

West Virginia Water Resources Research Institute

Annual Technical Report

FY 2005

Introduction

West Virginia Water Research Institute

Introduction

The West Virginia Water Research Institute (WVWRI) addresses the key water resource issues facing policy makers, agency staff and the public. Our research program is guided by the West Virginia Advisory Committee for Water Research. It includes representatives from the following:

West Virginia Department of Natural Resources West Virginia Bureau for Public Health West Virginia Chamber of Commerce West Virginia Coal Industry West Virginia Division of Environmental Protection West Virginia Farm Bureau U.S. Federal Bureau of Investigation U.S. Geological Survey U.S. Environmental Protection Agency U.S. Department of Energy - National Energy Technology Laboratory U.S. Department of Agriculture - Natural Resources Conservation Service U.S. Army Corps of Engineers - Huntington, WV District Canaan Valley Institute

The Advisory Committee develops the Institutes research priority list, reviews its progress and selects startup projects at its annual meeting. With this direction, the Institute recruits new researchers to study emerging water research issues. Because the Advisory Committee understands future regulatory and economic driving factors, these issues tend to grow in importance and have often led to follow-on funding from their agencies.

Funding Strategy The Institute receives a grant of roughly \$92,000 annually through the U.S. Geological Survey CWA section 104b program. We use this funding to develop research capabilities in priority areas and to provide service to State agencies, its industry and citizen groups. As a result of successful leveraging, we supported a program with an average yearly value of over \$2M. Our strategy relies on using the USGS section 104b funding to develop competitive capabilities that, in turn, translate into successful proposals funded by a broad spectrum of Federal and State agencies.

Our strategy also relies on maintaining a broad cadre of researchers within WVU and other institutions within the state. We also work with faculty from institutions across the country to form competitive research partnerships. As West Virginia University is the States flagship research institution, its researchers have played the dominant role. Over the past 15 years over 50 WVU faculty members have been supported by WVWRI projects while over 25 faculty from other State institutions have participated in the program.

Our funding strategy relies on successful competition for Federal dollars while teaming with State agency and industry partners. The later provide test sites, in-kind support and invaluable background data.

Research Capability

The bulk of our research is undertaken by academic faculty. Since West Virginia University is the flagship research institution in the State, its faculty have received the bulk of Institute funding. Over 50 WVU researchers have been supported by the WVVRI representing 20 departments. In addition, the Institute has a staff of ten, with three research contractors. Roughly half of the Institute is directly engaged in research projects.

Key Findings

Key findings of projects specifically funded by the USGS 104b program include:

Recommendations regarding changes to road/timber contract language to reduce occurrences of road-associated sedimentation to streams have been made to the Monongahela National Forest.

Springs and seeps located within the Second Creek and Indian Creek watersheds in Monroe County, WV have been classified into one of three groups based on surface geology; this provides a context in which spring/groundwater occurrence along the high mountains of the WV-VA border may be portrayed. This information will be useful to the Indian Creek Watershed Association and the Monroe County Planning Commission in documenting their groundwater resources and identifying those worthy of protection.

A Monroe County Planning Commission was developed in response to a Monroe County Planning Committee which held multiple meetings throughout the county as a direct result of assistance provided by the WVU law school with USGS 104b support. A major objective of this Planning Commission is to protect county water resources from new development and out of state withdrawals.

The West Virginia Legislature, through the Water Resource Protection Act, (WRPA), has recognized that water is a tremendous economic asset in West Virginia and should be managed with the same attention and respect as is given to other capital assets managed by the State. The WVVRI has made significant advances in responding to the WRPA research tasks in support of and in collaboration with WVDEP. Three findings stand out among others: The first is that one-time-event-driven research projects will continue to produce incomplete and potentially misleading findings until more resources are invested in expanding maintaining West Virginias water monitoring infrastructure.

Streamflow data are monitored and recorded in 50 of the States 159 watersheds (10 digit HUCs). Twenty-four of the States counties are not represented a a single stream gage. The second important finding is that the US Corps of Engineers Statewide Flood Report and the State All-Hazards Mitigation Plan both comprehensively address the flood-related research questions outlined in the Water Resource Protection Act (taking into consideration the stream flow data). Finally, framing the question around impacts on beneficial use was important. However, to address these issues in a detailed manner, they must be evaluated on a watershed basis, which would require significant local participation and feedback at the information gathering stages.

New Programs

In 2005, the West Virginia State Legislature recognized the lost economic and social value in abandoned contaminated lands or brownfields. The Legislature created the Northern and Southern Brownfields Assistance Centers to work with WVDEP and the WVDO to support community efforts to turn these

brownfields into productive land again. The Northern West Virginia Brownfields Assistance Center, housed at West Virginia University's Water Research Institute, empowers communities to plan and implement brownfields redevelopment projects in the States northern 33 counties by conducting general citizen and local government education efforts and by providing assistance to specific local communities interested in the reuse of brownfields in their communities. Support can be provided to help groups solicit grants and low-interest loans for site assessments, clean-ups, and environmental job training as well as provide support for preliminary legal and planning work. The Center prioritizes requests from communities that are already working on community-wide development planning and may be interested in integrating brownfields redevelopment into those plans.

Future Direction

The following programs of the WVVRI are expected to continue to remain stable and grown modestly into the future:

National Mine Land Reclamation Center Combustion Byproducts Recycling Consortium Hydrology Research Center Geo-Engineering Center WV Water Gaging Council Northern WV Brownfields Assistance Center

Outreach

The WVVRI performs outreach through meetings, workshops, conferences, site visits, web site, newsletters, and publications.

West Virginia Water Conference 2005

A conference was held in October, 2005 in which the WVVRI co-sponsored a watershed restoration conference with Canaan Valley Institute. This conference was supported in part by USGS 104b funds. This conference was held at the Radisson Inn, Morgantown, WV. More information can be found in the following project report.

West Virginia Water Conference 2006

A conference is planned for October 11-13, 2006 in which the WVVRI will serve as lead and co-sponsor with the West Virginia Bureau for Public Health, and the National Environmental Education Training Center. This 2-1/2 day event will be held at the Stonewall Conference Center in Roanoke, WV. This conference is currently in the planning stages.

WVVRI Web Site

A web site (<http://wvri.nrcce.wvu.edu>) contains information on all the WVVRI programs and projects. This site is updated on an on-going basis as new information becomes available.

WVVRI Brochure

A new brochure on the WVVRI is under development and will be distributed at the October 2006 water conference. It will be distributed at other meetings and events as well.

Newsletter

The WVVRI puts out a free quarterly newsletter on one of its programs: the Combustion Byproducts Recycling Consortium. This newsletter, Ashlines, is available on the CBRC page of the WVVRI web site at <http://wvri.nrcce.wvu.edu/programs/cbrc>.

Publications

Some WVVRI publications are listed on the WVVRI web site. A searchable publications database is planned.

Administrative dollars were put towards work in Monroe County to 1) Conduct a spring assessment and 2) Reserach possible legal avenues to use to protect county water resources. Two reports on the Monroe County work follow this introduction.

Springs and groundwater in a montane hydrogeological setting, eastern Monroe County, WV: a preliminary assessment

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Hydrogeology Research Center WV Water Research Institute NRCCE Building Morgantown, WV 26506

June 15, 2006 1. Problem and Research Objectives This investigation examined groundwater occurrence in a remote undeveloped region near the West Virginia-Virginia border. The area has abundant groundwater and relatively little current use, but great opportunity for expansion should development occur. In addition, the groundwater here is very high in chemical quality, supporting one public service district and a bottled water company as well as the local communities. The mountain recharge setting means the water is relatively pristine, and not subject currently to risk of contamination. The bottled water won a number of awards in competitive international water-tasting competitions. This investigation offered an opportunity to learn more about the hydrogeological setting and hydrochemistry of these springs.

In this investigation, springs were field-mapped classified according to surface geology, then sampled over a for water chemistry. We tested the hypothesis that there are systematic differences in water chemistry that are strongly influenced by aquifer lithology/geology and are a function of structure and stratigraphy. We chose an area of Peters Mountain in Monroe County, WV, between the towns of Centennial and Zenith. Peters Mountain lies on the leading edge of the Allegheny Front thrust-fault complex, and it forms the WV-VA border for a number of miles. This montane setting is thought to be typical of regions along the WV-VA border that are now under some threat of growth and development as infrastructure connecting the area to the Eastern seaboard improves. Water resources both quality and quantity may ultimately prove to be limitations to growth.

The purpose of this study was to test the hypothesis that there are systematic differences in groundwater chemistry within a karst flow regime that can be interpreted to reflect the source aquifer lithology, structure, and stratigraphy. To do this required collection of geochemical data for groundwater beneath Peters Mountain. Comparative statistical analyses were used to test this hypothesis and explore the project's results.

The objectives for this research were to: (1) locate and map groundwater discharge points (2) delineate major hydrologic zones along Peters Mountain (3) perform spring reconnaissance and quantify equilibrium geochemistry (4) apply statistical analyses to the chemical variables illustrating similarities and differences between aquifer groups (5) interpret how that variability influences groundwater chemistry

2. Methodologies Steps in the workplan involved Spring reconnaissance and mapping

From May-August 2004, 221 springs were located and 76 were measured for pH, temperature, and specific conductance (SC). In addition, discharge was estimated. Then, in July-August 2004, samples were collected at 22 springs for analysis of major ion chemistry.

Springs were located and mapped by traversing the mountainside with the fall line on foot to ascertain all visible spring locations. Locations were saved into a handheld GPS at the source of each spring.

Dataset A parameters measured at each spring included estimated discharge (Qest), elevation, specific conductance at 25o C (SC), pH, and temperature (t). Sampling and chemical analysis

Springs were selected for chemical analysis to be representative of the three main aquifer types in the area. Alkalinity, pH, and specific conductance were field measured, with major-ion chemistry analyzed in Morgantown (NRCCE laboratory).

Analysis of results Equilibrium partial pressure of carbon dioxide (PCO₂) and saturation indices with respect to calcite (SI_c) and dolomite (SI_d) were calculated for each water sample. Results were interpreted and contrasted between aquifer groups.

Spring locations and geology were presented on a GIS platform. Descriptive univariate statistics (variance, mean, median, and range) were calculated for all sampling locations. This produced a basis upon which to test variable pairs for correlation and to test for differences between sample means. Frequency histograms were calculated to test the distribution of individual variables. The T test was applied to test for significant difference in mean values between aquifer groupings. Bivariate correlation was also calculated for both reconnaissance and water chemical datasets.

3. Principal Findings

Springs and seeps were located within the Second Creek and Indian Creek watersheds and their waters analyzed for chemistry to interpret the similarities and differences between springs. Springs were classified into one of three groups based on surface geology. The three geological classes were Silurian/Devonian clastic rocks on the east slopes of Peters Mountain (Group 1), the Martinsburg Formation near the top of Peters Mountain (Group 2), and Ordovician carbonate aquifers on the west slopes of Peters Mountain (Group 3). In general, Group 2 occurred at high elevation; Group 3 at low elevation; and Group 1 occurred all up and down the east side of the mountain. Groundwater chemistry differed between the clastic and carbonate groups. Group 1 springs had chemical signatures similar to regional precipitation. Groups 2 and 3 had significantly higher concentrations of dissolved solids. There also were differences in the hydrochemistry between Groups 2 and 3, which both had a carbonate signature but varying magnesium concentrations attributed to the presence of dolomite. The spatial variations in geochemistry are interpreted to reflect the influence of lithology on the aqueous chemistry all of which, in turn, are a function of structure and stratigraphy.

The pattern of spring occurrence was markedly different between Groups. Group 3 springs were few in number, widely scattered, and of generally high discharge. These are thought to be influenced by conduit zones in the Cambro-Ordovician, and possibly in some cases by fault location. The Group 2 (Martinsburg) springs are much more frequent, relatively low in discharge, and occur in clusters on the upper slopes. They are thought to be the result of thin perched aquifers created by repetitively-interbedded shales and limey siltstones that characterize the Martinsburg here. Group 1 springs were widely scattered and relatively low in discharge. Group 2 springs appear to be controlled mainly by stratigraphy, while Group 3 is controlled by structure/faulting.

4. Significance of the Project This project develops a context in which lower Paleozoic spring/groundwater occurrence along the high mountains of the WV-VA border may be portrayed. It also reinforces a fact that is likely to be true even in other areas of different hydrogeological setting: both structure and stratigraphy are likely to be major controls in local hydrogeology and in influencing development/protection strategies for groundwater.

More specifically, there is an active local watershed-based group in Monroe County interested in documenting their groundwater resources and identifying those worthy of protection. This study will provide a basis for them to understand and classify their groundwater, and will give insights into which aquifers yield (a) the most desirable water quality (Group 2), (b) the highest quantity of water (Group 3), and (c) the most vulnerable groundwater to protect from contamination (Group 3).

5. Publications associated with the project Currently, only the Richards M.S. thesis (May 2006) is in print. A journal paper is anticipated. A copy of the thesis in PDF form is attached.

6. Presentations based on the project Donovan, J.J., 2006. Hydrogeological field investigations to support source-water protection strategies". Presentation to Advisory Board of WV Bureau for Public Health, WV Source Water Protection Program Annual Review, April 27, 2006, Charleston, WV.

7. Student Supported This was a small project, and therefore all the awarded funds was used for summer salary, travel, and chemical analyses for the master's thesis of Geoff Richards (M.S. 2006, West Virginia University). The thesis is entitled "Impacts of structure and stratigraphy on aqueous chemistry of Peters Mountain".

8. Notable awards and achievements None to date.

Monroe County: Legal Options to Protect Water Resources

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1-Problem and Research Objectives Problem and Research Objective 1

To assist the Monroe County Commission and citizens to assess whether citizens see a need for land-use planning and the establishment of a County Planning Commission to protect water resources, particularly springs and other ground water, in Monroe County.

Problem and Research Objective 2

To assist Monroe County Commission and citizens to evaluate the extent to which adoption of a subdivision ordinance tailored to protecting springs and other ground water would meet the land-use planning goals of Monroe County.

2-Methodology

Problem and Research Objective 1

Joyce McConnell, who teaches Water Resources Law, Property, Natural Resources and Land Use Planning at West Virginia University College of Law, met with a citizens group and members of the Monroe County Commission four times during the reporting period March 1, 2005 to February 28, 2006 to plan a process to assess the Monroe County citizens perception of the need for land-use planning in the County generally and the establishment of a County Planning Commission specifically.

The meetings took place in Monroe County, usually at the Senior Center. The meetings were well-attended with approximately 30 participants at each meeting. At the first meeting, Professor McConnell, accompanied by two law students, gave a power-point presentation on land-use planning principles generally. At the second meeting, Professor McConnell, assisted by two law students, gave a power-point presentation on the West Virginia Land Use Planning Law specifically.

At the third and fourth meetings, Professor McConnell assisted the citizen leaders with planning for county-wide citizen participation through community meetings.

Throughout the reporting period Professor McConnell assisted the citizens and County Commission members by answering specific questions by telephone or email.

Problem and Research Objective 2

Joyce McConnell supervised a law student to do research on subdivision ordinances designed to protect water resources. The student completed the research and drafted a subdivision ordinance for Monroe County that reflects the research findings. Joyce McConnell discussed the draft subdivision ordinance with citizen representatives and a member of the Monroe County Commission.

Principle Findings

Problem and Research Objective 1

1. Monroe County could address many of its water source issues by establishing a planning commission.
2. A planning commission will be able to operate most effectively in the County after community meetings are held throughout the County to explain the potential contributions of land-use planning generally and of a County Planning Commission specifically.

Problem and Research Objective 2

1. There are several land-use planning tools that West Virginia Counties are authorized to use once a County Planning Commission is established.
2. Of the land-use planning tools authorized, a subdivision ordinance that protects water resources is the most acceptable and necessary of the land-use planning tools.
3. Traditional Euclidian zoning is not an acceptable land-use planning tool for Monroe County to use to meet its goals of protecting water resources.

Significance of the Project

The significance of the project can only be evaluated in the context of the recent adoption of land-use planning law in West Virginia. The West Virginia Land Use Planning Act became effective in June 2004. Few counties in the state have adopted land-use planning mechanisms. Of these, most have been rapidly developing counties responding to development pressure from nearby states and cities. The best examples are those counties that border on Maryland, northern Virginia and are in close proximity to Washington, DC suburbs. Monroe County is one of only three rural counties (Fayette, Monroe and Greenbrier) to begin to use the land-use planning tools available to them to control growth to protect natural resources, such as water.

As one of the first rural West Virginia counties to explore land-use planning to protect water resources, Monroe County is exploring new territory. The significance of the project is that interdisciplinary teams of scientists, lawyers and planners were able to assist Monroe County in assessing needs for protecting water resources and using land use planning tools to meet those needs.

Using land use planning tools in rural areas is difficult for two reasons. First, rural residents often have an antipathy toward land use planning. Second, until there is development pressure, it is difficult to understand the threat that development, even minor development in the wrong locations, can bring to the quality and quantity of water. These two reasons make the success of the Monroe County project a significant contribution to understanding land use mechanisms in rural areas.

Publications associated with the project (pending or published)

Joyce McConnell is currently writing an article on West Virginia land use law and protection of water resources.

Presentations given associated with the project (past or pending)

Four presentations were given in Monroe County using funding from this project. Three additional presentations, using other funds, were given throughout the state of West Virginia using information produced through the project.

Students supported (indicate if they are B.S.; M.S.; Ph.D.; Post-doc; whether they completed a thesis or dissertation; title of thesis or dissertation; major; and if they received support from other awards.)

Two law students (J.D. degree candidates) received direct support from the project. One graduated in May 2005 and the other in May 2006. They each contributed to the production of two power-point presentations. One presentation was on the West Virginia Land Use Planning Act and the other was on West Virginia and federal water law. They did not receive support from other awards.

Students were also supported indirectly through grant funds that provided supervision of their research. by Joyce McConnell.

Notable Awards and Achievements associated with this project.

All of the achievements have been discussed above and all of these are achievements directly related to the project. However, there are no notable awards associated with this project.

Research Program

The following report represents Part 1 of work performed by J. Wang on forest road impacts to water quality. Dr. Wang received additional funding to perform Part 2 of the project in FY07.

Changes to In-Stream Suspended Sediment and Turbidity Following Improvements to a Forest Road in West Virginia

Basic Information

Title:	Changes to In-Stream Suspended Sediment and Turbidity Following Improvements to a Forest Road in West Virginia
Project Number:	2004WV26B
Start Date:	5/1/2004
End Date:	9/1/2006
Funding Source:	104B
Congressional District:	WV 01
Research Category:	None
Focus Category:	Non Point Pollution, Sediments, Water Quality
Descriptors:	None
Principal Investigators:	Jingxin Wang, Pamela Edwards, Joseph F. McNeel

Publication

Annual Report
(A Project Funded Through USGS 104b Program)

Title: Changes to In-Stream Suspended Sediment and Turbidity Following Improvements to a Forest Road

Investigators: Jingxin Wang and Pamela J. Edwards

1. Problem and Research Objectives

A forest road was constructed through a watershed in summer 2002. It was left in poor condition from fall 2002 through mid-summer 2003. In mid-summer 2003 its condition was improved through the installation of more and better water control features, sediment traps, seeding of the fill slopes and cut banks, and graveling of the driving surface.

Turbidity and suspended sediment levels in both the control and treatment watersheds fell within expected ranges during the 3 pretreatment years prior to road construction. By contrast, both parameters increased to very high levels on the treatment watershed during the spring and early summer 2003 before the road condition was improved and finalized; turbidity increased to levels that exceeded West Virginia Water Quality Standards. After road improvements were finalized, reductions in turbidity and suspended sediment were observed on the treatment watershed.

The objectives of this study are to continue stream water sampling through at least spring 2008 to determine:

- 1) if the turbidity and suspended sediment levels in the treatment watershed continues to decline through time to levels that no longer resulted in exceedences of West Virginia Water Quality Standards,
- 2) the pattern recovery as it occurred, and
- 3) whether storms with certain attributes (e.g., large volumes of precipitation, or events with periods of high intensity) continue to result in extremely elevated turbidity and suspended sediment (presumably due to sediment stored in the channel), even if more “average” storms no longer yield elevated sediment at the mouth of the watershed.

2. Methods

A paired watershed approach is being used for this study. The two watersheds are located along the Left Fork of Clover Run, on the Monongahela National Forest, Tucker County, WV. One watershed is used as the treated watershed and one as the reference or control watershed. Many parameters are being monitored as a part of this study; in this report we describe only those associated with the objectives given above.

Near the mouth of both watersheds, a stream monitoring station was established in 1999. At each site, stream stage is measured every 5 minutes with an American Sigma depth/velocity probe. Velocity measurements have proven to be inaccurate so velocity has been calculated using Manning's n to determine velocity across a variety of stages.

Discharge has been determined as the product of velocity x cross sectional area (determined from surveying the stream cross section where velocity is measured). During periods that stage measurements were unavailable because the probes malfunctioned or were broken, stage for the watershed of interest was estimated from regression equations developed using stage from nearby permanently gauged watersheds.

Two automatic stream samplers (ISCO and American Sigma) are housed in shelters at the mouth of each watershed. One of the samplers collects a sample every 24 hours (i.e., daily samples), while the other sampler is actuated during storms using precipitation actuation (i.e., stormflow samples). Storm samplers are programmed to collect a stream water sample every half hour during the summer when stormflow responses are flashy and peak sediment occurs early in the event, or hourly during the dormant season when stormflow responses are less flashy and require a substantially longer time to return to baseflow. Each ISCO or Sigma case has 24 1-L bottles. If the storm is continuing, new cases of bottles are placed in the field in order to characterize the sediment characteristics throughout the storm. The time that each sample is collected is recorded internally in the automatic collector's memory.

Many storms have been sampled since 1999 on both watersheds. The principal reasons that some storms have not been sampled or have not been sampled during the entire event are that equipment has malfunctioned or the flow in the 5 fords that must be crossed is too high to traverse safely, even in a full sized truck.

The samplers and data loggers are operated using separate 12-V marine batteries that are changed when the voltage drops to approximately 10 V. This assures that sufficient charge is available to operate the sampler or loggers throughout each storm or over the required time period. During the winter, the shelters are heated to above freezing using small propane lights. The heat given off by the lights is sufficient to 1) keep the collected samples above freezing, avoiding bottle cracking, 2) keep the instruments in a temperature range to assure operation, and 3) provide sufficient light to allow the technician to service them easily in the limited light situations commonly experienced during the winter.

