.29	96039.2411	396046.4922
0773-02-2006	Hoghole Run	4.43	93843.46888	397519.0355
0773-03-2006	Port Tobacco Cr.	1.57	94076.06171	398231.5134
0774-01-2006	Jennie Run (State Police Barracks)	2.43	100027.8525	401631.3412
0774-02-2006	Jennie Run UT	2.43	99151.04737	401651.2077
0774-03-2006	Jennie Run UT	2.14	98248.56389	401252.1228
0774-04-2006	Jennie Run UT (College of So MD)	3.86	98247.72321	401606.5086
0774-05-2006	Jennie Run	4.71	97776.06773	398716.6273
0774-06-2006	Port Tobacco Cr.	4.71	96252.74047	398615.1993
0774-07-2006	Port Tobacco Cr.	3.00	94137.75717	398110.3987
0774-08-2006	Jennie Run	1.57	98157.37998	400992.7595
0774-09-2006	Port Tobacco Cr. UT	1.00	95463.54784	401525.962
0774-10-2006	Port Tobacco Cr. / Pages Swamp	3.00	101599.5011	401210.1475
0770-01-2008	Port Tobacco River UT	1.57	89382.753	397312.255
0770-02-2008	Port Tobacco River UT	1.00	92386.974	398205.938
0770-03-2008	Port Tobacco River UT	3.86	91732.27708	398475.6415
0773-02-2008	Hoghole Run	2.43	94728.45649	396795.7244
0774-01-2008	Port Tobacco Cr. UT	2.71	94488.5	401090.106
0774-02-2008	Port Tobacco Cr. UT	1.29	95373.31655	400305.5887
0774-03-2008	Port Tobacco Cr. UT	4.71	98025.75572	397329.7994
0774-04-2008	Jennie Run UT	2.43	98160.833	400957.398
0774-05-2008	Jennie Run	3.29	99507.40198	400893.7466
0774-06-2008	Port Tobacco Cr. UT	2.43	94795.594	400979.604

Appendix D

Fish Survey Program Background

The Port Tobacco River once was a favorite location for recreational fishing for yellow and white perch and bass. In the spring, the banks just north of the Port Tobacco Marina would be crowded with men, women and children catching their limits of yellow perch; tournament fishermen would fish the grasses and piers for trophy bass. Over the past 20 years, the fish and consequently these fishermen have left the area.

From 2003 to 2008, PTRC partnered with the CCA to conduct yellow perch spawning survey/seining, and with the Chesapeake Bay Foundation (CBF) for fish ladder observations and maintenance activities. From 2008 to the present, PTRC members have conducted spawning and seining surveys. The purpose of the spawning surveys is to determine if the Port Tobacco River is healthy enough to begin the restocking of yellow perch. Egg mass counts for the following years were:

- 2003 – 0
- 2004 – 10
- 2005 – 97
- 2006 – 143
- 2007 – 97
- 2008 – 35
- 2009 - 56

In spite of the pollution levels in the northern portions of the Port Tobacco River, seining has netted the most diverse species and quantities of fish of any river in the area. Prior to 2007, our volunteer seiners rarely found menhaden in any local river, but in that year they counted 896 in the Port Tobacco River. Some of the rarest species, such as needlefish and pipefish, were also found in the River. See the Fish Survey Results 2008 in this appendix for an example of the numbers and species of fish netted. White perch and cat fish continue to be plentiful for the enjoyment of recreational fishermen.

Yellow perch are seldom caught in the River. However, during the environmental education sessions with middle school children at Chapel Point State Park in the fall of 2008, several yellow perch were netted and released. Our PTRC volunteers have trained over 400 students in educational field days like the ones at Chapel Point.