Samples are processed at the US Forest Service's Timber and Watershed Laboratory. Each stream water sample is processed first for turbidity and then for suspended sediment. Turbidity is determined using a Hach Ratio Turbidimeter. The sample is agitated in the bottle to distribute sediment particles evenly throughout the sample. An appropriate amount of the agitated sample is immediately poured into the sample vial and then placed into the turbidimeter. After approximately 10 seconds, the reading is recorded. The appropriate scale on the turbidimeter is used, depending upon the degree of turbidity in the sample. Results are expressed as Nephelometric Turbidity Units (NTU).

After the reading is taken, the sample is poured back into the original bottle and then suspended sediment concentrations are determined. The bottle and lid with the sample are weighed, and the bottle and lid weight are then subtracted to obtain the weight and volume of the sample. Following standard protocols, the volume in ml is assumed to be equal to the weight in g, since the density of water is approximately 1 g/cm^3 , and $1 \text{ ml} = 1 \text{ cm}^3$. Each sample is vacuum filtered through one or more pre-dried and pre-weighed ashless GF/C glass microfiber filters. Most samples require only 1-3 filters, depending upon the level of suspended sediment and amount of organic material present, though

some require more. Each bottle is rinsed with water as many times as needed to remove all of the suspended material. The rinse water also is filtered. The filters from each sample are dried at 100 °C for 2 hours and then re-weighed after cooling in a dessicator. This weight, minus the initial dry filter weight, is the total weight of suspended material (mineral + organic) in the sample (g/L). Once weighed, the filters then are burned in a muffle furnace at 550 °C for 1 hour and then re-weighed. The burned weight, minus the initial filter weight, is the weight of the mineral material only (mg/L), or suspended sediment. These data are recorded along with the sample number, and time and date of sample collection so that stream discharge can be applied to the suspended material and suspended sediment values to determine the total suspended material and total suspended sediment that were exported from the watershed during the storm or over the time period (e.g., annually) in question.

Pretreatment samples were collected from fall 1999 through summer 2002 from both watersheds. A forest road was pioneered through the treatment watershed in summer 2002; essentially no best management practices (BMPs) were applied to the road until summer-fall 2003, when the road in the watershed was completed. Stream water samples continued to be collected daily and during storms after the pretreatment period on both watersheds, and are expected to continue to be collected until spring 2008.

3. Principal Findings

Data analyses of the turbidity results are largely complete through 2005; however, analyses of suspended sediment concentrations and loadings are only in the preliminary stages. Therefore, the findings presented here involve turbidity. Analyses of objectives 2 and 3 of this study also are only in the initial phases, so they are not discussed in this report.

While funding for this project involves the recovery period after BMPs were applied to the road, results presented here include the period prior to that (pretreatment through the road construction period) to put the posttreatment/recovery data into context and to illustrate temporal changes.

Daily Samples:

With few exceptions, turbidities associated with the daily stream samples were low (Fig. 1). Prior to disturbance, turbidities from the reference and treatment watersheds, respectively, generally were < 40 NTU and < 20 NTU. The first elevated turbidity from the treatment watershed in 2001 and the only one from the reference in 2002 were associated with daily samples collected within storm events. The greatest daily peak in 2001 (in the treatment watershed) was associated with a sample taken during a period in which a leaf jam was affecting the turbidity; more than 30 percent of the associated total suspended solid concentration was organic material.

Daily samples were not collected from June 8, 2002 through May 28, 2003. However, based on the preponderance of substantial increases in daily turbidity values in the growing season of 2003 from the treatment watershed (Fig. 1), it is likely that daily turbidities during part of the 2002 growing season also were elevated. Higher streamflow throughout 2003 compared to previous years may have allowed the suspension of greater amounts of sediment (Fig. 2), but the very low turbidities in December 1999 during

equally high flows, along with the low turbidities in the reference during 2003, indicate the frequent occurrence of higher turbidity values in 2003 occurred because of the elevated levels of available sediment in the treatment watershed.

The daily samples indicate that background levels prior to road construction on the treatment watershed were < 20 NTU (Fig. 1). After road construction in 2003, treatment watershed turbidities for the daily samples regularly were well above the allowable 30 NTU level (assuming 20 NTU background + 10 NTU allowable increase from the WV Water Quality Standards).

Stormflow Samples:

Prior to the start of road construction, the peak turbidities (i.e., single maximum value for each event) recorded during storm events on the reference and treatment watershed were typically < 100 NTU, and usually much less than 100 NTU (Fig. 3). Only 5 of peak storm turbidities on the treatment watershed were > 100 NTU, and only one exceeded 100 NTU on the reference watershed. The highest measured turbidity from the treatment watershed prior to road construction occurred in 2000 (366 NTU) and the highest from the reference watershed in 2001 (106 NTU). The distributions of turbidity values for all storm samples (i.e., not just the peak turbidity values) collected before road construction show that in the treatment and reference watersheds, respectively, approximately 94 and 92 percent of the samples had turbidities ≤ 10 NTU. Turbidity becomes visible to the human eye when it reaches about 5 NTU; thus, even though turbidities occasionally increased to visible levels, they were elevated for only a short time within each storm in the absence of disturbance.

No stormflow samples were collected from June through September 2002 during the period of active road pioneering, but once road pioneering was completed the peak turbidities for many of the sampled storms increased markedly. Peak turbidities regularly were hundreds of NTU or higher in 2003 (Fig. 3). The largest peak turbidity, 2352 NTU, was recorded on July 8, 2003; this storm had an estimated recurrence interval of 1.5 yr based on historical flow data from a nearby watershed, and was the second largest event of water year 2003. By contrast to pre-road conditions, turbidity levels throughout the storms also were markedly higher on the treatment watershed immediately after road construction.

Turbidity Hysteresis

Throughout the entire study for the reference watershed, and prior to road construction on the treatment watershed, turbidity responses were typical for headwater streams in central Appalachian forests. Turbidity increased quickly in response to increasing discharge, peaked prior to or near the time of peak discharge, and then receded to low levels more quickly than the hydrograph (Fig. 4). This type of response is indicative of a system that has a limited supply of available sediment for transport and is defined by clockwise hysteresis of turbidity in relation to discharge (Fig. 5).

Storm sampling following the start of road construction began in October 2002. Storms that were sampled sufficiently long to examine turbidity relationships with discharge showed that turbidity peaked prior to discharge and had clockwise hysteresis until spring 2003. Beginning in April and extending through fall 2003, turbidity sometimes peaked after discharge, and the hydrograph returned to baseflow conditions

more rapidly than turbidity returned to pre-storm levels (Fig. 6). This behavior resulted in counterclockwise hysteresis (Fig. 7). The lag between peak discharge and turbidity and resulting counterclockwise hysteresis indicates the sediment sources that were controlling turbidity were from sources upstream or in a tributary. In this stream, the sources of sediment during counterclockwise hysteresis primarily were from the areas around the first and third stream crossings, where mechanical contributions during stream crossing construction (during pioneering in 2002 and completion in 2003) and gravity and precipitation-driven contributions of stream crossing fill and hillside fillslope erosion were observed to be much higher than the watershed as a whole. Check dams were installed in the streams in 2002 below these crossings to contain sediment; thus, while they were in place they provided these upstream, concentrated sediment sources. The check dams were removed from the stream in September 2003, and the sediment that had been stored in them became flushed and dispersed throughout the downstream reaches. As a result, the last storm for which counterclockwise hysteresis was observed occurred in October 2003; later storms returned to patterns of clockwise hysteresis.

4. Significance of the Project

The ability to examine temporal recovery after BMP implementation provides a unique opportunity. Rather than simply examining if sediment levels return to pretreatment conditions and how long that recovery takes, this study is undertaking a more thorough and complex examination of sediment routing/behavior changes. The final product should provide a clear picture of why it is essential to prevent in-stream sedimentation rather than simply stopping it once it has occurred. In the most general terms, this project illustrates the need for implementation of BMPs as quickly as possible after disturbance. More specifically, recommendations regarding changes to road/timber contract language to reduce occurrences of road-associated sedimentation have been made to the Monongahela National Forest.

5. Publications Associated with the Project

“In-stream turbidity changes resulting from forest haul road construction” Planned for submission to Journal of the American Water Resources Association. Currently out for external review prior to journal submission, as per Forest Service requirements.

A masters thesis and at least 2 resulting journal articles from that thesis are anticipated within the next ~12-15 months

6. Presentations Given Associated with the Project

Some of the turbidity hysteresis results were presented by a third party as part of a lecture concerning the effects of forest management on water quality at the Environmental Science and Forestry Department at the State University of New York, Syracuse.

7. Students Supported

William Sharp, M.S. Student (His thesis is close to be done.)

8. Notable Awards and Achievements

None.

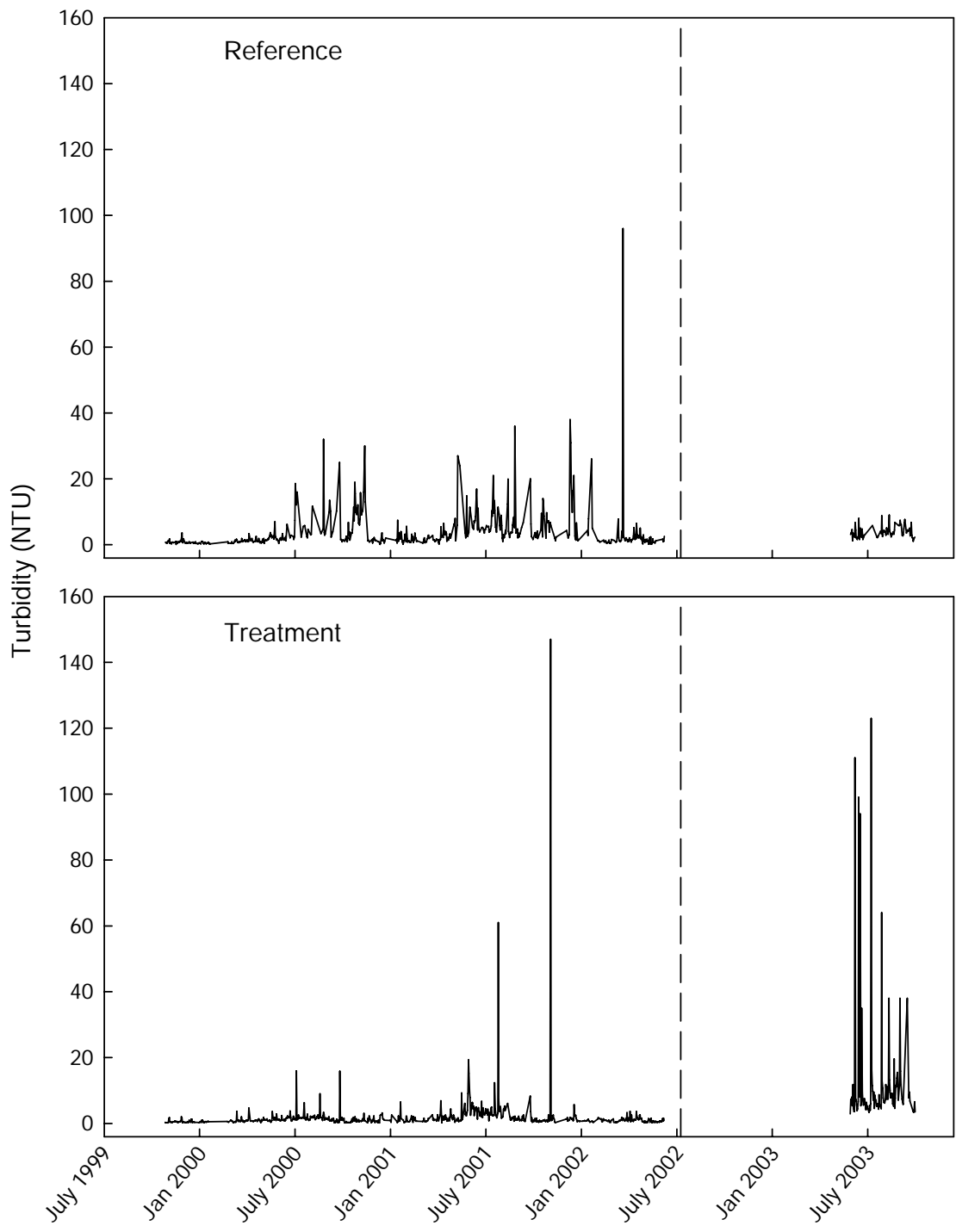


Figure 1. Daily turbidity from treatment and reference watersheds. Vertical line indicates initiation of road construction

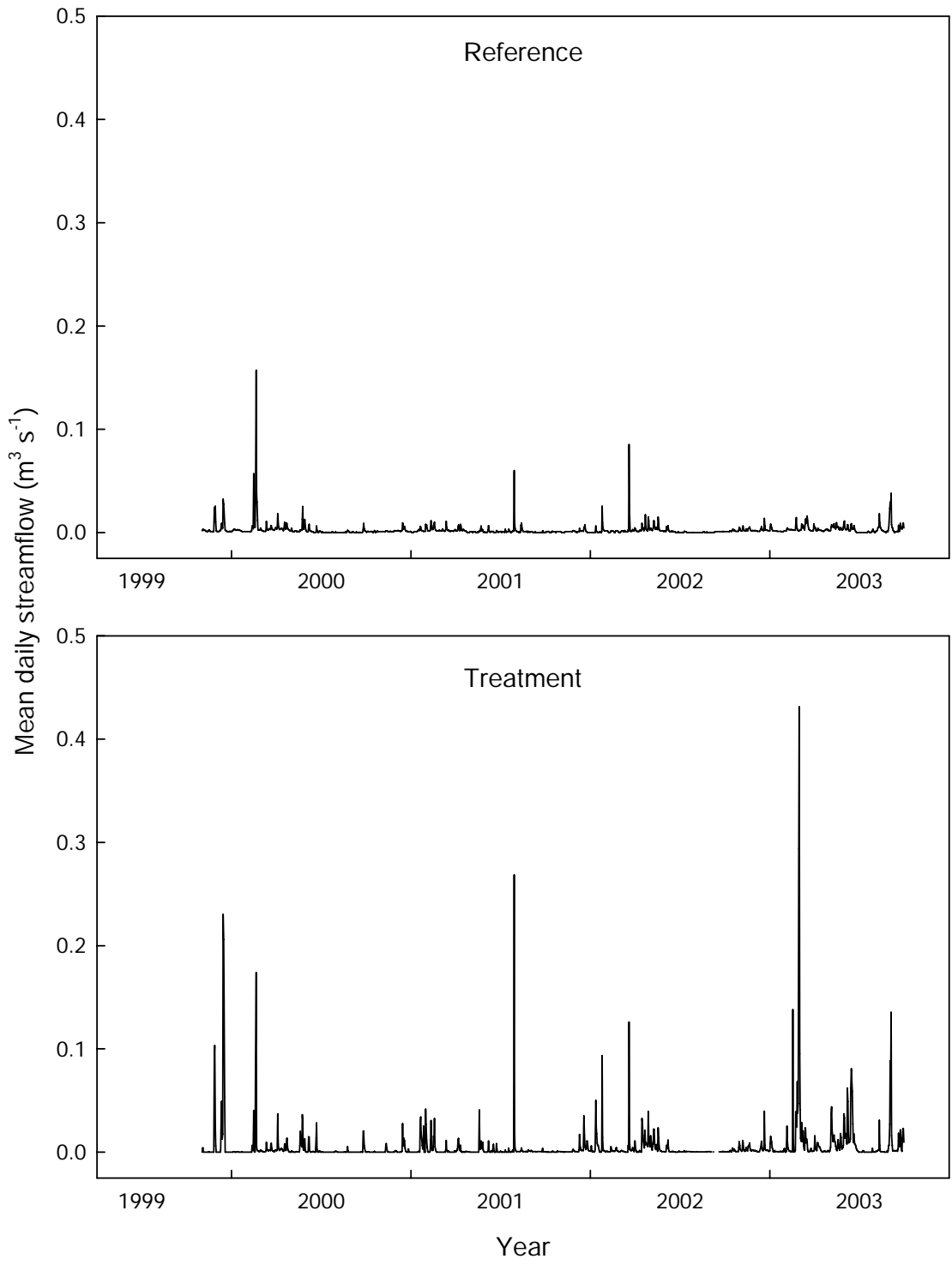


Figure 2. Daily streamflow from treatment and reference watersheds.

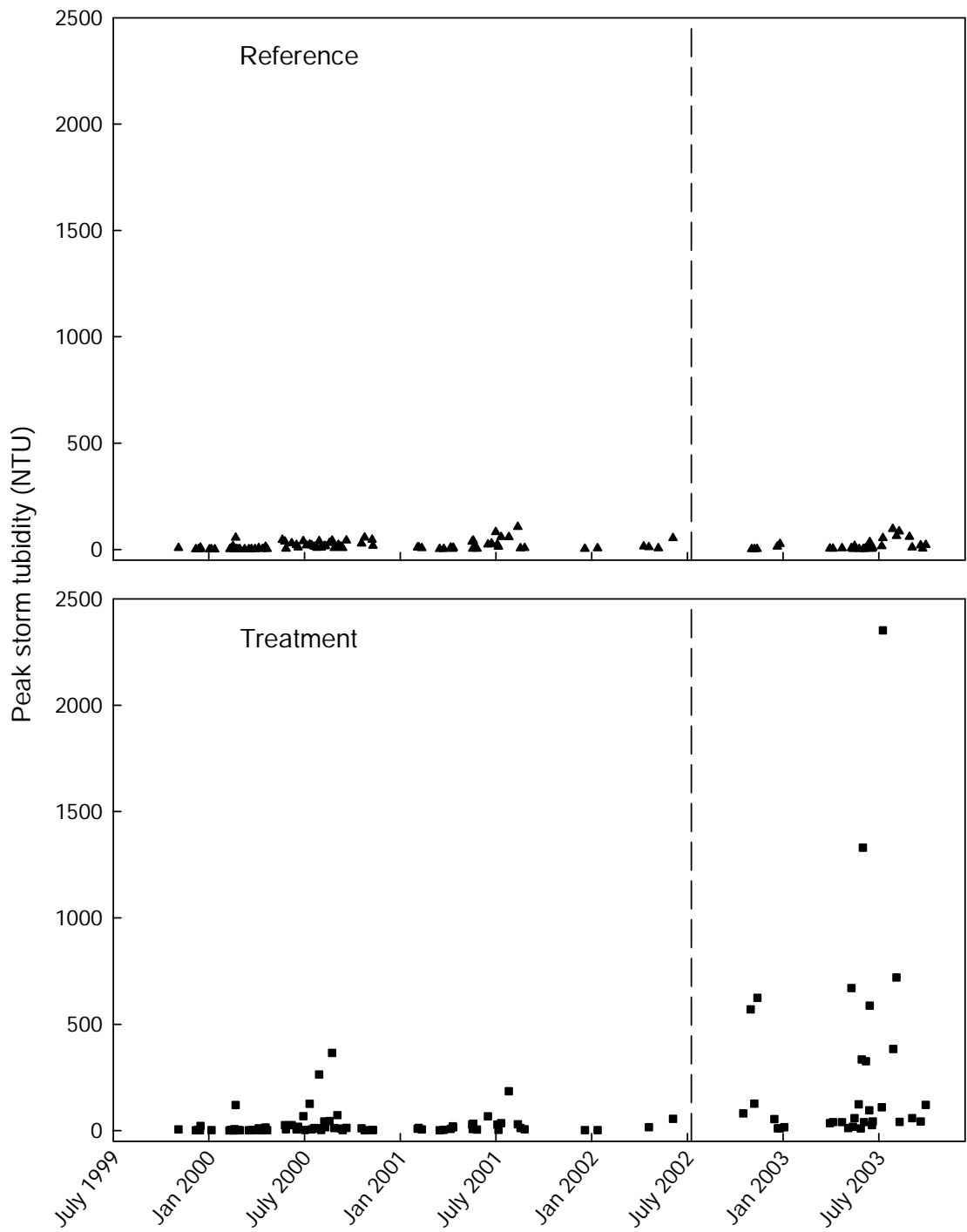


Figure 3. Peak stormflow turbidity from treatment and reference watersheds. Vertical line indicates the initiation of road construction.

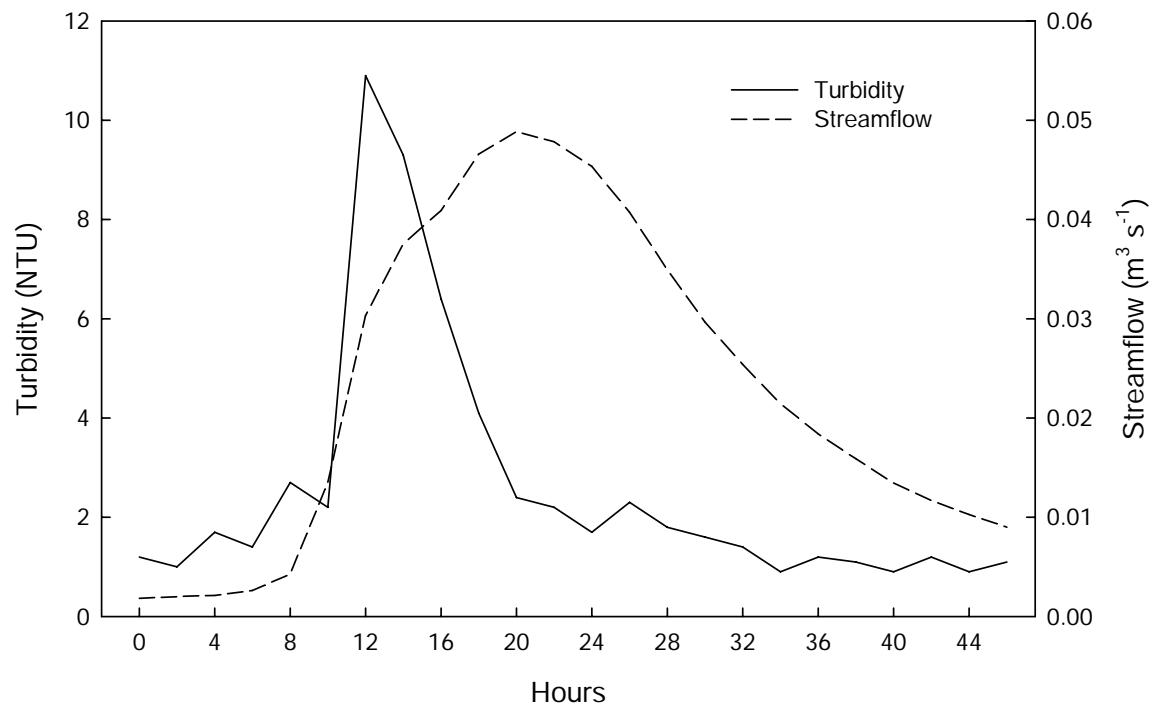


Figure 4. Turbidity and discharge for a representative storm (April 3-5, 2000) from the treatment watershed prior to road construction activities. These responses are also typical for the reference watershed throughout the entire study period.

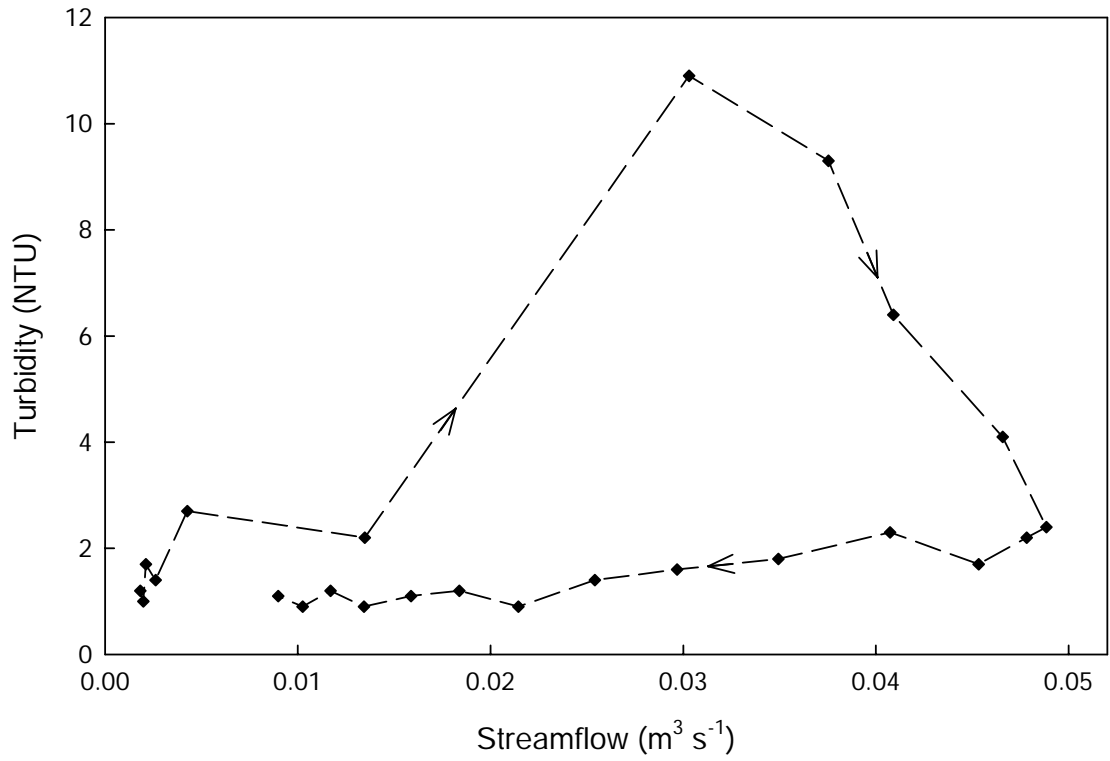


Figure 5. Clockwise turbidity hysteresis for the storm shown in Figure 4.

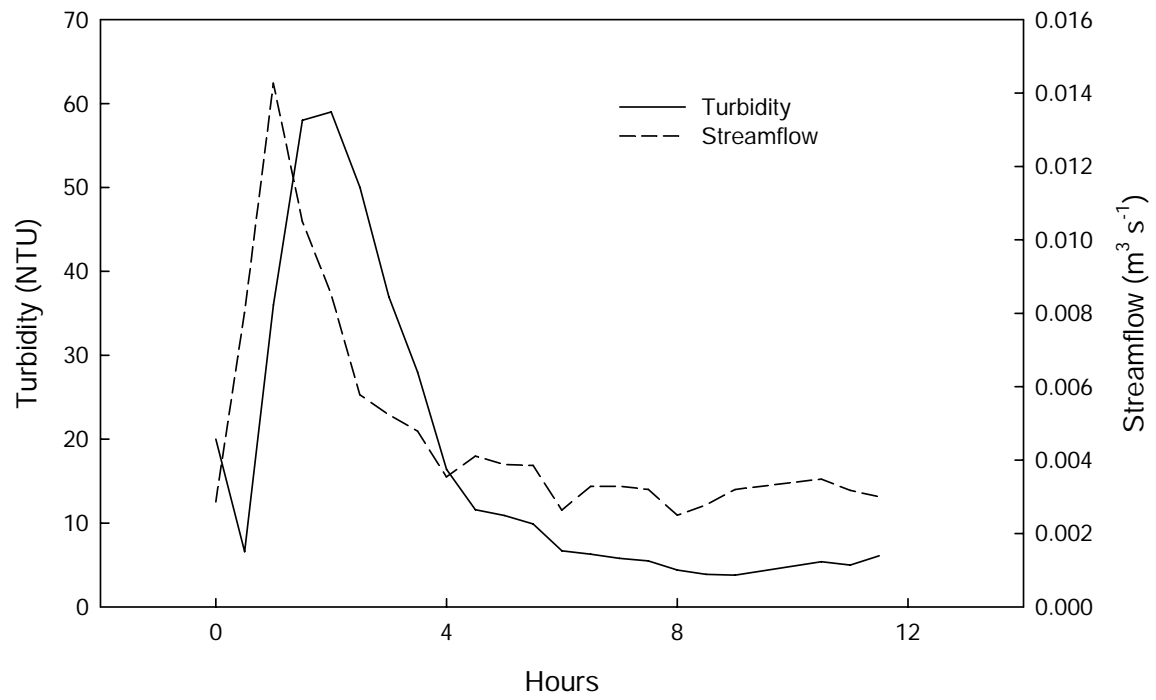


Figure 6. Turbidity and discharge relationships for a representative storm (May 15-16, 2003) on the treatment watershed during road construction.

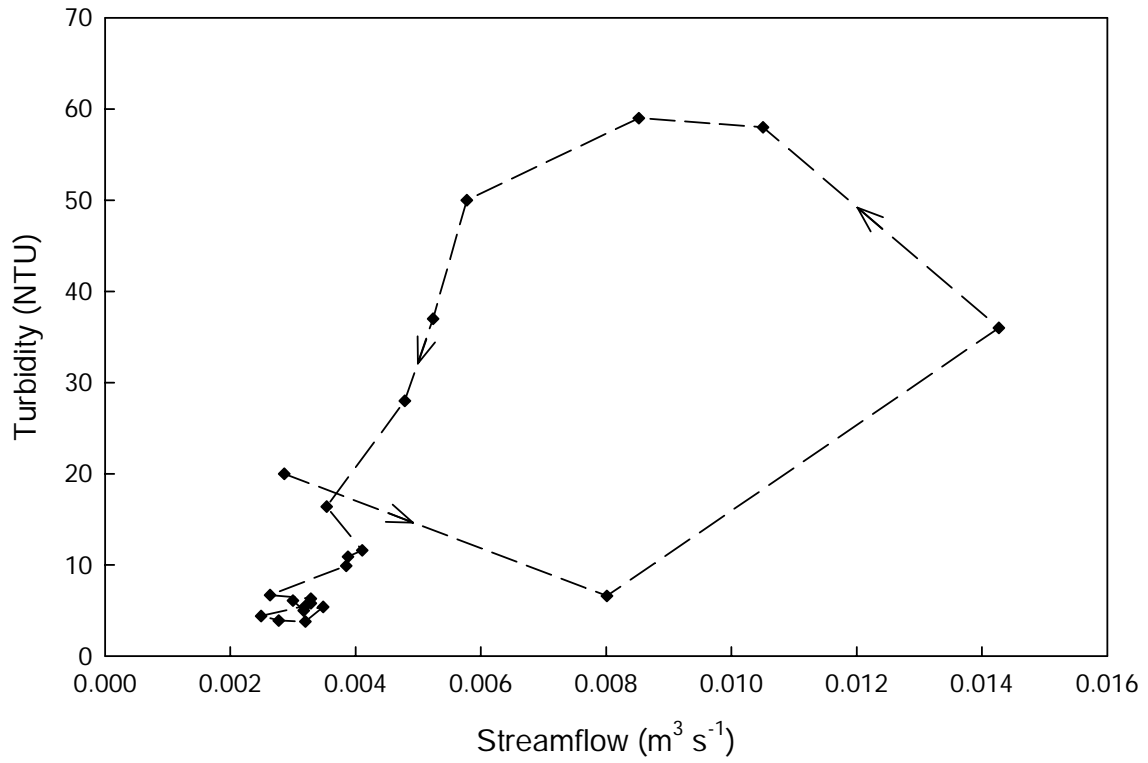


Figure 7. Counter-clockwise hysteresis for the storm shown in Figure 6.

Information Transfer Program

There were two information transfer projects this year: 1) Assistance to WVDEP to conduct a state water survey and 2) A state water conference. Reports for both projects follow.

West Virginia Water Resources Inventory and Assessment

Basic Information

Title:	West Virginia Water Resources Inventory and Assessment
Project Number:	2005WV52B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	West Virginia #1
Research Category:	Climate and Hydrologic Processes
Focus Category:	Water Quantity, Water Use, Water Supply
Descriptors:	None
Principal Investigators:	Richard Herd, John D. Quaranta, Paul Ziemkiewicz

Publication

West Virginia Water Resources Inventory and Assessment

**West Virginia Water Resource Protection Act Water
Resources Inventory and Assessment**

WV Water Research Institute

Submitted to

United States Geological Survey
Tamara Vandivort, WV Water Research Institute

Submitted by

West Virginia Water Research Institute
West Virginia University

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June 2006

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ABBREVIATIONS AND ACRONYMS

CEGAS	Center for Environmental, Geotechnical and Applied Sciences
CVI	Canaan Valley Institute
HUC	Hydrological Unit Code
IMS	Information Management System
MU	Marshall University
NCDC	National Climate Data Center
NFIP	National Flood Insurance Program
NWS	National Weather Service
OES	Office of Emergency Services
PDSI	Palmer Drought Severity Index
USGS	United States Geological Survey
WRI	West Virginia Water Research Institute
WRPA	Water Resource Protection Act
WVDA	WV Department of Agriculture
WVDEP	WV Department of Environmental Protection
WVU	West Virginia University

1 Introduction

In March 2004 the West Virginia Legislature adopted Senate Bill 163, the Water Resources Protection Act, which recognizes the need to inventory, assess and evaluate the State's water resources for present and future use and enjoyment and protection of the environment. The Legislature recognized for the first time, in statute, that the state's water resources are vital and essential for preserving and promoting the quality of life and economic vitality of the state. The Act calls for a one-time, limited assessment of the *quantity* of the state's water resources. It provides for: claiming and protecting state waters for the use and benefit of its citizens; evaluating the nature and extent of its water resources; and identifying activities that impede the beneficial uses of the resource. This is the first statewide initiative to compile and analyze the disparate water quantity related data and information from multiple public agencies, universities and private sources.

The legislation requires the Secretary of the West Virginia Department of Environmental Protection (WVDEP) to inventory, assess and evaluate the State's water resources and propose a strategy for water quantity management. The Secretary is to accomplish this mission by soliciting the assistance and cooperation of federal and state agencies and universities who have management responsibility and research capabilities related to state water resources and report to the Legislature by December, 2006.

The objective of this project was to provide technical support to the WVDEP in identifying, collecting, assessing, reconciling and analyzing the State's water resources to fulfill the mandate of the Act. To accomplish this objective the Water Resource Institute at West Virginia University (WVWRI) and the Center for Environmental, Geotechnical and Applied Sciences (CEGAS) at Marshall University formed a program management entity titled the *West Virginia Center for Water Resource Management* (Center). The Center, under the co-direction of Dr. Paul Ziemkiewicz (WVWRI) and Dr. Tony Szwilski (CEGAS) utilized internal funding sources to assist DEP in addressing the higher priority information and research needs (for WVWRI, USGS 104 (b) funds were utilized). Research priorities were determined in a joint effort between Center and WVDEP representatives.

While internal funding was used for the first of this two year project, additional work for the second year was to be funded by state or private funds. A small additional grant of USGS 104 (b) funds was solicited by and allocated to WVWRI to undertake a state-wide and inter-agency monitoring stream gage and groundwater well needs assessment and prioritization project. Provision of funding was discussed by the Water Resources Committee of the Legislature in December, but no funds were allocated by the end of the legislative session. As a result, some of the tasks have not been completed.

This report provides the status efforts and results of WVWRI findings relating to the project elements assigned by WVDEP to WVWRI and shown in Table 1. Our key conclusions to date, however, can be summarized briefly.

Our research efforts generated three key findings that are important for WVDEP efforts to recommend a state water quantity management program. The first is that historical land and water resource monitoring data are insufficient to reliably answer the research questions outlined in Table 1. Unfortunately, this is not a problem of past data collection gaps but rather current and growing problems in maintaining the state's water data collection infrastructure. Much of this report focuses not on providing definite answers. Rather, it is an evaluation and illustration of what data exist and where there are critical data gaps with respect to the research questions outlined in the WRPA.

The second notable issue is that water resource evaluation and planning require significant input at the local and regional levels; state-level datasets and regulatory efforts cannot capture important dynamic and location-specific information flows and on-going resource management practices (formal or informal, and often qualitative rather than quantitative). Eastern and mid-Atlantic states' water resource management programs increasingly consist of both a state-level water resource data monitoring program and county or watershed-based water resource management and planning programs.

Finally, domestic and international trends in water resource planning all support the concept of integrated water resource management (IWRM). Land use, water quality, and water quantity must be studied as interrelated systems. Additionally, science, policy, law, economics, and the social contexts are all part of any water resource management question, but such interdisciplinary analysis requires quantitative data and trend analysis as a foundation. Technical, science-based information can lose important significance if taken outside of economic or policy context.

This report first outlines the **research questions** that identified in the Act and allocated to WVWRI. The second section outlines our **research strategy or methodology**. The third section reviews the **results** of our research with commentary on data gaps and other shortfalls mentioned above. This section first covers issues of flooding, followed by a section on drought and low flow issues, and then one on water conservation issues. In both the flood and drought sections, information available to the state is presented, and mapped when possible. In each case, preliminary findings are detailed to illustrate data gaps. Finally, a list of presentations and papers is presented at the end of the report.

Table 1 Highest priority project elements addressed by WVWRI to assist DEP in meeting the requirements of SB 163

Element 4: Historical and Current Conditions That Indicate Low Flow and Flood / Drought Conditions.

4.1 Identify areas of concern regarding historical or current conditions that indicate low flow conditions or where drought or flood has occurred or is likely to occur that threatens the beneficial use of the surface water and groundwater

4.2 Examine historical conditions that may exacerbate flooding

4.3 Map drought and flood prone areas

Element 5: Evaluate Current or Potential In-Stream or Off-Stream Uses that Contribute to or are Likely to Exacerbate Natural Flow Conditions to the Detriment of the Water Source.

Element 9: Practices to Reduce Water Withdrawals.

9.1 Past and present conservation techniques that will reduce water use in industrial commercial and residential sectors

2 Methodology

The following work plan for WVWRI Water Resource Protection Act 163 is based on our intended research methodology. As the project progressed, the methodology was altered based on time, data, and funding short falls. These are discussed in the **Results** section of this report.

Element 4: Historical and Current Conditions That Indicate Low Flow and Flood/Drought Conditions.

Approach: *Flood and drought metrics will be developed and applied to historical data to determine areas that are drought and flood prone. Drought and flood threats to the beneficial use of surface and groundwater will be discussed qualitatively based on published and collected cases that are illustrative of impact on various uses.*

4.1 IDENTIFY AREAS OF CONCERN REGARDING HISTORICAL OR CURRENT CONDITIONS THAT INDICATE LOW FLOW CONDITIONS OR WHERE A DROUGHT OR FLOOD HAS OCCURRED OR IS LIKELY TO OCCURE THAT THREATENS THE BENEFICAIL USE OF SURFACE AND OR GROUNDWATER

4.1.1 Drought Metrics: 5-factor index (precipitation, soil moisture, groundwater, streamflow, reservoir levels) for assessment of 3 severity levels of drought (watch, warning, emergency) to be developed that could serve as drought indicator and applied to historical data to determine drought-prone areas. Coordinates with neighboring states' approaches (PA, VA).

4.1.1.1 Precipitation

- A. Obtain NOAA precipitation data for all sites in West Virginia with 30 year or more period of record.
- B. Determine the number of drought occurrences and duration of occurrence at each station based on the Pennsylvania precipitation deficit table.
- C. Plot station locations in the GIS.
- D. Use precipitation deficit to map the extent of drought in the state for one occurrence by month to illustrate drought monitoring relevance.
- E. Compare incidence of drought as determined in item B above to historical drought declarations.

4.1.1.2 Stream Flow

- A. Obtain (hourly) stream flow data from all gages USGS gages in West Virginia with a 30-year or greater period of record.
- B. Obtain all historic percentile data for these same gages.
- C. Plot stations in the GIS and assign counties to gage data
- D. Create percentile data for these gages where it is absent.
- E. Use percentile data to map at least one drought statewide.
- F. Compare incidence of drought as mapped in D to historical drought declarations and precipitation deficit data generated in 4.1.1.1.
- G. Compare drought flows against available 7Q10 flows.

4.1.1.3 Groundwater

- A. Obtain (daily) water level data from USGS operated wells.
- B. Obtain all historic percentile data for these same wells.
- C. Plot stations in the GIS and assign counties to gage data based on USGS regions.
- D. Create percentile data for these wells where it is absent.
- E. Use percentile data to map at least one drought statewide.
- F. Compare incidence of drought as mapped in D to historical drought declarations, precipitation deficit data generated in 4.1.1.1, and stream flow data generated in 4.1.1.3
- G. Identify mine discharges and natural springs, or ground water based public water supplies that may be used to augment the water well data.

4.1.1.4 Soil Moisture

- A. Obtain historical (Weekly) Palmer Drought Index data from NOAA
- B. Plot stations in the GIS and assign counties to the index data
- C. Map Palmer data for at least one drought statewide.
- D. Compare incidence of Palmer drought index with the other indices previously generated.

4.1.1.5 Drinking Water Supplies/Reservoirs

- A. Identify lakes or reservoirs used to supply public water supply systems.
- B. Obtain water level records and stage storage data from selected water supplies in each of the States climatic regions.
- C. Create percentile ranking on the reservoir storage volume.
- D. Map reservoir data for at least one drought statewide.
- E. Compare reservoir index with other drought indices previously generated.

4.1.2 ***Drought Implications for Beneficial Use*** – *these reports will primarily be qualitative analyses based on illustrative published and collected case studies.*

4.1.2.1 Recreational fishing

4.1.2.2 Swimming

4.1.2.3 Aquatic habitat

4.1.2.4 Recreational boating

4.1.2.5 Transportation

4.1.2.6 Electric power generation (Lake Lynn, Albright, Glen Ferris)

4.1.2.7 Water Supply

4.1.2.8 Effects of water use restrictions

4.1.3. ***Flood Metrics - Comparison of Various Flood Indicators and Declaration Data***

- A. Perform a frequency analysis on the number of counties where OES has declared flood emergencies.
- B. Analyze precipitation data to determine percent-exceeded level that correlates with flood declaration.
- C. Analyze precipitation record to determine indicated flooding frequency and compare these data to incidence of flood declaration.
- D. Analyze hydrograph data to determine the percent-exceeded level that correlates with flooding.

- E. Compare precipitation and hydrograph methods; determine if some watersheds have lower or higher flooding thresholds.

4.1.3 ***Flood Implications for Beneficial Use – qualitative research and collected case reviews***

- A. Transportation
- B. Water Intakes
- C. Sewer Systems / Combined Sewer Overflow
- D. Channel Alterations
- E. Impacts on ground water
- F. Surface water quality

4.2 EXAMINE HISTORIC CONDITIONS THAT MAY EXACERBATE FLOODING.
--

4.2 Historic Conditions that May Exacerbate Flooding

- A. Summarize findings from State Flood Report and other state and academic flood research

4.3 MAP DROUGHT AND FLOOD PRONE AREAS.

4.3 Map Drought and Flood Prone Areas

4.3.1 *Mapping Drought Prone Areas*

- A. Utilize precipitation deficit mapping to identify areas of historic sub-normal precipitation.
- B. Utilize occurrences of stream flow below the 90 (or other) percentile to generate drought frequency mapping.
- C. Utilize soil-mapping techniques to identify drought susceptible soils.

4.3.2 *Mapping Flood Prone Areas*

- A. Generate map of flooding based on historic OES flood declarations.
- B. Generate and evaluate percentile stream flow data to determine suitability of method for flood mapping. If suitable generate flood frequency mapping.
- C. Assemble digital FEMA floodplain maps and compare percentile streamflow data to flood plain maps.

Element 5: Evaluate Current or Potential In-Stream or Off-Stream Uses that Contribute to or are Likely to Exacerbate Natural Flow Conditions to the Detriment of the Water Source.

Approach: Changes in flow volume and/or velocity may have adverse effects on the volume and quality of water in streams or groundwater supplies. For example, dams tend to reduce peak flows while securing minimum flows. Controlled dams also eliminate the natural variability of flow on which riparian flora and fauna can rely. Development including buildings, roads, and other impermeable surfaces exacerbate high flow conditions and minimize or eliminate ground-water recharge. Other land use modifications including mining, timbering, and farming change the rainfall – runoff – infiltration relationships for large land areas within the State thus changing natural peak flow and low flow conditions in the receiving streams and aquifers. Consumptive uses must be identified and the degree to which they diminish stream flow identified. The timing and conditionality of non-consumptive water use is also important

5.1 Dams

- A. Utilizing DEP survey, permit files and reservoir GIS mapping identify reservoirs that provide water for consumptive use.
- B. Obtain facility-operating data.
- C. Quantify water consumption by watershed.

5.2 Intake / Users

- A. Obtain data from DEP survey and select water users to identify quantity concerns related to drought, flood, and growth policy.
- B. Utilize these data to identify water quantity problems on a statewide basis.
- C. Impact of significant users exempt from the DEP survey where there is a low-flow impact on ground or surface water (e.g. mining, drilling, quarrying, water bottling facilities, agriculture). Scenario analysis/evaluation.