FISH SURVEY RESULTS 2008

DATE	SITE	Perch, Yellow (year zero)	Perch, Yellow (year 1+)	Anchovy, Bay	Bass, Largemouth	Bass, Striped	Brown Bullhead	Bluefish	Bluegill	Catfish	Crab	Crappie	Croaker	Darter, Tesselated	Drum, Red	Eel	Goby, Naked	Herring, River	Hogchoker	Jelly, Comb	Killifish, Banded	Killifish, Striped	Menhaden	Minnow, Sheepshead	Mosquito Fish	Mummichug	Needlefish	Perch, White	Pipefish,	Pumpkinseed	Shad, Gizzard	Ray, Cownose	Shiner, Golden	Shiner, Spottail	Shrimp	Silverside, Atlantic	Silverside, Inland	Spot	Sunfish
6/28	Port Tobacco							8			1		59						1		5	8	541			7	10	117	2	1	6			1	34	158	1		
7/26	Port Tobacco					10		4		1	1		30		1			4				1	26				2	71		1	1					263		4	
8/28	Port Tobacco			TNTC		4		2					4							TNTC			2			1	1	37		1	6			1		TNTC			
6/14	McIntosh Run				9	1								6		1					2				2	6				13			6	1		7	63		
8/2	McIntosh Run				1							3		1												2				3	1			1					
8/30	McIntosh Run		1	1	1				3	2		15		1							2		1			24		1		11	4		13	55		92			1
7/12	St. Leonard Creek					9					10		1		1	1					7	50	6	53		53	6	4	3		2				6	196	TNTC		
8/16	St. Leonard Creek					1					10						4	8			61	73		TNTC	5	88		3	2		5				425	TNTC			

TNTC = Too Numerous to Count

Appendix E

Port Tobacco River Watershed

		2007																2008										2008					
	Date	10/6	10/9	10/9	10/9	10/9	10/9	10/30	10/30	10/30	10/30	10/30	10/9	10/30	10/30	10/30	10/30	6/2	6/2	6/2	6/2	6/4	6/4	6/2	7/23	7/23	7/23	7/29	7/29	Aug	Aug	Aug	Aug	Aug	Aug
	Sample Type	SW	SW	PW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	PW	PW	PW	PW	SW	SW	SW	SW	SW	SW	PC	PC	PC	PC	PC	SPC
Compound Class	Compound	Z1A	Z4A	PW4	Z5A	Z6B	PT-12	PT-12	PT-14	PT-25	PT-28	PT-28	PT-33	PT-37	PT-38	PT-46	PT-48	Z8A	Z6B	Z5A	PW6	PW8	PW8	R-8	R-8	PT-12	PT-25	PT-38	PT-46	PW5	PW8	PT-12	PT-38	PW48	PT-48
Detergent Degradates	4-Cumylphenol	X	X																																
Detergent Degradates	4-Nonylphenol (sum of all isomers)		X		X																														
Detergent Degradates	4-tert-Octylphenol																					X													
Detergent Degradates	4-tert-Octylphenol diethoxylate							X	X						X	X																			
Detergent Degradates	4-tert-Octylphenol monoethoxylate																															X			
Fragrance/Flavorants	3-Methyl-1H-indole (skatol)	X	X		X			X	X		X				X	X	X					X		X		X	X	X			X		X	
Fragrance/Flavorants	Acetophenone	X																																	
Fragrance/Flavorants	AHTN				X			X						X	X	X	X												X				X	X	
Fragrance/Flavorants	Camphor				X																	X						X	X						
Fragrance/Flavorants	Galaxolide, or HHCB							X							X	X	X												X				X	X	
Organophosphate Esters	Tributyl phosphate	X	X		X			X	X						X	X	X												X				X		
Organophosphate Esters	Triphenyl phosphate	X	X	X	X			X	X						X	X	X																		
Organophosphate Esters	Tris(2-butoxyethyl) phosphate	X	X	X	X			X	X		X			X	X	X	X			X					X	X	X	X					X		
Organophosphate Esters	Tris(2-chloroethyl) phosphate	X	X	X	X	X	X	X	X		X	X		X	X	X	X					X			X		X	X				X	X	X	
Organophosphate Esters	Tris(dichloroisopropyl) phosphate	X	X	X	X		X	X			X		X	X	X	X	X								X			X					X	X	
Other Compounds	3-tert-Butyl-4-hydroxyanisole (BHA)															X																			
Other Compounds	5-Methyl-1H-benzotriazole										X					X	X				X	X						X							
Other Compounds	Benzophenone	X	X	X	X			X					X			X	X											X					X		
Other Compounds	Bisphenol A	X	X	X	X													X	X			X								X	X				
Other Compounds	Caffeine	X	X	X	X														X						X									X	
Other Compounds	Carbazole				X								X									X													
Other Compounds	Cotinine		X													X	X							X	X										
Other Compounds	Isoborneol	X																																	
Other Compounds	Isophorone	X	X		X			X	X	X		X	X	X	X	X								X	X					X	X	X	X	X	
Other Compounds	Methyl salicylate							X	X	X	X	X		X																	X	X	X	X	X	
Other Compounds	p-Cresol	X	X					X	X		X	X		X	X	X	X								X					X	X	X	X	X	X
Other Compounds	Pentachlorophenol			X	X											X	X																		
Other Compounds	Phenol	X	X																						X										
Other Compounds	Triclosan				X											X	X																		
Other Compounds	Triethyl citrate							X								X	X								X	X			X						
Other Compounds	1,4-Dichlorobenzene															X	X																		
Other Compounds	Tetrachloroethene														X																				
Other Compounds	Tribromomethane (bromoform)																								X	X		X							
PAH's	1-Methylnaphthalene		X																																
PAH's	2,6-Dimethylnaphthalene									X			X												X	X									
PAH's	2-Methylnaphthalene		X																												X			X	
PAH's	Anthracene		X								X											X					X								
PAH's	Benzo[a]pyrene																					X	X		X		X								
PAH's	Fluoranthene	X		X				X			X		X		X	X	X					X	X		X		X								
PAH's	Phenanthrene	X	X		X			X					X						X			X			X		X		X	X	X		X	X	
PAH's	Pyrene	X		X				X			X		X		X	X	X					X	X		X		X								
PAH's	Naphthalene	X	X		X			X								X								X											
Pesticides	3,4-Dichlorophenyl isocyanate							X			X	X		X	X	X	X				X							X							
Pesticides	9,10-Anthraquinone			X				X	X		X	X		X	X	X	X					X											X		
Pesticides	Atrazine							X			X		X												X	X									
Pesticides	N,N-Diethyltoluamide (DEET)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X													X	X	X	X	X	X
Pesticides	Isoxaben	X	X					X	X		X					X	X							X				X			X		X	X	
Pesticides	Metolachlor							X			X														X	X									
Pesticides	Prometon		X					X		X	X			X		X	X								X	X									
Pesticides	Isopropylbenzene				X																														
Plasticizer	Bis(2-ethylhexyl) phthalate	X	X								X				X	X	X																		
Plasticizer	Diethyl phthalate	X	X	X	X				X					X	X	X	X					X			X										
Plasticizer	Diethylhexyl phthalate																																	X	
Sterols	3-beta-Coprostanol		X	X	X	X										X																			
Sterols	beta-Sitosterol									X												X													
Sterols	beta-Stigmastanol																					X													
Sterols	Cholesterol	X	X	X	X	X		X		X	X		X	X	X	X	X				X							X							