5.3 Land use

- A. Obtain historic land use maps in digital format and evaluate these maps for changes in land use over time. Specifically, for changes in forest acreage, mining acreage, agricultural acreage, open water, and impervious surface area by watershed.
- B. Evaluate these results for implications to changes that may be to the detriment of the water resource.

Element 9: Practices to Reduce Water Withdrawals: Review the past and present conservation techniques that will reduce water use in industrial, commercial and household sectors.

Approach: Review Federal, State, and Local statutes to identify any rules that may address water conservation techniques or practices (voluntary or mandatory). Agencies would include but not be limited to: Environmental Protection Agency, Department of Energy, Department of Agriculture, Monongalia County Commission, West Virginia Public Service Commission, West Virginia Development Office, West Virginia Department of Environmental Protection, local public service districts and/or utility boards.

3 Results

3.1 FLOODING

Objective. The Water Resource Protection Act (WRPA) research elements related to flooding entail the identification and mapping of historically flood-prone areas of the state (Elements 4.1, 4.3), the anthropogenic factors exacerbating flood conditions (4.2), and areas in which high flows negatively affect beneficial uses (4.1).

Floods are seemingly easy events to define and identify. In West Virginia, however, no uniform and accepted definition exists to facilitate event tracking, thus complicating attempts to evaluate flooding events and trends in the state. Floods can be defined as when flow exceeds bankfull, when flows expand beyond 100-year flood plains, or when flows begin to threaten human safety and property. As well, flood “proneness” can vary by frequency, severity, and economic impact. Additional complexities include the differences between natural flood patterns, flash flooding, and human-exacerbated flood flows (e.g. from sedimentation, inappropriate land use practices), and human-exacerbated flood damages (e.g. inappropriate and uninsured development in floodplain).

The State of West Virginia has funded significant research on flooding over the past few years. The Flood Advisory Technical Taskforce Report, the State Flood Plan, and the State All-Hazards Plan are key resources for analysis of flooding in West Virginia. These reports provide the foundation for flood analysis requested in Element 4.

Three findings stand out among the others in this section. The first is that one-time-event-driven research projects will continue to produce incomplete and potentially misleading findings until more resources are invested in expanding maintaining our state’s water monitoring infrastructure. Monitoring infrastructure is necessary if trends, anomalies, and problem areas are to be identified and evaluated within historical context. Streamflow data are monitored and recorded in 50 of the state’s 159 watersheds (10 digit HUCs). Twenty-four of the state’s counties are not represented by a single stream gage.

The second important finding is that the US Corps of Engineers (USACE) Statewide Flood Report and the State All-Hazards Mitigation Plan both comprehensively address the flood-related research questions outlined in the Water Resource Protection Act (taking into consideration the stream flow data). This report references those findings and adds some new information, but the original reports should be referenced for more complete flooding information, specifically relative to Element 4.2, “Conditions that exacerbate flooding.”

Finally, framing the question around “impacts on beneficial use” was important. However, this aspect of the question can only be addressed generally. To address these issues in a detailed manner, they must be evaluated on a watershed basis, which would require significant local participation and feedback at the information gathering stages.

3.1.1 Conditions that indicate where flooding has or is likely to occur

Elements 4.1, 4.3

This section presents four approaches to identifying and mapping areas where flooding has or is likely to occur. These are as follow: 1) identify existing flood monitoring data; 2) identify indirect

indicators of flood events (insurance damages); 3) conduct statistical analysis on historical stream flow data; 4) model land and stream characteristics that are likely to contribute to flood events. The four approaches are used because of the paucity of direct flood monitoring data and lack of a consistent definition of flooding.

3.1.1.1 Direct flood monitoring data

West Virginia monitors the threat of flooding in the state on a real-time basis based on precipitation (iFLOWS program) but invests little in maintaining flood records after the immediate threat at hand disappears. The **State Office of Emergency Services** and the **National Climate Data Center** are two agencies that maintain a historical record of flooding in the state (Figures 1 and 2).

Unfortunately, each agency has different criteria and methodology for measuring flooding and, therefore, analysis of their data indicates contradictory flood-prone areas as well as dramatically different perspectives on flooding frequency. OES data are based on official emergency declarations, while NCDC data reflects a variety of sources including staff observations, citizen phone calls, and newspaper clippings. OES floods are limited to the most severe cases that warranted FEMA intervention. In determining areas that are “flood-prone,” however, based on the Figures 1 and 2, there appears to be a difference between areas that are prone to frequent floods (NCDC, Figure 2) and areas that are prone to severe floods (OES, Figure 1).

NCDC also provides the state’s only historical record of flash flooding in the state (Figure 3). This is not necessarily an accurate representation of actual flash flooding events. A quick glance of the low estimated number of flash floods over the past 10 years, particularly in southern counties such as Mingo, Wyoming, and McDowell Counties warrants concern over the meaningfulness of these numbers. Flash flooding numbers are based in part on predictions of heavy rainfall that generate flash flood warnings. These warnings are then noted as actual events if newspapers or citizen/employee calls verify that flash flooding did occur in the county.

The rate of flash flood verifications to flash flood events is not uniform across all counties. As a result, the total numbers by county are erroneous, as are the indicators of relative flash flooding problems among different regions of the state. Finally, because these numbers have only been tracked for ten years, it is not possible to identify trends such as increased or decreased flooding in watersheds or counties.

OES Floods 1994-2004
Numbers of Floods shown in County

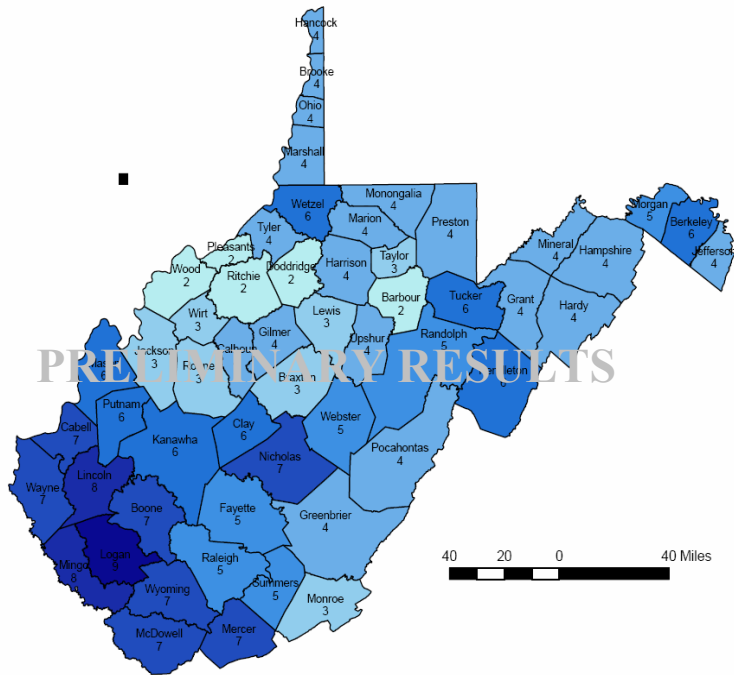


Figure 1 Floods 1994-2004, OES

NCDC Floods 1994-2004
Number of Floods shown in County

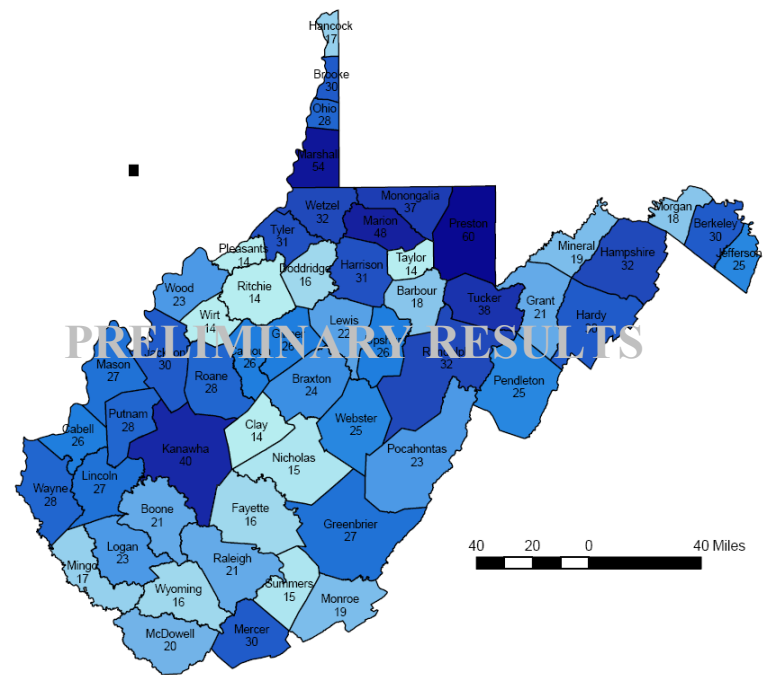


Figure 2 Floods 1994-2004, NCDC

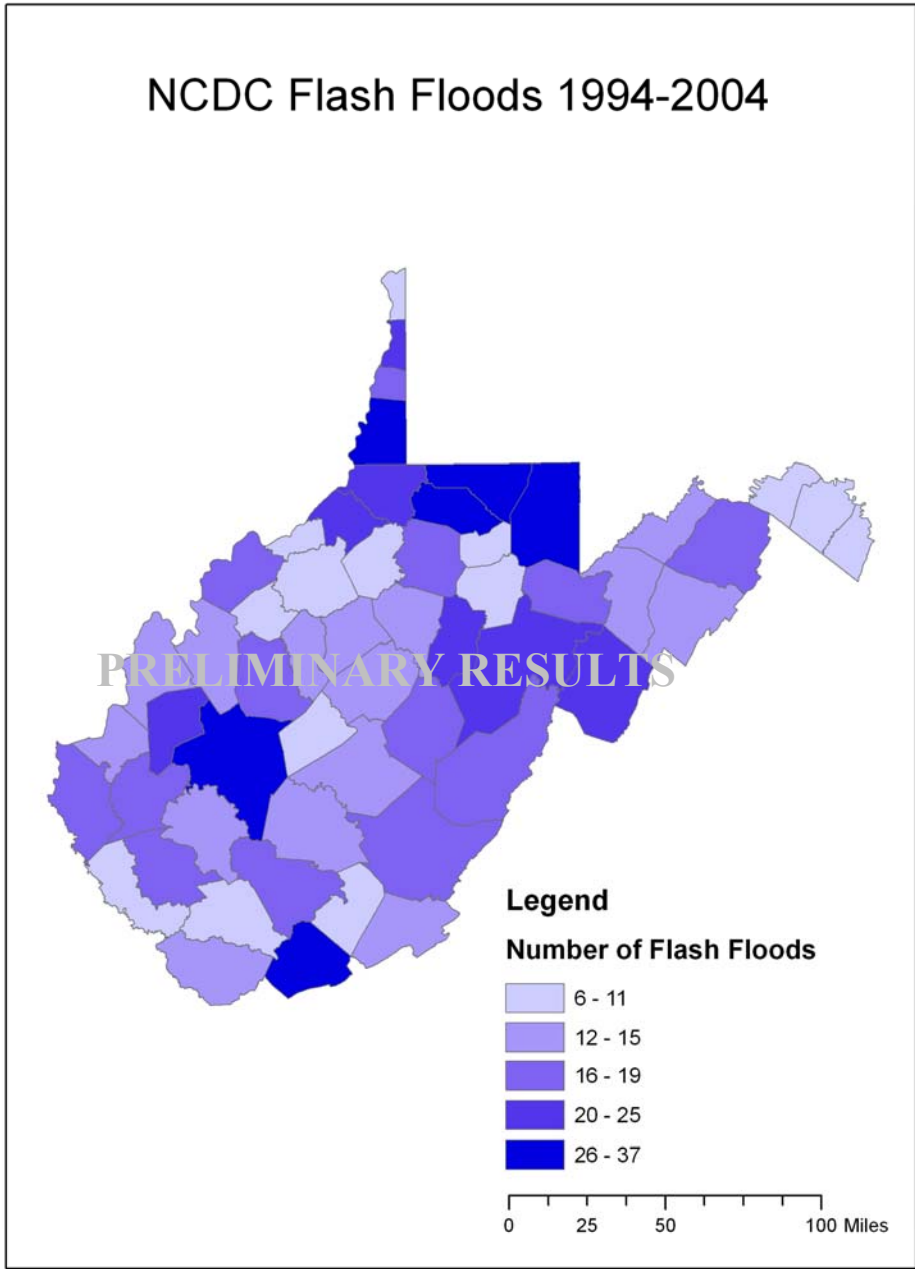


Figure 3 Flash Floods 1994-2004, NCDC

3.1.1.2 Indirect flood monitoring data

One approach to measuring the incidence of flooding and, in particular, economic impacts of flood events is to evaluate the costs of flood damages. The State All-Hazards Report used this approach by evaluating National Flood Insurance Program (NFIP) payment trends. The maps below (Figure 4) illustrate relative scale of payments as well as recurrence rates of claims.

The cost estimates reflect only damage to properties insured by the NFIP. As a result, the distribution of claims and damages paid by this program reflects the distribution of flooding in the state skewed by the uneven distribution of NFIP coverage. According to the OES, NFIP coverage rates of floodplain structures range from 10-90% across the state (mean coverage is only 34% per county).

For the final report, pending data availability, we would like to include a map that illustrates NFIP coverage rates relative to number of floodplain structures. This would help to identify some of the insurance coverage disparity biases across counties that now appear to be flood cost differences.

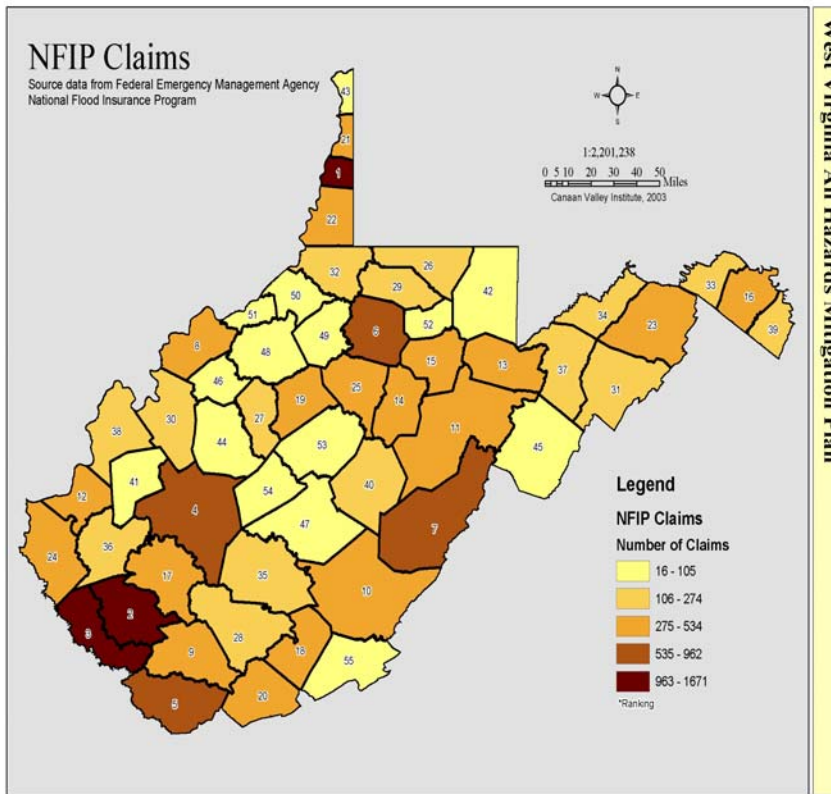
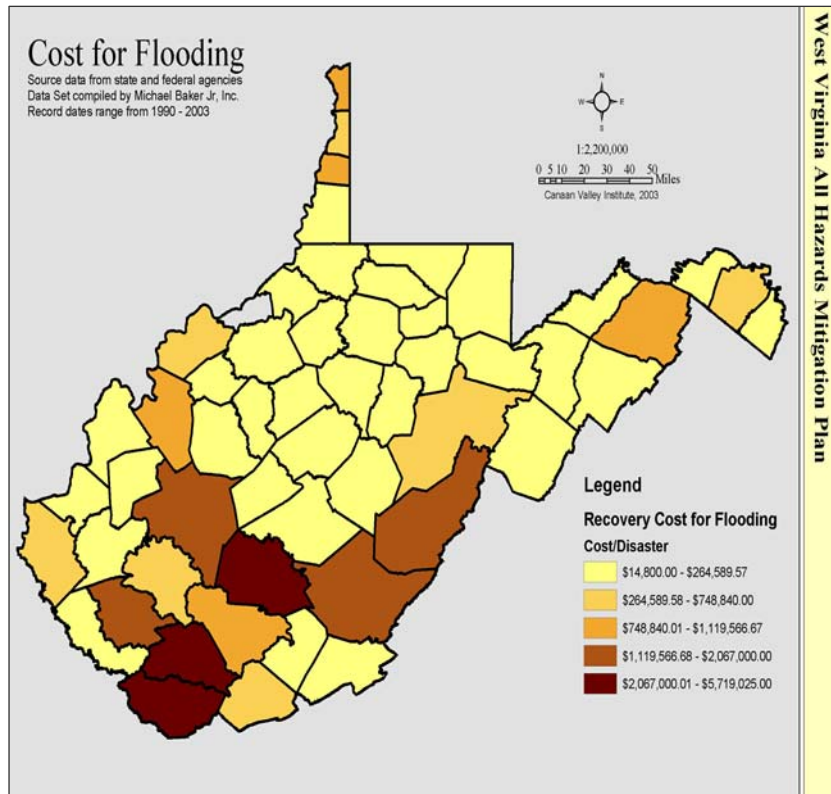


Figure 4 National Flood Insurance Program Payments, 1990-2003

3.1.1.3 Statistical analysis of stream flows

It is reasonable to imagine that streamflow gages would be good indicators of flood events. Flows on ungaged low order stream (smaller streams) cannot reliably be linked to gaged flows on higher order streams (larger rivers). While the USGS is working to develop a methodology to link small stream flows to monitored behavior on high order gaged streams, the model accuracy will be limited by lack of land use data in many areas. Furthermore, the model may be successful at detecting regular floods on low-order streams but will not predict tributary flash flooding. Detecting unreported flash floods, given the paucity of stream gage stations and limited historical detailed meteorological data, will be challenging well into the future. For the short term, attention can be directed to improving the methodology of collecting and tracking flood and flash flood reports to the NCDC.

Afore mentioned limitations considered, stream gage analysis was conducted on all gages with at least 30 years of data in the state (where watersheds crossed state boundaries and there were no gages in WV, gages were used from neighboring states). These data were compared with the period of record available for each gage to determine the statistical 5, 10, 50, and 100-year flood flows and the frequency of their occurrences over the past 30 years. The maps below (Figure 5) indicate relative flooding frequencies among different gages for two of the calculated levels of flood severity (percent time in a 10-50 year flood and percent time in >100 year flood).

Information in the maps of Figures 5 and 6 should be interpreted with caution. Gage station flow analysis **cannot** be extrapolated to indicate flooding trends by watershed or county because of the problems with relating gaged and ungaged streamflow behavior within a watershed (described above). Furthermore, the interpretive value of these maps is limited due to extensive gage funding cuts in 1994. Many gages were taken off-line in 1995, so analysis was conducted on those gages with a 30-year period from 1964-1994. As a result, no 100-year or greater floods appear to have occurred in McDowell County over the past 30 years according the maps in Figure 5. Yet, the county suffered two 500-year floods since 2000. Watersheds that currently have real time or “on-line” flow monitoring gages are shown in Figure 7.

The final approach to gage data collection as an indicator of flooding was to combine National Weather Service (NWS) flood stage (height) estimates with USGS flow data by using ratings tables (flow to height conversion equations). Flood heights have been established by NWS agents’ trips to each gage station in which they identified a local flood stage based on community input regarding the flow height at which floodwaters would begin to cause a threat to lives or property. Using USGS ratings curves, we determined what flow would raise the river to the NWS flood stage. Then, using historical USGS flow data, we produced a statistical analysis of historical flow data to determine the flood stage recurrence interval (how often flows would reach flood stage heights).

The results are mapped in Figure 6. There are clearly problems with the inputs to this analysis since some gages appear to experience flood stage exceedence every year or two while others have recurrence intervals that indicate thousands of years between floods. Without making site visits to and analyses of each gage station, it is not possible to determine whether data inaccuracies lie with the stage heights recorded or with the ratings curves provided by the USGS.

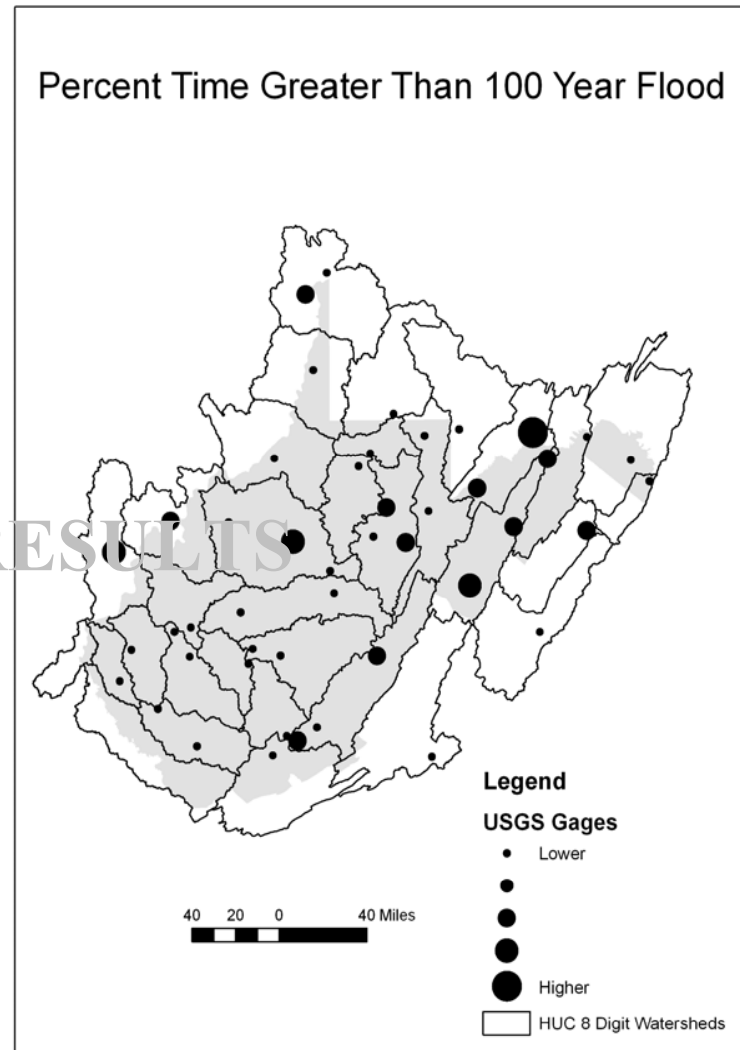
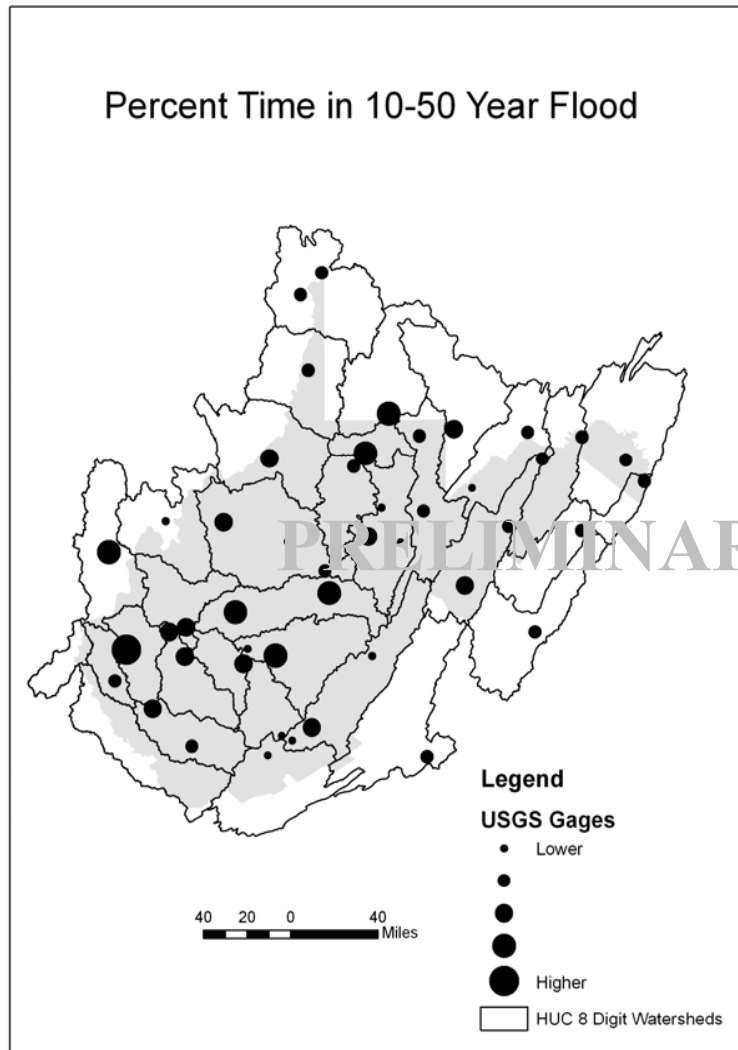


Figure 5 Relative indicator of flood frequencies among relevant gage stations, 1965-1994

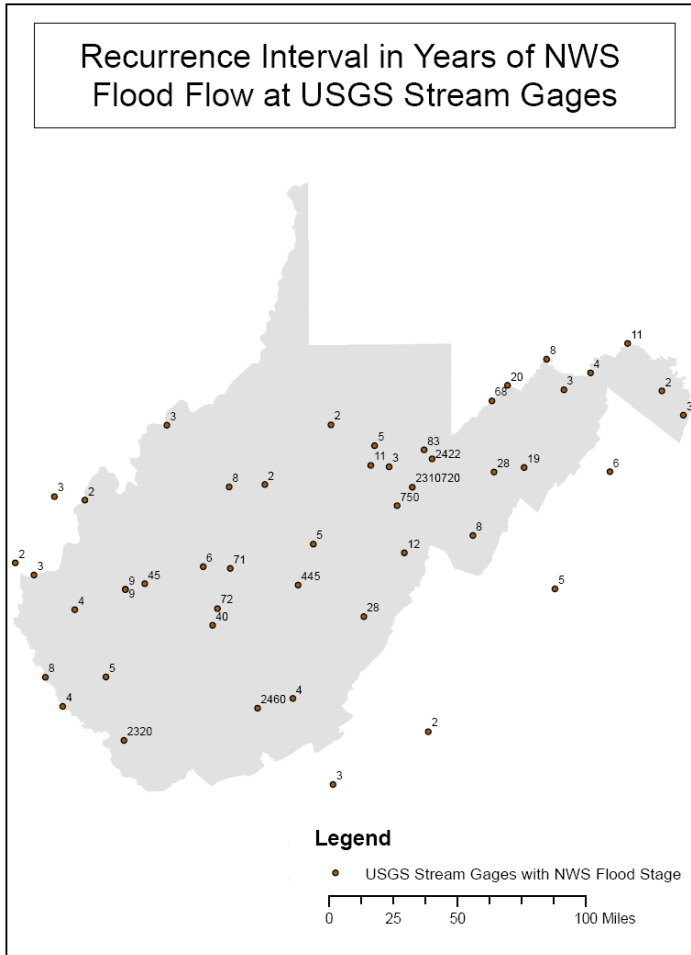


Figure 6 Recurrence Intervals for NWS-Defined Floods

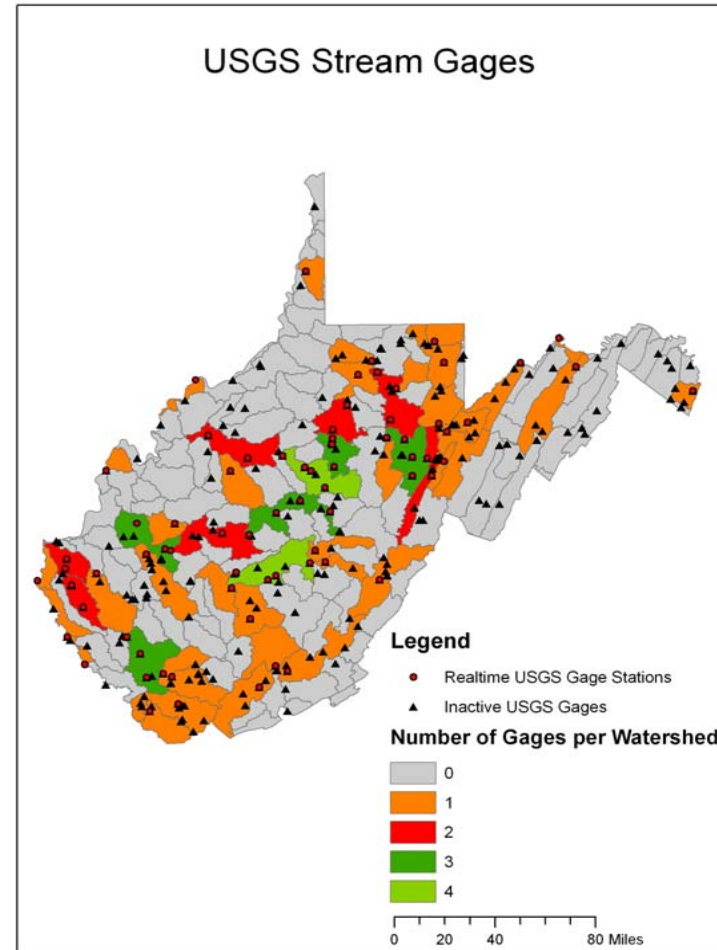


Figure 7 Watersheds with Active USGS Stream stations

3.1.1.4 Modeled Flooding Risk Factors

The Water Research Institute intended to model flood vulnerability by watershed at the 10-digit HUC level. While data quality constraints would have limited the reliability of the map generated, development of such a general model would be important for future efforts, in anticipation of comprehensive state water planning efforts. Had funding been made available, the model would have integrated flood-related factors including the following:

- Slope/Topography
- Land use/imperviousness
- Stream sinuosity/Vegetative cover
- Soil type
- Storage capacity/wetlands
- Watershed area

3.1.2 Factors that Exacerbate Flooding (Element 4.2)

As noted earlier, a great deal of state-funded work has recently been completed in West Virginia on flooding. The “West Virginia Statewide Flood Report” was written by a Task Force of experts from various State and Federal agencies responding to the governor’s call to address the increasing number of devastating floods in the State. The Report notes that flooding has affected all 32 major watersheds and all 55 counties of West Virginia. USGS work on flood trends, valley fill impacts, and the Flood Advisory Task Force report are additional important and publicly funded reports that address flood issues in the state. Findings from these reports will be summarized for the bulk of our response to this task in the final report to the state.

Factors reviewed in the state report of primary importance include the following:

- Precipitation and Runoff
- Floodplain Development
- Resource Extraction (mining, timbering, natural gas exploration, etc.)
- Valley Fill
- Mine Subsidence and “Blowouts”
- Water Transfers
- Dams
- Channel Restrictions
- Insufficient Flood Prevention

3.2 DROUGHT

Objective. *Drought analysis is to a) determine areas where historical drought and low-flow conditions have threatened beneficial uses of water (Task 4.1) and b) map drought-prone areas of the state (Task 4.3).*

The same complexities make flood events difficult to define and map also plague the issues of drought and low flow. Many of these complexities are discussed in section 3.2. The variety of drought definitions that exist introduces some of the variety of factors at play in drought analysis. Four drought definitions are often used to discern various sources and effects: meteorological, hydrological, agricultural, and socioeconomic (Table 1). With the exception of meteorological drought, differentiating between natural and anthropogenic causes of water scarcity is difficult to impossible. Consumptive resource use, interbasin transfers and landuse change are among many factors that can exacerbate dry meteorological conditions and cause supply-demand imbalance.

Droughts affect people, the economy, and the environment differently depending on the event's stage, severity, timing, and spatial impact. Agricultural productivity is affected when the soil moisture becomes too low for optimal plant development. This can result from a short-term precipitation deficit. Diminished flow in major navigable rivers is one of the last impacts of a long-term drought. These rivers have large watersheds that may extend beyond the meteorological drought; also the base flow of rivers is sustained by groundwater discharge, which is not strongly influenced by short-term precipitation deficits. Conditions that indicate where low flow conditions have or are likely to occur (Elements 4.1, 4.3)

<p>Meteorological Drought - a measured departure of precipitation from normal and the duration of a dry period for a given geographic area.</p> <p>Hydrological Drought - amount of surface and groundwater relative to normal levels as measured by streamflow, snowpack, and lake, reservoir and groundwater levels. There is usually a delay between lack of precipitation and reduced water levels in streams, lakes and reservoirs. It can occur from a persistent meteorological drought <i>and/or</i> unsustainable withdrawal and consumptive use rates.</p> <p>Agricultural Drought - inadequate soil moisture for a particular crop at a particular time. Factors include precipitation, ground water/reservoir levels, evapotranspiration, weather conditions, accessible irrigation technology, crop variety and stage of growth, soil type, and relative availability of water/moisture in prior growing stages.</p> <p>Socioeconomic Drought - physical water shortages affect the health, well being, and quality of life of the people. Measurements integrate consumption patterns, production technologies, and resource management practices with natural climatological patterns.</p>

Table 2 Types of Drought

3.2.1 Existing Drought Indicators

The National Climate Data Center (NCDC), Office of Emergence Services (OES) and the WV Department of Agriculture (WVDA) each use different systems for drought declaration. Mapping the history of these declarations serves primarily to illustrate inconsistency in the states' current capacity to evaluate and address water scarcity problems. OES and NCDC droughts are mapped (Figures 8 & 9) for period of record (POR). NCDC declarations are based on a variety of information sources including weather reports, local calls and newspaper stories. OES drought declarations are based only on events that require FEMA payments. WVDA

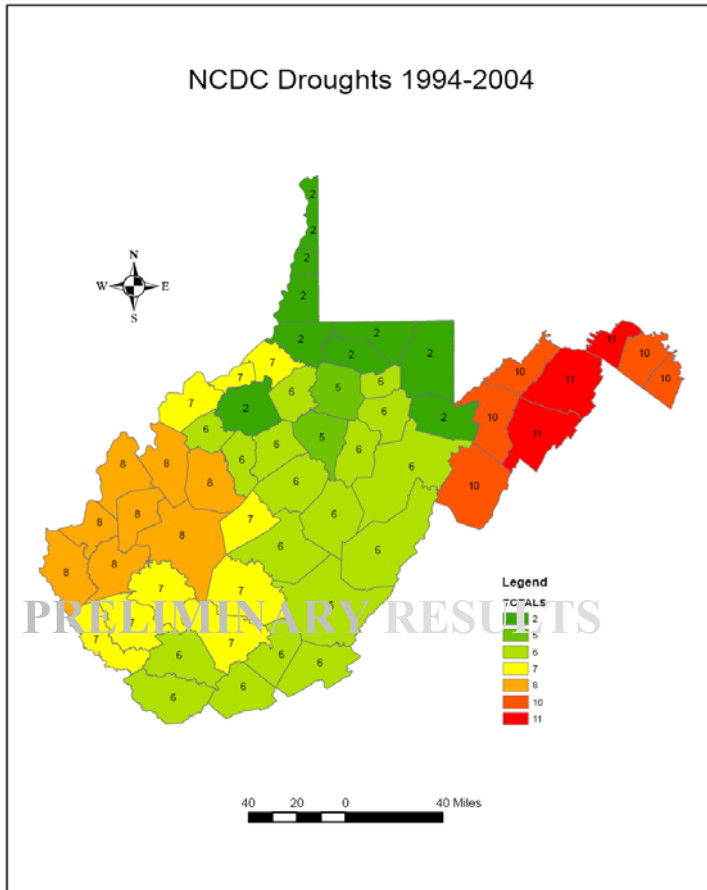


Figure 9 NCDC Reported Droughts 1994-2004

drought declaration history is based on payments made to farmers due to agricultural droughts declared by WV, bordering states, or the Federal Department of Agriculture. Data on these droughts are available in discontinuous intervals over the past two decades making a mapped analysis unreliable.

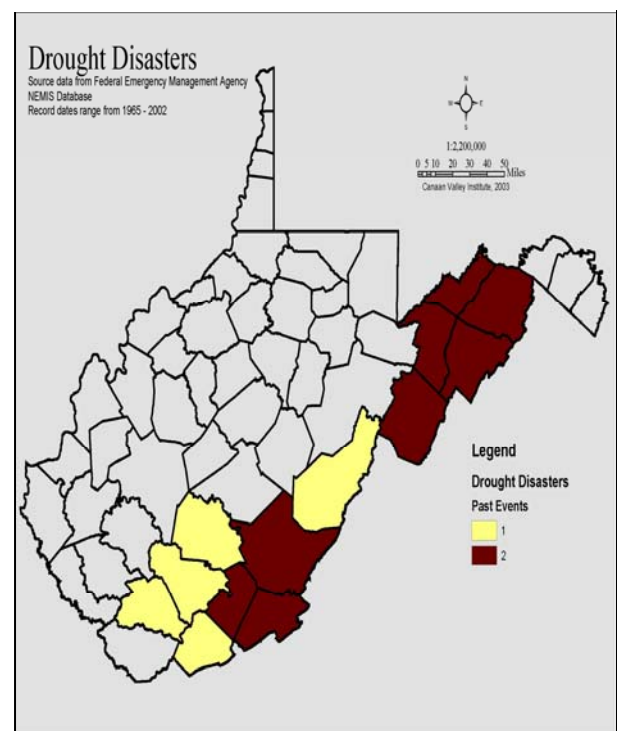
Upon review of the existing maps, it is evident that there are contradictions among data sources and indicators. An important interim finding is that more data collection and investment in reliable data analysis methodologies is necessary to produce reliable indicators of drought prone areas. Furthermore, a standardized approach to local-level data collection is likely to be the best source of information for the impact of low flows and drought on beneficial uses as well for identifying anthropogenic factors.

Figure 8 OES Reported Droughts 1965-2002

3.2.2 Alternative Approach: Drought Severity Index

Drought monitoring trends in a region are generally based on an index of multiple drought indicators. An index of multiple drought indicators is useful because water resources are affected differently given the severity, timing, and duration of a drought and differences across topographies and geological contexts can also play a role in drought.

Looking to neighboring states' models, most rely on five indicators - precipitation, streamflow, soil moisture, groundwater, and reservoir levels - to comprehensively determine drought conditions. For WV, we combine only three indicators in an index to provide a snapshot of historically drought-prone areas including precipitation, streamflows, and the Palmer Drought Severity Index (PDSI – soil



moisture). Groundwater and public water supply reservoir levels should be included as additional index variables, but the number of gages and period of record for existing gages are insufficient to support a reliable analysis (Figures 10 and 11).

The three-factor index does not necessarily provide a reliable indicator of relative drought-prone areas in the state. The model does, however, demonstrate the objective standard for WV. Pennsylvania and other neighboring states use drought indices both as a tool for historical record keeping as well as an on-going drought monitoring mechanism (<http://www.dep.state.pa.us/dep/subject/hotopics/drought/>). As a monitoring mechanism, the index allows state officials to declare drought watches, drought warnings, and drought emergencies in different regions of the state depending on the severity of drought in that area. A standardized set of voluntary and mandatory conservation practices are automatically announced and implemented under each category. With a standardized procedure for declaring drought at different levels of severity, agencies are better able to balance physical resource needs with political pressures when declaring droughts and suggesting conservation practices.

The following maps (10 & 11) illustrate why groundwater and reservoir data cannot be used for WV drought monitoring. These are followed by maps that illustrate the remaining three drought indicators (soil moisture – Figure 12; precipitation – Figure 13; and streamflow – Figure 14). Finally, the equation used to calculate state index values is presented with an explanation of methodology and resulting maps.

The results of the application of the multifactor index at the county and watershed level are illustrated in Figures 13 & 14. It is evident from these figures that the areas affected by historical drought severity and frequency differs based on spatial-unit boundaries.

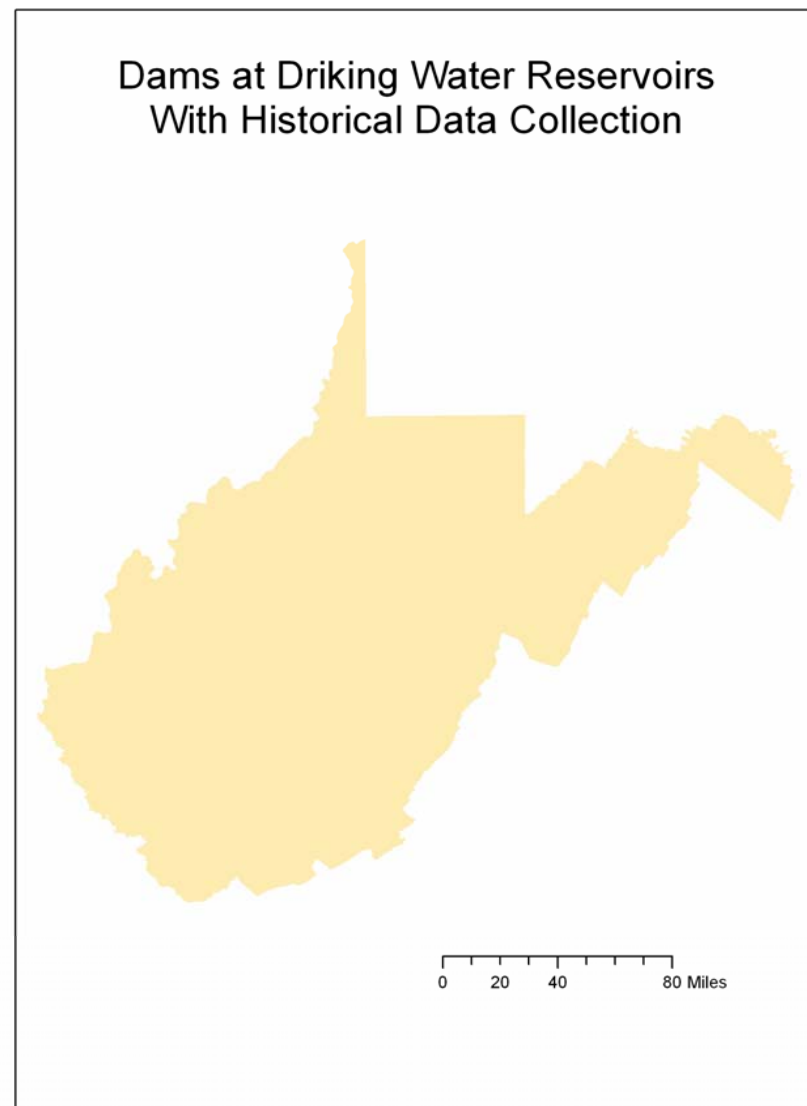
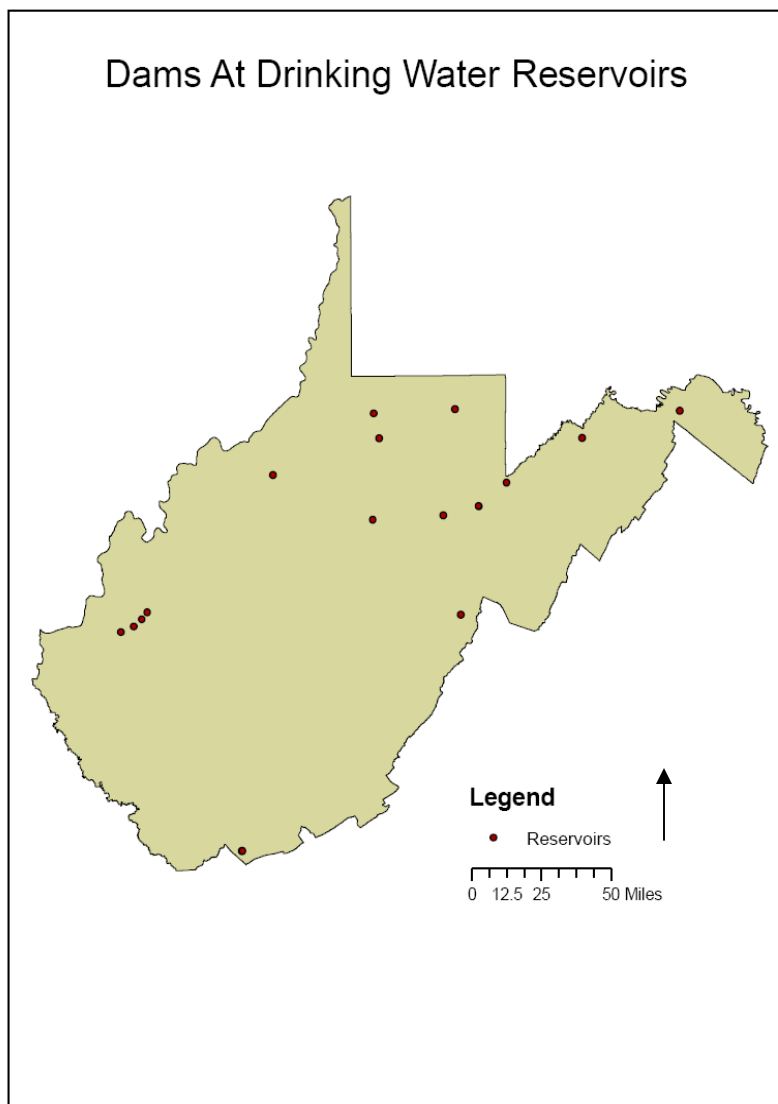


Figure 10 Public water supply reservoirs with monitoring data collection capacity

This indicator is used in surrounding state, but is not used in the drought index for this report because of lack of data.