Useful sewage indicators, from Hyer (2007)

A multiple-tracer approach for identifying sewage sources to an urban stream system: USGS Scientific Investigations Report 2006-5317, 89p. (Study conducted in Fairfax County, Virginia)

Class	Compound	Use
Detergent Degradates	4-Nonylphenol (sum of all isomers)	Nonionic detergent metabolite
Detergent Degradates	4-tert-Octylphenol monoethoxylate	Nonionic detergent metabolite
Fragrance/Flavorants	3-Methyl-1H-indole (skatol)	Fragrance, stench in feces and coal tar
Fragrance/Flavorants	AHTN	Flavor, odorant, ointments
Fragrance/Flavorants	Galaxolide, or HHCB	Musk fragrance (a naphthalene)
Other Compounds	Caffeine	Stimulant, beverages; very mobile
Other Compounds	Cotinine	Primary nicotine metabolite
Other Compounds	Triclosan	Disinfectant, antimicrobial
Plasticizer	Diethyl phthalate	Plasticizer for polymers and resins
Plasticizer	Diethylhexyl phthalate	Plasticizer for polymers and resins; pesticide iner

- Wilkison and others (2002) untreated sewage data
  - Concentration > 0.75 µg/L and in at least 75 % of samples
- Hyer (2007) NCPI sewer-line sample data
- Hyer (2007) NCP4 septic-system sample (septic-tank truck after pumped from a 16-family development in Fairfax,VA)
- whether the compound was indicative of domestic sewage