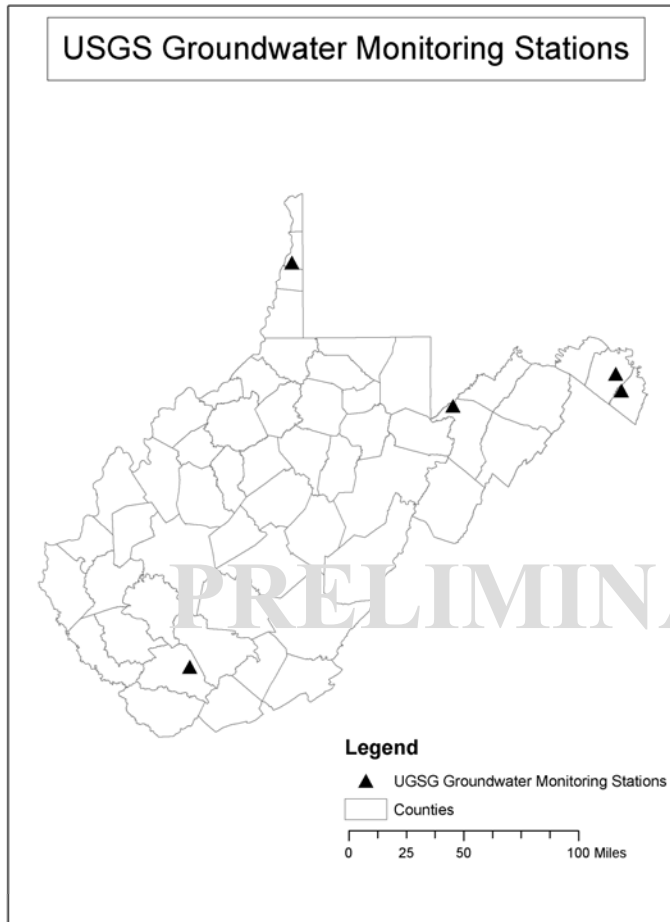


Figure 11 USGS Groundwater Monitoring Stations
 Two of the five remaining monitoring wells are slated to be turned off this year due to federal budget cuts. This indicator is not used in our index.

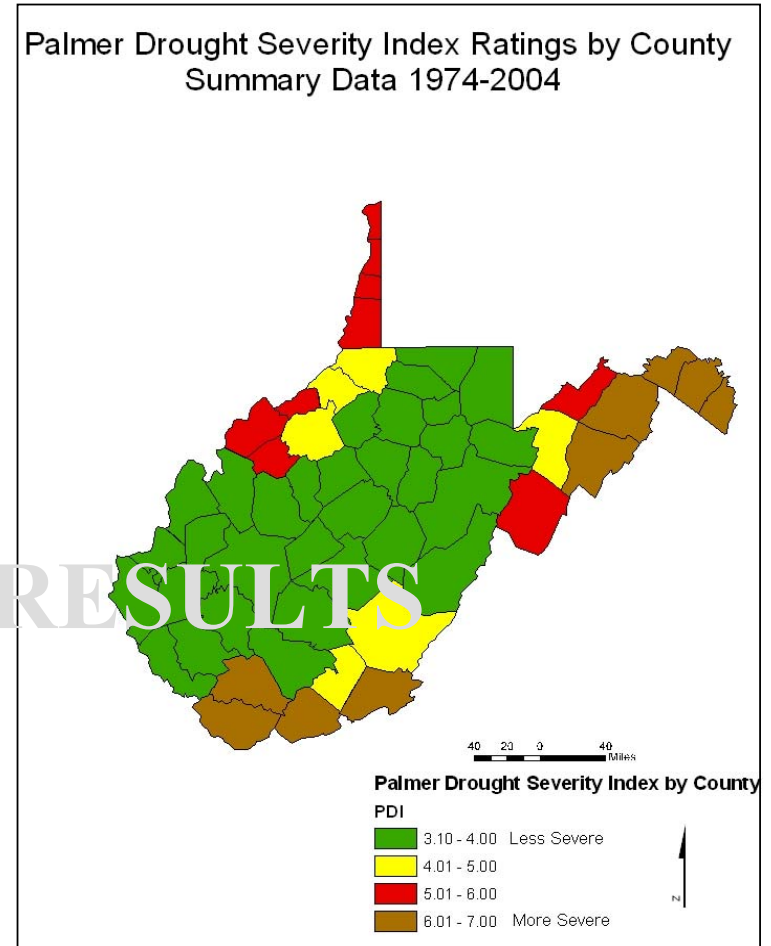


Figure 12 Soil Moisture Drought Indicator (PDSI)
 This indicator is used in our index.

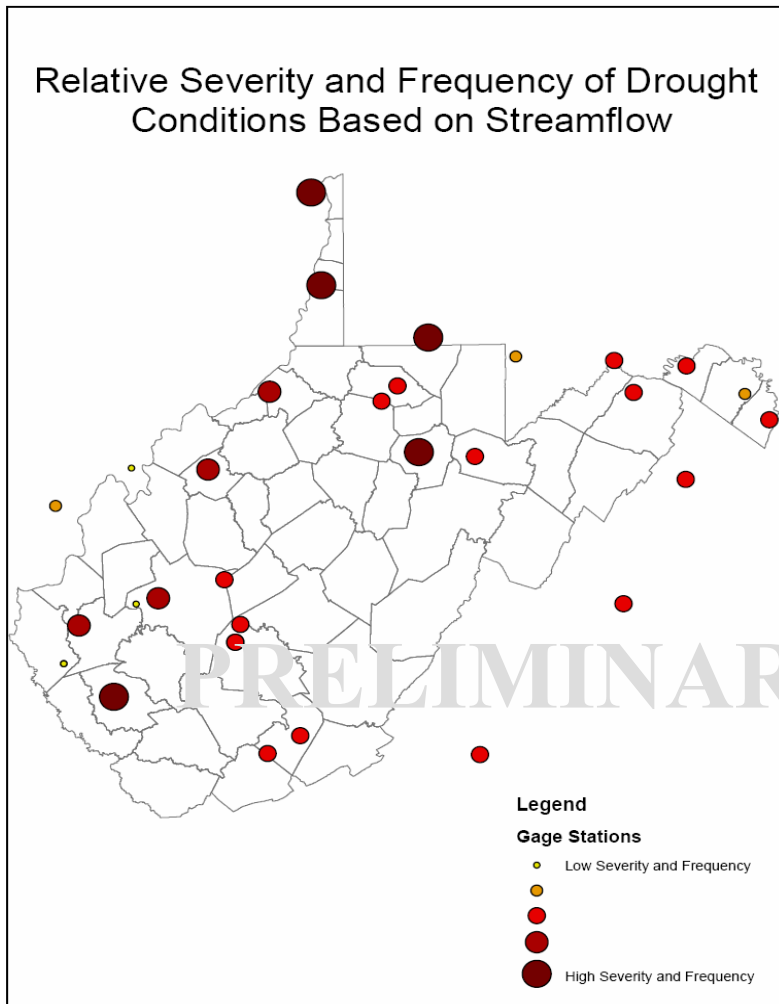


Figure 13 Streamflow Drought Indicator

State coverage by stream gages, particularly gages with 30-years of historical data, is not good. Data collected above were used in the index calculations, though it is not recommended that a stream gage point be used as an indicator of flow patterns for its own watershed or neighboring watersheds.

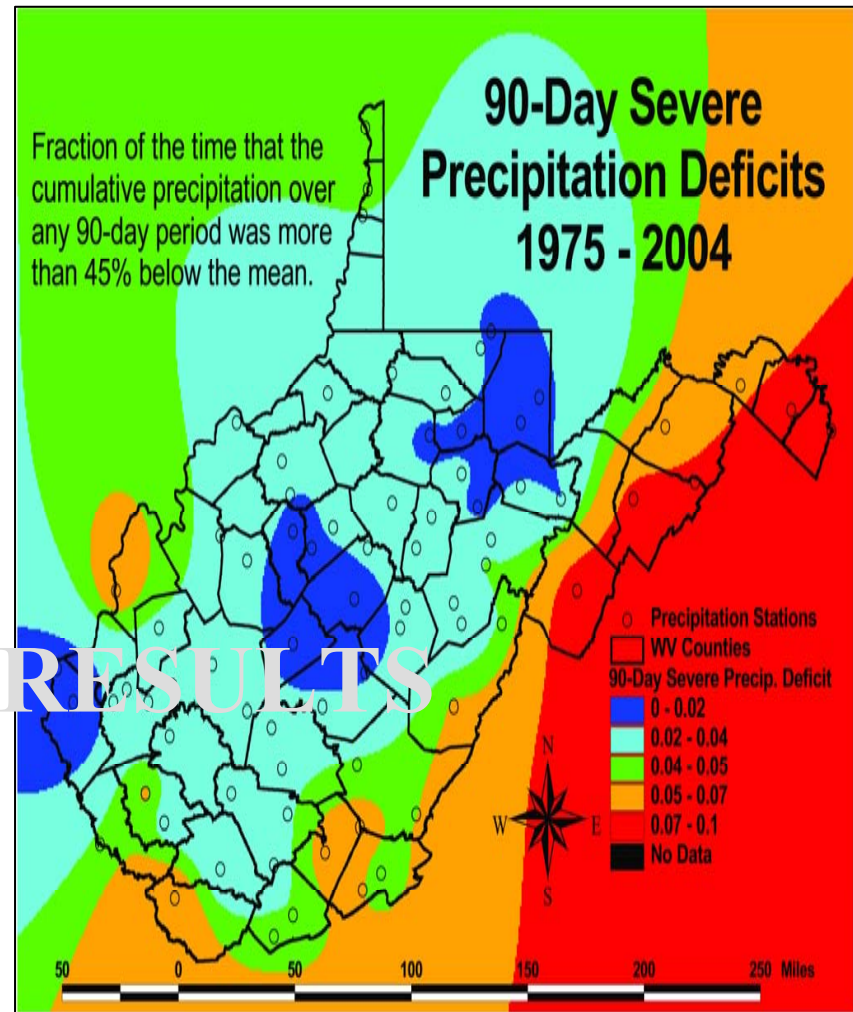


Figure 14 Precipitation Drought Indicator

This indicator is used in the index. The 90-day deficits indicate medium-term precipitation deficits, 30-day (short-term) and 360-day (long-term) deficits are also calculated and included in the index. Precipitation station coverage in the state is adequate.

The combined data for the drought index are spatially based on precipitation gage location. Each precipitation gage is assigned a corresponding PDSI value (climatological region) and a corresponding stream gage based first on shared watershed and then, where there are multiple stream gages in a watershed, by proximity. At each gage site, all three indicators are evaluated separately, on a daily basis over the past 30 years, for drought severity ratings. Precipitation station points are assessed by number of days spent in drought, with each day being weighted by the severity of the drought ranking of each indicator and by the number of the three factors indicating drought (one, two or three indicators in extreme or sever drought on any given day). Cumulative index values for each station are then gridded across the state, and spatially-weighted values assigned to each county and 8-digit watershed.

DROUGHT INDEX VARIABLES

- X Reservoir levels
- X Groundwater
- Soil moisture (Palmer Drought Severity Index)
- Precipitation
- Stream gages

$$D_i = \frac{1}{9} [P_i^{30} + P_i^{90} + P_i^{365} + 3S_i + 3I_i]$$

D = Drought severity index for a particular precipitation gage.

t = Time index, days.

$\#$ = Duration of the total precipitation deficit code; 30, 60, or 365 days.

P_i^t = The t -day total precipitation deficit code.

S_i = 30-day mean stream discharge flow rate deficit code.

I_i = Palmer drought index code for precipitation

Figure 15 WV Drought Index Equation

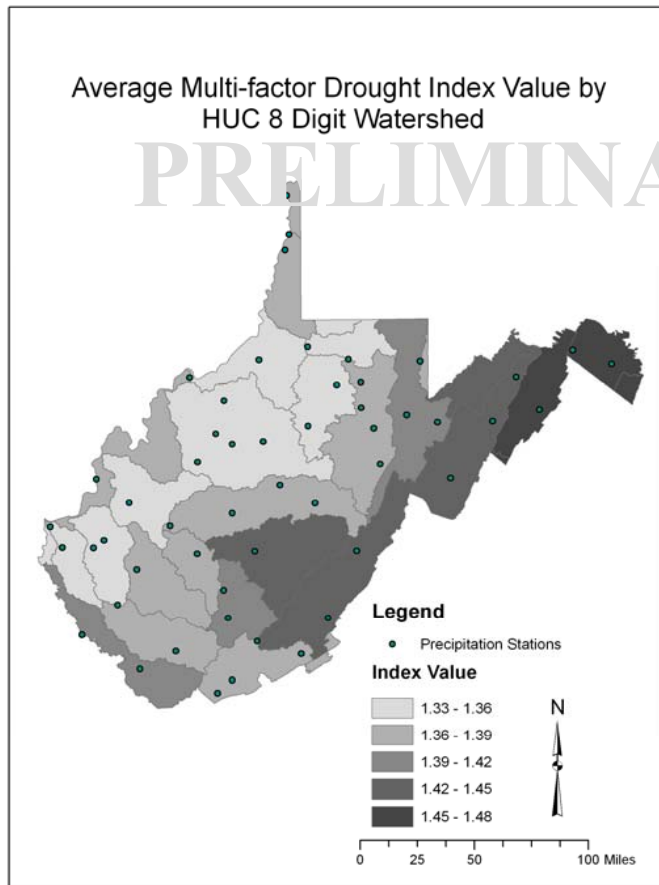


Figure 16 Drought Index by 8-Digit Watershed

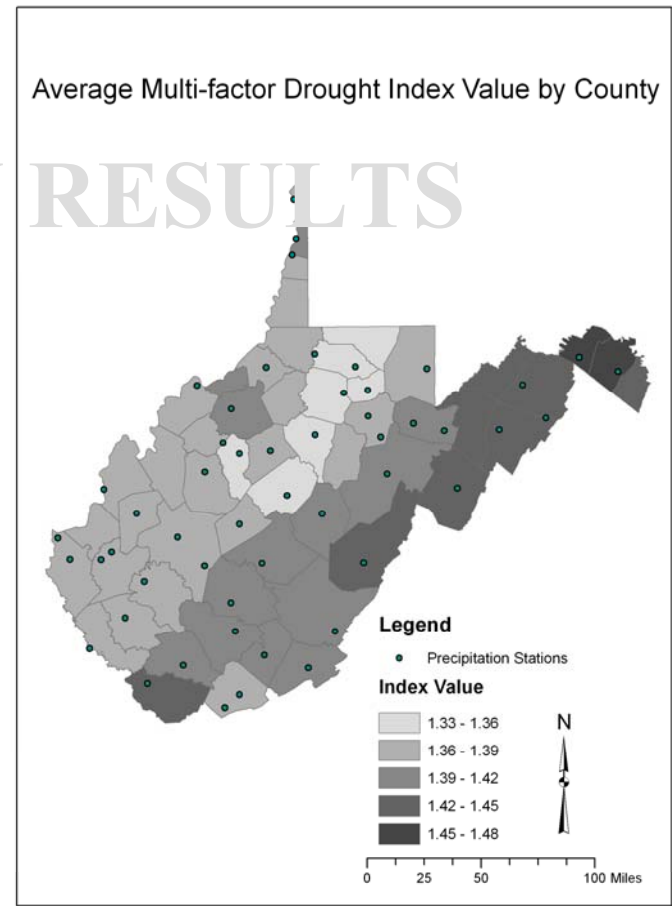


Figure 17 Drought Index Values by County

3.2.3 Impact of drought and low flows on beneficial use (4.1)

Data do not exist for most drought/low flow impacts on beneficial uses at the local or state levels. Furthermore, because drought affects beneficial uses of water resources differently depending on the season, duration, and type of drought as well as region-specific competing demands on water resources, it is difficult to extrapolate generalizations from case-specific data. But below are some important issues that should be considered in the evaluation of state water resources.

<p>NON-CONSUMPTIVE</p> <p>Ecological Services</p> <p><i>Habitat</i></p> <p><i>Effluent dilution</i></p> <p><i>Temperature/oxygen regulation</i></p> <p><i>Ambient/soil moisture</i></p> <p><i>Input to natural production functions (tree, plant, animal growth)</i></p> <p>Recreation/Tourism</p> <p><i>Swimming</i></p> <p><i>Fishing</i></p> <p><i>Boating/rafting</i></p> <p><i>Aesthetic/existence values</i></p> <p>Direct Market Services</p> <p><i>Aquaculture</i></p> <p><i>Public utility supply</i></p> <p><i>Hydro-energy production</i></p> <p>Transportation</p> <p><i>Barge and boat movement</i></p> <p>CONSUMPTIVE USES</p> <p><i>Industrial/commercial</i></p> <p><i>Public utility supply</i></p> <p><i>Energy production</i></p> <p><i>Agriculture</i></p> <p><i>Water bottling</i></p> <p><i>Mining/natural resource extraction</i></p>
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The section below identifies main categories of beneficial water use and describes how low flow conditions could impact those uses. Information was requested for drought-impact estimates for at least one case in each category. This is followed by a review of the US Army Corps of Engineers' drought-based integrated water resource management strategy in the Kanawha River Valley, which focuses on balancing the protection of different types of beneficial use during resource scarcity.

Beneficial uses of water can be classified as consumptive or non-consumptive. Non-consumptive uses can be further divided into the following categories: ecological services, recreation and tourism, direct-market services, and transportation. The list in Table 1 is by no means complete. Each region and watershed has a unique docket of water users and resource needs, which are often interrelated and interdependent. Some of these would be addressed by a survey or focus group meetings of water resource management stakeholders. State programs like Pennsylvania's have watershed or regional committees to monitor, manage, and seek public feedback on such region-specific issues continually.

Table 3 Beneficial Uses Affected by Low Flow Conditions

Ecological services of stream flows include natural habitat and effluent dilution, temperature and oxygen regulation, and it functions as an input in the production of natural goods and services. Naturally occurring low flow conditions reflect the

expected fluctuations of dynamic ecosystems. These natural events should be understood and anticipated in land and water use planning and development.

An unnatural increase in the frequency or duration of low flow conditions may have a negative impact on the beneficial use of water through the destabilization of natural

streambed morphology, degradation and reduction of wildlife habitat and other ecological services such as prevention of eutrophication. Low flows reduce stream velocity and result in the reduced capacity for the water to carry out natural stream-cleansing services, leading to embeddedness and loss of aquatic habitat.

Drought conditions can also have costly effects on state forest ecosystems. Drought increases tree susceptibility to disease, and it is identified by the State All Hazards Plan as a factor in the spread of wildfires. Drought-related losses were compounded in 1999 by extensive forest fires understood to have been an effect of the dry weather conditions. Between 1991 and 2000 on average 1,080 wildfires burned 65,435 acres per year in West Virginia costing the state \$196,700,200 (almost exclusively in the Southwestern region of the state). Wildfires can reduce post-fire landscapes' ability to retain soil moisture in the short run, exacerbating sedimentation and flash flooding factors.

Water-based recreation and tourism is widely recognized to be an engine of economic growth at local and state levels. Tourism and amusement-related sectors are leading the state in employment generation where other traditional sectors are declining. Fishing and boating are two important water-dependent recreation industries in the state.

Low flows can reduce fishing and rafting opportunities directly through insufficient flow and/or indirectly if reduced water quantities translate into quality problems that produce odor, public health threats, and reduced stream clarity. Whitewater rafting alone has consistently attracted over 200,000 visitors to the state annually for the past decade. As surrounding states invest in the development of competing recreation and tourism industries, protecting water quality and quantity will become increasingly important.

WV Department of Agriculture figures indicate that WV aquaculture (primarily for trout stocking) is a \$2 million-a-year subsector activity that generates an additional \$1 million in related income and taxes. Anglers' visits alone generate \$2.5 million per 20,000 fishing trips. According to the DNR, trout stocked in 1999 were significantly smaller than previous years due to drought conditions that started in the summer of 1998 (1.9 trout per pound down from the average 1.5 – more than a 20% production loss). Groundwater sources for commercial fishery production and adequate stream flows to attract anglers and protect fish habitat are important economic resources that are sensitive to natural flows.

Direct market services include aquaculture, public water utilities, and hydro-energy production. Drought threatens these uses when there is insufficient water to continue operations at full capacity. Reduced capacity for these users relates directly to reduced production and/or increased costs of production – resulting in lost revenue accordingly. In the cases of public utilities and hydro-energy production, drought-related production reductions often occur at the same time demand increases (watering lawns, swimming pools, running air conditioning etc.). Potential losses in each case are site and drought specific.

In Berkeley County in 2002, drought caused a 25% reduction in water supply as a result of a 50% reduction in the flow rate of two major springs. While the county is attempting to

prepare for the next drought, population growth will inevitably result in future socio-economic droughts. Maryland granted temporary permission to increase daily maximum withdrawals from the Potomac River by over 30% (2.67 to 3.864 MGD) and emergency withdrawals of 5.52 MGD.

County officials are concerned about growing groundwater scarcity due to the increased percent coverage of impervious surfaces in the county (limiting aquifer recharge) and degraded groundwater quality (reducing the quantity of useable water supply/increasing treatment costs). Costly temporary building and development halts have already been implemented in the Eastern Panhandle and parts of Maryland due to water scarcity.

Consumptive uses of water include industrial manufacturing, public utilities with trans-basin service districts; energy production that requires water for cooling towers, agriculture that exports production, water bottling facilities, and mining/natural resource extraction operations that result in bulk transfers of groundwater to surface water.

Drought and low flow conditions threaten energy production when discharge stream temperatures or flows limit facilities' discharge water or when intake water temperatures or flows reduce cooling capacity of the plant. Power companies do not keep records of drought-related production losses and estimates of such losses would have to be made on a facility-by-facility basis. Power generation is affected by drought because temperature and flow of cooling water supply are determinants of the plant production capacity. The impact on each plant is unique and event-specific.

Agriculture production is threatened by drought when goods are smaller in size, misshapen, or diseased due to drought stress. The Department of Agriculture compiled historical data on financial compensation for drought-related agriculture losses but the data was not continuous enough to generate a meaningful report. Though during the 1999 drought alone, USDA reported the \$200 million in agriculture-related drought losses.

There are 155 DHHR-licensed water-bottling facilities in the state (11 are WV-owned). Water bottling facilities are not required to report the quantity of water they extract to any state agency (with the exception of the current DEP survey). There are no regulations that require facilities to measure the effects of pumping on neighboring wells or to determine baseline supplies/flows. Facilities are only regulated by DHHR for water quality and facility sanitation regulations. Low flows can threaten water-bottling facilities if other users who rely on surface water are forced to switch to groundwater sources, becoming competing users. As well, excessive surface water consumption can reduce groundwater recharge rates in some cases depending on the region's geology, hydrology and economic activities.

Monroe County, home to a number of spring water bottlers and a growing population, is currently working to prevent conflict over surface and groundwater supplies through countywide planning. Jefferson County's efforts to plan for future water supplies were limited to public utility planning. The county's Source Water Assessment and Protection Program (SWAP) specifically notes that a new water-intensive manufacturing facility or

water-bottling facility in the area would result in severe water scarcity for the public water utility.

3.2.4 Evaluate current or potential in- or off-stream practices that may exacerbate low flow conditions (Element 5)

As stated above, distinguishing natural from anthropogenic causes of water scarcity can be difficult to impossible. Understanding the relationship between surface and groundwater movement, particularly in karst areas, can make it nearly impossible to predict where and to what degree one user's withdrawal or diversions may impact another's supply. This complication is compounded by the fact that there is little to no data on withdrawal quantities – making it impossible to understand how those withdrawals impact the hydrology around them.

Five general category practices have been identified to date as exacerbating low flow conditions. These problems are interrelated in many ways, as is illustrated in the discussion below. But general categories include the following:

- Over-extraction (DNR v Tingler, 2005)
- Rapid growth/contamination (Eastern Panhandle)
- Competing uses (USACE Shared Vision balance of energy, boating, and ecology interests in Gauley basin during drought)
- Resource extraction (mining/quarries; Pennsylvania Act 54)
- Sedimentation (Hurricane, WV)

The WVU Hydrogeology Research Center attempted to identify natural and water resource extraction-based impacts on water levels in aquifers of the Eastern Panhandle, but has largely found the indicators to be confounding, even with significant project-based measurement and monitoring expenditure. DEP efforts to allocate liabilities in stream and well dewatering cases surrounding sub-surface mining operations are also hindered by problems distinguishing between natural and anthropogenic flow factors. Lack of flow and groundwater monitoring data further limits our ability to provide a comprehensive analysis of this already complicated question.

Among the most important practices that exacerbate natural low flow conditions are over-extraction of water for consumptive uses and bulk water transfers (most often related to natural resource extraction). Countless anecdotes circulate of well owners who lose their water supply due to new water extraction practices on a neighboring parcel or due to underground mining activity. In these cases, lack of data and information about groundwater extraction, supply, and underground water flows becomes a serious problem.

In WV, stream and well dewatering problems that stem from nearby mining activity cannot be tracked or monitored without extensive manual research. Pennsylvania mandates regular collection and reporting of mine-related dewatering data (Act 54). WVDEP could use the PA program as a guide for collecting similar pertinent information in order to better monitor this problem.

The WVDNR faced water scarcity problems in Randolph County (WVDNR vs Tingler) when a neighbor began pumping groundwater next to a DNR fish hatchery. The resulting reduced spring flows on DNR property caused the hatchery to close (the case was recently ruled in favor of DNR).

Interestingly, many anthropogenic factors that cause and/or exacerbate low flow conditions can also exacerbate flood conditions. Increased coverage of impervious surfaces and increased erosion are two such factors in West Virginia. Increased sedimentation (the state's leading water quality impairment) from landuse practices that lead to erosion causes sediment to accumulate in streambeds (aggradation). Raised streambeds exacerbate flooding and erosion problems, but result in streams that are increasingly shallow, wider, and warmer, losing more water to evaporation and having lower dissolved oxygen levels than they would in their natural condition.

In Figure 18, the Hurricane Public Water Supply Reservoir illustrates how land use, flooding, and low flows or water scarcity are related issues. Inappropriate land use practices at construction sites (sub-photo) upstream from the reservoir caused almost \$.5 million in damages to this reservoir. Dredging was necessary to increase the water supply. Reduced water storage capacity also brought the floor of the reservoir dangerously close to developed structures and roads. And finally, sediment transport brings with it the transport of pathogens that can contaminate streams and reservoirs. A special enforcement sweep upstream and throughout Putnam County resulted in 119 Notices of Violation at 33 of the 41 inspected sites.



Figure 18 Sedimentation of the Hurricane Reservoir exacerbates low flow conditions and rapid flooding

Landuse changes that significantly increase the degree of imperviousness in a watershed is another contributor to both drought and flood events – this includes mine land reclamation

practices as well as urbanization practices. Water that would otherwise percolate into soil and underground aquifer systems instead flows directly into surface water streams, often transporting contaminants such as pesticides, oils, sediments, and other watershed-specific contaminants – a problem particularly in sensitive karst area. Increased surface flow volume and velocity can exacerbate flooding in the short run and destabilize streambeds in the long run.

Canaan Valley Institute was working to develop geospatial models of sediment-based relationships between landuse and changing stream morphology in a sub-watershed of the Little Kanawha as part of its work to update FEMA maps in the watershed. This project is temporarily on hold, but such information would provide important lessons for other areas of the state. Landuse-based reduced flows cannot be summarized quantitatively for the state with existing data. Landuse-related factors are also absent in USGS low-flow modeling efforts.

Drought management Drought's impact on various beneficial uses can also vary depending on how the drought is managed by local and state official and by each water user. A drought warning and response system can help users plan for water scarcity by employing water conservation measures at early onset, by understanding their own use in the context of other users and the watershed system, and by preparing users to contribute to watershed or county-based contingency plans that have been worked out to be acceptable to stakeholders prior to an emergency. The case below illustrates how integrated water resource management reduced and distributed the impact of drought on beneficial uses in a way that was politically accepted due to stakeholder participation in the planning process. It further illustrates how flows can be managed, at least on some streams, by planning for natural low flow conditions.

The Kanawha River The Kanawha River and its tributaries drain 12,300 square miles of land starting in North Carolina and crossing into Virginia and West Virginia before joining the Ohio River. Major tributaries in the state include the Gauley, the New, the Elk and the Greenbrier. Minimum in-stream requirements maintain fish and wildlife habitat, transportation, and ecological services (primarily dilution of downstream effluent discharges) but rely on reservoir releases from Summersville and Sutton dams. The whitewater industry provides the region with millions of dollars in revenue every summer and Appalachian Power Company has hydropower plants on three corps multipurpose reservoirs and owns a fourth reservoir at Claytor Lake.

A drought that began with low rainfall in 1987 and continued through the fall of 1988 restricted important whitewater releases during weekdays, costing millions of dollars in lost local revenues. US Army Corps reservoir releases eventually fell below what was necessary to maintain minimum in-stream flow requirements (for ecological services, wildlife, and transport) at a perceptible cost to water quality and habitat.

USACE convened a study team of experts to evaluate the situation and develop a series of policy alternatives to the status quo management plan. For each alternative, impacts on lake recreation, water quality, rafting, navigation, and hydropower were evaluated. A group of stakeholders was convened to debate the various management scenarios and the

corresponding implications. Debate and discussion eventually lead to the endorsement and implementation of situation-tailored plan to manage water resources that both protected the ecological and economic services of the watershed resources.

In 1993, when drought again required exceptional water resource allocation decisions be made, informed and experienced stakeholders reconvened with the Corps using the “Shared Vision” model and decided on a new strategy given the specific drought conditions they faced.

The regional drought watch was lifted after heavy rains eliminated the resource scarcity problem, however, the Kanawha case study illustrates the usefulness of and need for regional drought readiness and management planning. Each drought event poses different types of scarcity depending on when it occurs, duration and other events going on at the time. Each region faces different water resource demands and may prioritize needs for each drought event differently given the temporally and regionally unique context. This is particularly useful when water resource uses can be coordinated to facilitate multiple-use management of scarce resources. Combining the participatory and information-driven approaches of the Shared Vision model helped to develop a team of local experts interested in and capable of finding the best management solution for the region. Such participation is likely to provide additional benefits of stakeholder cooperation during the implementation phase of any drought mitigation plan.

4 Conservation Practices

Identify practices to reduce water withdrawals (Element 9)

Given the state's abundance of water resources, water conservation has not been priority for many lawmakers or regulatory officials. Water conservation practices, in water rich regions, reduce costs associated with water diversion, filtering, transportation, and wastewater treatment.

4.1 WVDEP Survey Results

In preliminary results from the WVDEP Water Users Survey, 76 of 383 respondents claimed to practice some type of water conservation practices. These respondents fell within at least 23 different SIC sectors. Of those 76 respondents, some of the water conservation practices listed were not voluntary or were implemented for objectives that were unrelated to conservation strategies but resulted reduced water use. Practices fell into three Conservation Categories of 1) on-site water reuse or recycling; 2) leak or excess water use detection systems; and 3) eliminating or reducing water use need by employing alternative methods to achieve the same goals.

Washington Works (plastics), in Wood County, stands out among the respondents as having implemented one of the biggest water-saving systems in terms of gallons of water conserved. The plant's survey indicates only, "*Site procedures are in place that include the review of projects impacting water consumption. This review includes consideration of water conservation in the approval process.*" The estimated water savings at the plant, which uses ground and surface water for "*Cooling Water, Chemical Reactions, & Steam generation*", is 50,000,000 gallons per month. The facility has capacity to withdraw 3,260,400,000 gallons per month.

The facility is considering plans for "*a project involving the recovery and recycling of steam condensate used in steam production at the site is under consideration. This project would conserve the use of ground water.*" Washington Works' planned projects in Wood County would save 13,000,000 gallons per month at an estimated cost of \$2,000,000.

Likewise the Follansbee Coke Plant (129,600,000 gallon monthly withdraw permit) in Brooke County is saving 31,248,000 gallons per month by using cooling water that was previously discharged as boiler feed water.

Both the Follansbee and Washington Works plants fall into Conservation Category 1, intra-system water reuse. In Conservation Category 2, leak or excess water use detection, Huntington Alloys Corporation (28,000,000 gallon monthly withdraw permit) installed leak detection system that reportedly saves the facility 10,000,000 gallons monthly.

A number of coal processing plants cited efforts to reduce water use by recirculating water from sediment ponds back through the facility (Conservation Category 1) and by paving or otherwise treating dusty roads to reduce the use of water in dust-suppression activities (Conservation Category 3).

4.2 Case: Toyota

While not the largest water user in the area, the new Toyota Plant in Buffalo, WV is certainly one of the more innovative and progressive facilities in the state in terms of implementing voluntary conservation standards. The plant is implementing conservation plans that will save them millions of gallons of water per year. While there is no water shortage in the Buffalo area, Toyota understands that capturing, filtering, transporting water, and treating excess wastewater are all costly activities. Reducing use, therefore, reduces operating costs. Toyota's goal is to match the plant's own zero solid waste discharge standard in the area of water resources.

According to Toyota's environmental specialist, Sean McCarthy, stormwater from about 100 acres of impervious surface (building and parking lot) is already captured and used for landscape irrigation (20-25 acres), saving the plant .5 million gallons/year.

Currently, the plant is losing 14 million gallons/year to evaporation while operating its cooling compressors and tower. In an effort to reduce this loss, the plant is in the final research and development stages of an on-site water treatment facility that will help save 10-11 million evaporated gallons/yr. This move will also reduce the plant's demand on the local public water utility to three million gal/yr. Just 20 miles outside of Charleston, this demand reduction will provide the city of Buffalo with important opportunities to extend public service to growing residential and commercial demand without incurring additional capital costs for water system expansions.

5 Conclusions

The West Virginia Legislature, through the Water Resource Protection Act, has recognized that water is a tremendous economic asset in West Virginia and should be managed with the same attention and respect as is given to other capital assets managed by the state. WRI has made significant advances in our efforts to respond to the WRPA research tasks in support of and in collaboration with WVDEP.

Evaluation of the state's water resources is a necessary precursor to developing a water resource plan or associated water resource management strategy. Learning now that there are data and information gaps, understanding why different types of information are important, and learning about water resource data and evaluation practices in other states in the region are critical activities.

Our objective is to provide a final report to the WVDEP containing a comprehensive evaluation of the state water quantity issues defined in SB 163 to the extent possible with existing data. Complementary qualitative data should be collected from local stakeholders (government, private, and organizational) who work on a daily basis with water resources but was not an activity that we could undertake with existing resources. With additional funds sought in 2005, we are working to develop an interagency report gages and wells in the state that will identify gaps and prioritize needed new investments. This will compliment a WRI memorandum to WVDEP which served as comparative summary of water quantity management plans and water quantity monitoring resources in surrounding states. Collectively, this information should provide a solid policy guide with which our state's decision makers can make an active and informed decision about whether and how to continue state efforts to assess and manage our water resources.

6 Publications and Reports

Four quarterly reports were submitted to the WV DEP working group on the WV Water Resources Protection Act throughout the 2005 calendar year.

Herd, R.S. and A.M. Schrecongost, Water as a Commodity: Managing WV Water Resources for Economic Development. Presentation to WV Manufacturers, Annual Meeting, June 7, 2005, Morgantown, WV.

Schrecongost, A.M., WV Water Resource Protection Act, Program Assessment and Management. Presentation to Jackson Kelly Water Resource Seminar, September 7, 2005, Charleston, WV.

Herd, R.S. WV Senate Bill 163, WV Water Resources Inventory and Assessment. Presentation to WV Water Research Institute Advisory Committee annual meeting, October 25, 2005, Morgantown, WV.

Schrecongost, A.M., WV Water Resource Protection Act, Program Assessment and Management Status Report. Presentation to Water Resources Committee of the WV State Legislature, December 2005, Charleston, WV.

West Virginia Water Conference 2005

Basic Information

Title:	West Virginia Water Conference 2005
Project Number:	2005WV54B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	WV 1st
Research Category:	Not Applicable
Focus Category:	Water Quantity, Water Use, Water Quality
Descriptors:	
Principal Investigators:	Tamara Vandivort

Publication

State: WV
Project Number:
Title: West Virginia Water Conference 2005
Project Type: Information Transfer
Focus Category: Water Quantity, Water Quality, Water Use
Keywords: Water, Conference, Policy, Research, Education, Economics
Start Date: 3/1/05
End Date: 2/28/06
Congressional District: WV 1st
PI: Tamara Vandivort
Email: tvandivo@wvu.edu
Co-PI's: None

Goal

The ultimate goal of this conference was to encourage and empower the growth of a thriving restoration industry in the Highlands.

Objectives

To reach this goal, the conference objectives included the following:

- Identify and assess the economic, ecological, and social benefits of restoration
- Identify existing funding streams that are supporting restoration and assess future funding opportunities
- Identify challenges to a thriving restoration industry and suggest solutions.

With this information a consortium was formed to prepare a report (attached) that defines the benefits of restoration and lays out a plan for effectively accessing funds for restoration. The Consortium will market this plan and follow up on report recommendation to support integrated restoration in the Highlands.

Methods, Procedures, Facilities

The West Virginia Water Research Institute teamed with Canaan Valley Institute, for conference planning, agenda development, and planning committee participation.

Conference Planning Committee

This committee was comprised of representatives of key stakeholders from the following organizations:

- West Virginia Water Research Institute
- West Virginia University College of Law
- West Virginia Board of Public Health
- West Virginia Division of Environmental Protection

- Marshall University
- Canaan Valley Institute
- U.S. Environmental Protection Agency
- U.S. Geological Survey

Communications included physical meetings, conference calls, and email. This group worked together to achieve the following:

- Developed a theme
- Created an agenda
- Selected a location
- Selected and invited moderators and speakers
- Enhanced the mailing list from the previous 2 conferences
- Selected avenues for promoting the conference

The theme of the 2005 conference was *Revitalizing Communities through Restoration: Linking Social, Economic and Natural Assets*. The following is the final agenda:

Agenda

General Registration: Monday 8:00 — 9:50 am
 Exhibitor Setup: Monday all day
 Poster Setup: Monday between 3:45-4:00 pm and 5:30-6:00 pm

Monday, October 24: Setting the stage—Restoration industry perspective

Session 1

Moderator—Tom DeMoss, US EPA Region 3

- 10:00 am Conference context, goals, and format
Kent Thornton, FTN Associates and Conference Sponsors
- 10:15 am Why a restoration industry—the needs in the Highlands
R. Pomponio, EPA Region 3
- 10:40 am Possibilities for a thriving integrated restoration industry
Storm Cunningham, Revitalization Institute
- 11:20 am Describing the restoration industry today
Keith Bowers, Biohabitats, Inc.
- 12:00 pm Lunch (provided) with presentation on historic perspective on community revitalization:
Then and now
Bob Miller, Georges Creek Watershed Association

Session 2

Moderator—Jenny Newland, Canaan Valley Institute

- 1:30pm Why should we invest in restoration?
Caren Glottelty, Heinz Endowments
Bobby Lewis, West Virginia Development Office
Terry R. Sammons, Sammons Law Offices PLLC
- 2:30 pm Moderated question and answer session with prospective funders
- 3:00 pm Building a restoration Silicon Valley—Characteristics of an industry cluster and assets and obstacles in the Highlands
Lisa Wainger, University of Maryland
- Break 3:45 - 4:00 pm

Session 3

Moderator—Kent Thornton, FTN Associates

- 4:00 pm Case study #1 — Building local business through restoration emphasizing small business growth in The Kiski-Conemaugh Basin
Rob McCombie, Westsylvania Heritage Corporation
- 4:30 pm What triggers government investment in integrated restoration?
Kent Thornton, FTN Associate
- 5:00 pm Summarizing the day and previewing tomorrow
Moderator
- 6:00 pm Hors D'oeuvres, Refreshments, and Community Revitalization. An interactive, multimedia session providing the opportunity for community groups and restoration-related businesses to tell their stories

Tuesday, October 25: Paying for restoration and community revitalization

Continental Breakfast 7:13 am

Session 4

Moderator—Richard Herd, WVLJ Water Research Institute

- 8:15 am Case study #2 Restoration = Access: Nine Mile Run Clean-Up
Marijke Hecht, Nine Mile Run Watershed Association
- 8:45 am How can we define and measure social benefits? *David Robertson, Virginia Tech*

- 9:15 am Overview of markets for restoration and a roadmap for market integration
Todd Petty, West Virginia University
- 9:40 am Opportunities for Market-Based Incentives for Restoration
Jessica Fox, EPRI Solutions
- Break 10:00 — 10:20 am
- 10:20 am Restoration as Mitigation Programs and the Legal Issues *Kristy Bulleit, Hunton and Williams*
- 10:40 am Opportunities for Restoration as Mitigation — Power Company Perspective *Doug Dixon, EPRI Solutions*
- 11:00 am Opportunities for Restoration as Mitigation — Mining Industry Perspective
Larry Emerson, Arch Coal
- 11:20 am Stream and Wetland Restoration Banking Program in North Carolina
Bill Gilmore, North Carolina Ecosystem Enhancement Program
- 11:40 am Moderated question and answer session with speakers
- 12:00 pm Lunch (provided)

Session 5

Moderator—Janie French, Canaan Valley Institute

- 1:00 pm Development panel discussion: What can they offer to entrepreneurs to entice them to start restoration businesses in their communities or counties?
Bobby Lewis, WV Development Office
Brad Zearfoss, Somerset County Planning Commission
- 2:00 pm Case Study # 3—Restoration Pays: Feather River Coordinated Resource Management
Leslie Mink, Plumas Corporation
- 2:45 pm Creating and marketing community assets *Aaron Dushau, WinRock International*
- Break 3:15 — 3:30 pm

Session 6

Moderator—Todd Petty, WVU Division of Forestry

- 3:30 pm Investment panel discussion: What excites venture capitalists and investors?
3:30 Mark Nicholson, The Progress Fund

3:45 Fred Baer, *Natural Capital Investment Fund*
4:00 Scott Rotruck, *Morgantown Chamber of Commerce*
4:15 Panel Discussion

- 4:30 pm Case Study #4—Restoration Breeds Investment: Morgantown Waterfront Redevelopment
4:30 Bill Coffindaffer, *West Virginia Agricultural Land Protection Authority*
4:45 Evan Hansen, *Downstream Strategies*
5:00 Panel Discussion with Morgantown Leaders
- 5:15 pm Adjourn with map and directions for self-guided tour of Morgantown Waterfront
- 5:30 pm Rail-Trail Bike Ride: Meet with your bikes, helmets, and water at the Radisson.
Peggy Pings will lead an educational bike ride along both the Deckers Creek and Mon River
Rail-Trails, returning by dark. If you don't bring your own bike (single speed is fine), 9 rental bikes are available at Wamsleys (304-296-2447); call to reserve a bike. Peggy is an Outdoor Recreation Planner with NPS-Rivers & Trails Program and Mon River Trails Conservancy.
Optional dinner afterwards at La Casa or Oliverio's, within a short walk.

Wednesday, October 26: Confronting challenges and moving forward

Continental Breakfast 7:15 am

Session 7

Moderator—Kent Thornton, FTN Associates

- 8:00 am Defining morning activities (breakouts/brainstorming) *Moderator*
- 8:15 am Laying out the charge
Torn DeMoss, EPA Region 3
- 8:30 am Breakout sessions to develop recommendations for building a restoration industry in the Highlands
- 9:45 am Break, consolidation of recommendations by Moderator and breakout facilitators
- 10:15 am Vote on consolidated recommendations *Participants*

- 10:30 am Brainstorm possible actions to address top recommendations and move integrated restoration forward in the Highlands
Moderator
- 11:45 am Closing Remarks: What to expect and how to get involved
Moderator
- Noon Adjourn

Facility

The Radisson Inn, Morgantown, West Virginia was selected as the venue for this conference due to its location and availability.

Registration and Materials

Registration was handled by Canaan Valley Institute. Lunches and materials were provided to approximately 150 attendees. Materials included a brochure on the activities of the WVVRI and a calendar of West Virginia Springhouses provided by the WVVRI free of charge to all participants.

Exhibits

Approximately 10 exhibitors participated in the conference including an exhibit on the WVVRI.

Publicity/Technology Transfer

The conference was publicized in a number of ways as follows:

- Press releases to television, newspapers, and radio.
- West Virginia University and WVVRI web sites.
- Post cards mailed to WVVRI conference mailing list.
- Announcements provided to all on planning committee to distribute via their own agency web sites and mailing lists.
- The conference agenda, directions to the facility, an on-line registration form, and presentations were placed on the Canaan Valley web site.

Revitalizing Communities Through Integrated Restoration: Linking Social, Economic, and Natural Assets

Answering Questions About Growing an Integrated Restoration Industry in the Highlands

Introduction

How do you spend \$2 trillion worldwide and not have most people know about it? Put it into revitalizing communities through restoration of the built and natural environment. That was one of the messages from a Conference on *Revitalizing Communities Through Integrated Restoration: Linking Social, Economic, and Natural Assets*. This Conference was held from October 24 through 26, 2005 in Morgantown, WV in the Radisson Hotel at Waterfront Place – a location that epitomizes the conference theme.

Waterfront Place was built on brownfield sites along the Monongahela River. Leaders in the Morgantown community wanted to revitalize the downtown area, so they created a vision in the community of what could be, strengthened relationships among community groups, and built trust (i.e., social capital) that generated economic capital to revitalize the downtown area. New hotels, riverfront amphitheaters, walkways, and shopping areas arose and brought people into downtown Morgantown. Economic revitalization led to increased awareness of the condition of the Monongahela River and its contribution to the ambience and quality of life in the downtown area. Acid mine drainage had turned the river orange and eliminated most fish from the river. The River is being restored and sport fish again swim in the river past Morgantown. Through the development of social capital and economic revitalization came the environmental restoration of the Monongahela River, a natural asset. Integrated restoration merges social, economic, and ecological factors to restore natural assets, increase the economic viability of the region, and contribute to an improved quality of life desired by citizens.

*The Revitalizing
Communities Conference
successfully achieved its
purposes and moved us
closer to a thriving
restoration industry.*

The ultimate goal of the Conference was to encourage and empower the growth of a thriving restoration industry in the Mid-Atlantic Highlands. The Conference had three purposes to achieve this goal:

1. Identify and assess the social, economic, and ecologic benefits of restoration,
2. Identify existing funding programs that support restoration and assess future funding opportunities, and
3. Identify challenges associated with creating a thriving restoration industry in the Mid-Atlantic Highlands, and suggest solutions to these challenges.

This paper documents the Conference success in achieving these three purposes and moving the Mid-Atlantic Highlands toward the goal of a thriving, integrated restoration industry. In achieving these purposes, it also provided answers to some important questions:

- What is integrated restoration?

- Why emphasize integrated restoration in the Highlands?
- What makes you think it can be done?
- Who is going to pay for it?
- Who is championing this?
- What are the greatest challenges?
- What are the greatest opportunities?
- Where should it start?
- Who is going to make sure it happens throughout the Highlands?

What Is Integrated Restoration?

Integrated restoration is the intersection of social and economic capital with environmental restoration of natural assets (forests, streams, wetlands, lakes, estuaries) (Figure 1). The environmental, economic, and social sectors are interdependent and when an integrated systems approach is used for environmental restoration and management, social and economic sectors also benefit. Integrated restoration emphasizes complementary social, economic, and environmental programs; leveraging of funds from multiple sources and programs; partnerships among government agencies, non-government organizations, and private sector businesses; and greater cost-effectiveness for all projects, programs, and agencies. Integrated restoration is based on the premise that humans are part of, not apart from, the environment. By linking the restoration of natural assets with economic development, communities can benefit socially, economically, and environmentally and experience a better quality of life (See Text Box-next page). For example, stream restoration contributes not only to improved riparian habitat and water quality, it can also create jobs (heavy equipment

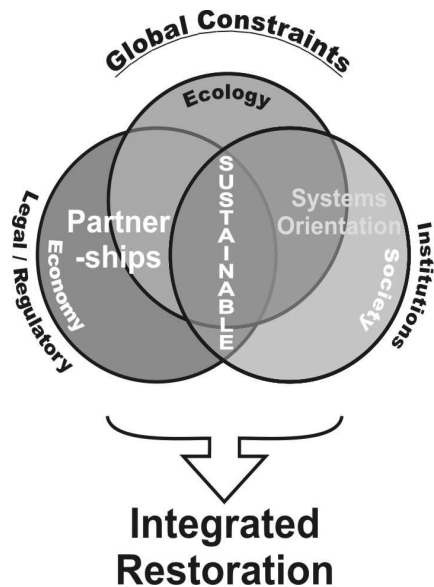


Figure 1

Integrated restoration includes social, economic, and environmental sectors.

Every sector – social, economic and environmental – benefits from integrated restoration.

operators, skilled agromists, laborers, horticulturists, engineers, etc.) during stream restoration (natural stream design and construction, bank stabilization and revegetation, etc.) and potentially afterward through recreational activities (fishing, rafting, etc.). In addition, stream restoration contributes to improved community aesthetics and well-being – essential elements of quality of life. Integrated restoration

can also occur through economic development, as in the example of Waterfront Place. Inner city enterprise zones and community development projects can provide jobs, increase employment, enhance community pride, and contribute to a desire and appreciation for environmental amenities such as parks, clean streams, water features, and green infrastructure. A key part of integrated restoration is forming partnerships and engaging the community in the process.

This Conference was based on the assumption that an integrated restoration industry could be created in the Highlands. The Conference was successful in documenting and

demonstrating that an integrated restoration industry is feasible and already exists in a nascent state in the Highlands.

Why Emphasize Integrated Restoration in the Highlands?

If you have ever been to the Highlands, you know it is a special place. The Mid-Atlantic Highlands contain clear mountain streams, verdant forested mountains, rich cultural heritage, and industrious people. This region contains the largest area of interior temperate, hardwood forests in the world, with a rich diversity of tree species. Its streams contain as many types of fish, mussels, and crayfish as any temperate streams in the world. The Nature Conservancy identified the Mid-Atlantic Highlands region as one of its top six priorities for conservation because of the

The Highlands are a special place with a legacy of problems being solved through the Highlands Action Programs.

high total species richness of both its plants and animals, and the presence of some species found nowhere else in the United States.

The Mid-Atlantic Highlands region also has a legacy of problems forged by past environmental and economic decisions. These problems are the result of past exploitation that fueled an economy

outside the region. Some of the legacy environmental problems include habitat loss, stream sedimentation, forest fragmentation, acid rain, acid mine drainage, flooding, and invasive non-native species. These are just a few of the problems arising from human activities such as urban infringement; timber, agriculture, and mining practices; and stream alterations. In addition, there is also a legacy of social and economic concerns in the Highlands. In some Highland counties, up to 50% of the children live in poverty. Parts of the region struggle with high unemployment rates, low high school graduation rates, low labor force participation rates, and some of the lowest per capita incomes in the nation.

With problems also come opportunities. R. Pomponio, Director of the EPA Region 3 Environmental Assessment and Innovation Division discussed the Highlands Action Program and its goal of transforming the legacy of scarred natural environment, and underserved people into a promising future of sound environmental and socioeconomic stewardship. Through the Highlands Action Program, there are opportunities to take advantage of the skills and resources within the region that cannot be duplicated anywhere else – its people, history and cultural heritage, institutions, climate, scenic beauty, wide-open vistas, biological diversity, and globally significant forests. These opportunities, however, can be realized only through integrated restoration – integrating the social/cultural, economic, and environmental sectors. Not only does EPA believe in integrated restoration within the Mid-Atlantic Highlands, it has set the following major restoration goals for 2025:

- 25,000 stream miles will be restored using collaborative and non-traditional measures including the establishment of 5000 acres of riparian buffer, in stream habitat, and watershed protection;

Environmental Restoration Yields Economic Dividends

A recent study of the economic benefits of restoring Deckers Creek in West Virginia – specifically, restoring aquatic life, swimming, and scenic quality – determined that the welfare improvement estimates for full restoration of all three attributes ranged between \$12 and \$16 per month per household. When these estimates were aggregated up to entire watershed population, the benefit from restoration was estimated to be about \$1.9 million annually.

- 5,000 sq. miles (3.2 million acres) of forest revitalization and restoration will occur within ecological corridors collaboratively designed by various agencies and local communities; and
- 3,000 additional restoration jobs will be created.

Achieving these goals will provide both ecological and economic results.

- 105,954,000 tons per year of sediment will no longer enter Highlands streams;
- 645,000 tons per year of nitrogen and phosphorus, and proportional amounts of sediment, will be removed or prevented from entering the Highlands stream network;
- 50% increase in sport fishing stream length and tons of fish harvested will occur;
- 17,500 additional recreational fishing days will be provided; and
- 3,885,000 tons per year of carbon will be sequestered.

The Highlands Action Program is described and documented in the Report, *Mid-Atlantic Highlands Action Program: Transforming the Legacy* (CVI 2002).

What makes you think it can be done?

It's already being done! (Figure 2). Look at Table 1. These are just a few of the places where integrated restoration has been successful in revitalizing communities. K. Bowers, Biohabitats, provided a list of Lessons Learned from the many integrated restoration projects that have already been conducted throughout the Highlands and elsewhere in the U.S. (Table 2). The question is not, "can it be done?", but rather, "which communities are the best candidates for integrated restoration projects that would contribute to the growth of an integrated restoration industry?"



Figure 2. Environmental restoration in the Highlands is being done.

Table 1. Selected Highlands Restoration Projects

Restoration Project	Description
Nine Mile Run, PA	High-end condominium development on a Brownfield site promoted a local group of artists to champion stream restoration of Nine-Mile Run, creating a natural asset with a tranquil, aesthetic beauty and walking trails, and which added to the property value of the new development.
Allegheny Trail, PA	Trail from near Pittsburgh connected to C&O Canal trail at Cumberland, MD. Championed by businesses and property owners along the trail who gained economic benefits from trail development and restoration.
Kiski-Conemaugh River Basin, PA	Small group of citizens formed an alliance, developed a basin plan, and systematically began restoring watersheds and streams within the basin. Over \$10 million has been invested, streams are being restored, and people are engaged. Stories of success are shared with children through the Westsylvania Adventure – a day-long outing in the basin.
Georges Creek, MD	Georges Creek Watershed Association championed stabilizing the stream channel and installed an innovative treatment system for acid mine drainage to restore the stream and reestablish brook trout. Interest and effort has continued beyond this project.
Paint Creek, WV	Four people decided to clean up the stream and restore brook trout. A Watershed Association was formed and enlisted the local school board, a coal company, and local citizens to achieve their goals. Community efforts continue through county-wide youth education programs and recreational programs.
Bennett Branch, PA	Local landowners championed the restoration of 1,500 feet of severely eroding streambank. Creation of a riparian wetland has improved fish habitat and water quality conditions and brought fishing back as an activity for local families and visitors.
Horseshoe Run, WV	Local citizens banded together to complete restoration of 3,400 feet of streambank to stop bank erosion, property loss and nuisance flooding in this rural watershed, saving landowners money and worry. Future restoration of 3.8 miles of Horseshoe Run will boost the ecological conditions in the stream and address the most serious erosion and sedimentation issue in the watershed.
Snowy Creek, MD	The Crellin, MD community was sparked by an educator to restore Snowy Creek near the community grade school. The project treats acid mine drainage discharging into Snowy Creek, provides a living environmental laboratory to educate students on environmental and historical issues, and provides a direct connection between the town's past and its future.
Deckers Creek, WV	Local citizens championed this project to restore the stream, heavily impacted by mining in the 1900's and expect that this work, and planned future work, will generate an estimated \$14 million in economic impacts to the surrounding communities.
Cheat River, WV	Local citizens formed a watershed association to address acid mine drainage problems in the largest free-flowing watershed in the eastern US. These citizens are restoring a once-thriving whitewater rafting industry, a decimated sport fishery, protecting an endangered salamander species and restoring the scenic beauty of the area.

Table 2. Lessons Learned About Environmental Restoration (after Bowers)*

Lessons Learned	Brief Description
1. Top down – Bottom up support	Environmental restoration was originally mitigation-driven (top-down), but it is receiving bottom-up support. Integrated restoration is not either-or; it is both top-down and bottom-up.
2. Blurring the boundaries	Restoration is, and must be, an interdisciplinary effort involving planners, engineers, fisheries biologists, horticulturists, etc.
3. Outside the box	Consider opportunities for environmental restoration at broader scales with broader benefits. For example, planners can incorporate restoration with development.
4. It's a business	Restoration is not free. It must be treated like a business with performance measures and profit margins for it to become an industry.
5. Building bridges – restoring ecosystems	Professional certification (PE) is required to build bridges. Ecosystems are intricately more complex; professional certification in the industry is needed.
6. Skilled work force	Restoring ecosystems requires a skilled work force, from individuals using heavy equipment to agronomists and horticulturists.
7. Working capital	Loaning institutions and sources of capital are needed for environmental restoration, just as they are for any construction project.
8. Design-Build	Restoration projects are moving toward design-build, following the trend in the water treatment industry.
9. Low bid	You get what you pay for. A restoration industry should begin with a qualifications-based selection process, then negotiate fee.
10. Not another demonstration project	Environmental restoration has been successful. Additional stream, wetland, or watershed demonstration projects are not needed. It works! Build on the lessons learned.
11. Enforcement	Mitigation has been a driver for restoration, but there has been no post-project inspection to document successful mitigation. A “punch-list” approach is needed for post-projects to ensure the industry remains credible.
12. “Climate” change	Restoration can have a significant effect on peoples lives, in generating community pride, and changing the “climate” of the community. These changes need to be considered as part of the project.
13. Bipartisan support	Restoration is apolitical. Local counsel members need to understand restoration can also contribute to the security and economics of the community.
14. Invasive species	Invasive species can be a real threat to ecosystem restoration. Some communities inadvertently introduce invasive species as part of the restoration process by using non-native vegetation.
15. Sustainable design – LEED	Green building designs (Leadership in Energy and Environmental Design) need to consider the surrounding site as well as the building. Restoration can contribute to better energy efficiency.
16. Technology	Greater technological innovation is needed. Patenting technology will help the industry grow.
17. In the ground is only the beginning	Adaptive management and monitoring are essential for sustaining the success of the restoration project.
18. Not just successes	Documenting failures is as important as documenting success. We can learn more from failures than successes.
19. Inclusive	Everyone in the community needs to be considered, and, if possible, included.
20. Celebrate	Celebrating success not only rewards participants, it builds community pride and accomplishment.

* Keith Bowers, Biohabitats, Inc. Describing the Restoration Industry Today. Revitalizing Conference. 2005

Who's going to pay for it?

Many agencies are already providing funding for different aspects of integrated restoration (Table 3). There are also funding institutions who want to be partners in an integrated restoration industry. The Natural Capital Investment Fund and the Progress Fund are two organizations created to provide low interest, venture capital loans for environmental conservation and improvement projects, and were represented at the Conference. The issue is not the availability of funds, but rather the leveraging of funds. Leveraging funds means combining the money available for different elements of integration restoration (e.g., rural development grants, Section 319 funds, welfare to work programs, construction grants for wastewater treatment facilities, rivers, trails and conservation assistance, etc.) within the same project and local community. Currently, there is over \$11 billion available for integrated restoration, but these funds are divided among multiple agencies and organizations for different purposes.

Over \$11 billion are available for integrated restoration IF leveraged properly.

Creative approaches in applying for, and leveraging, funds; engaging additional partners and stakeholders; linking watershed, stream/wetland and community elements together; and interacting with government and non-profit organizations would permit an integrated restoration industry to grow. Some of these creative approaches were discussed at the Conference. For example, market-based incentives, particularly water quality and conservation-based trading, and mitigation banking are currently providing funding opportunities for integrated restoration projects. The Chesapeake Bay Program has initiated a pilot study on water quality trading. California has initiated a conservation trading program aimed at protecting threatened and endangered species. The California program encourages the creation and protection of large contiguous habitats for these species to offset the loss of small, but unsustainable, habitat areas being developed within the range of these species.

An example of creative mitigation banking is the Ecosystem Enhancement Program (EEP). This program, created by the North Carolina Department of Transportation, restores stream and wetland ecosystems to mitigate the environmental destruction that occurs in the development of transportation networks. The EEP is a proactive program that restores streams and wetlands up to seven years in advance of the construction of roads, bridges, or other transportation corridors requiring the mitigation. This proactive process means that stream and wetland restoration procedures can be monitored over time to ensure they are effective at mitigating habitats destroyed during highway construction. Restoration effectiveness and its associated benefits could be improved by leveraging funds to implement watershed best management practices in those watersheds where restoration is occurring, engaging local community groups or watershed associations in the process.

Who is championing this?

There are champions in every community and their characteristics are as varied as the communities. Every example of integrated restoration described at the Conference occurred because

Every community has it's champions.

someone in the local community was passionate about an issue that lead to integrated restoration and revitalizing their community. Identifying a champion is the easy part. The challenge is providing them with the needed resources, tools, and funding.

What are the greatest challenges in growing an integrated restoration industry?

L. Wainger, University of Maryland, discussed some of the economic considerations in creating an integrated restoration industry. Some of the challenges identified based on economic criteria included:

- Isolation – multiple businesses in close proximity can attract more customers and share resources. Integrated restoration business currently are not co-located.
- Specialized market – integrated restoration is a niche or specialized market that currently has a limited customer base.
- Needs not equal to demand – currently the need exists, but the demand for restoration has not been created.
- Spatial mismatch between areas with restoration needs and areas with highest levels of infrastructure and inputs – many restoration projects currently are in rural areas, but the resources and customers are more urban.
- Highlands competing with outside businesses (isolation, climate, etc. become important) – currently restoration requires similar skills as the construction industry, which is established and booming.

A nominal process was used to permit participants to identify the challenges at the Conference. Two small groups brainstormed this question, listed challenges, and then moved through a consensus process to rank the top challenges for growing an integrated restoration industry in the Highlands. The top ranked challenges were:

- Lack of education/understanding of the restoration industry and its contribution to revitalizing communities, including what is meant by restorative development.
- Community leadership and buy-in missing
- Difficulty in identifying primary funding sources
- Poor communication of the message – sending technical message to non-technical audiences
- Lack of enforcement by regulations



Figure 3 Restoration is jobs – drawing on heavy equipment operators, and other skilled workers.

Table 3. Agencies and funding programs for Highlands integrated restoration.

Department of Agriculture Programs	
Fund for Rural America Research, Education, and Extension	Rural Telephone Loans and Loan Guarantees (RUS)
National Rural Development Partnership	Rural Telephone Bank Loans
Rural Community Development Initiative	Rural Economic Development Loans and Grants
Cooperative Forestry Assistance	Resource Conservation and Development
Schools and Roads Grants to States	Rural Abandoned Mine Program (RAMP)
Schools and Roads Grants to Counties	Environmental Quality Incentives Program (EQIP)
National Forest Dependent Rural Communities	Conservation Reserve Program
Water and Waste Disposal Systems for Rural Communities	Conservation Security Program
Solid Waste Management Grants	Forest Legacy Program
Community Facilities Loans and Grants	Environmental Justice Small Grants Program
Business and Industry Loans	Forest Land Enhancement Program
Rural Development Grants (RBEG) (TDG)	Grassland Reserve Program
Water and Waste Disposal Loans and Grants (Section 306C)	Small Watershed Rehabilitation Program
Rural Cooperative Development Grants (RTDG)	Urban and Community Forestry Challenge Cost-Share Grants
Empowerment Zones Program	Watershed Protection and Flood Prevention Program
Rural Business Opportunity Grants (RBOG)	Wetlands Reserve Program
Rural Electrification Loans and Loan Guarantees (RUS)	Wildlife Habitat Incentive Program
Appalachian Regional Commission	
Appalachian Regional Development	Appalachian Local Development District Assistance (LDD)
Department of Commerce	
Economic Development Technical Assistance	Public Works and Development Facilities Program
Public Telecommunications Facilities – Planning and Construction (PTFP)	Minority Business Opportunity Committee
NOAA Open Rivers Initiative	NOAA Community-based Habitat Restoration National and Regional Partnership Grants
NOAA Community-based Restoration Program Individual Project Grants	NOAA CRP - NFWF Chesapeake Bay Small Watershed Grants Program
NOAA CRP - Trout Unlimited Embrace-A-Stream Grants	American Rivers River Restoration Grants
Department of Defense	
Section 1135	Environmental Restoration
Section 206	Aquatic Ecosystems Restoration
Department of Education	
Fund for the Improvement of Education (TIE)	Capacity Building for Traditionally Under-served Populations
Ready to Learn	Community Technology Centers
Twenty-first Century Community Learning Centers	Rural Education Achievement Program (REAP)
Ready to Lean Television	Dropout Prevention Program

Table 3. Continued

Environmental Protection Agency	
Construction Grants for Wastewater Treatment Works	Drinking Water State Revolving Fund
Wetlands Protection Development Grants	Environmental Education Grants
Environmental Justice Grants to Small Community Groups	Environmental Justice Collaborative Problem-Solving Cooperative Agreement
Solid Waste Management Assistance	Environmental Justice Small Grants Program
Brownfield Pilots Cooperative Agreements	Five Star Restoration Program
Abandoned Mine Land Reclamation Program Brownfields Clean-up	Nonpoint source Implementation Grants (319 Program)
Chesapeake Bay Small Watershed Grant Program	Targeted Watershed Grants Program
Federal Emergency Management Agency (FEMA)	
Flood Mitigation Assistance Program	
Department of Health and Human Services	
Project Grants for Facilities to Improve the Health Status of Minority Populations	Community Services Block Grant
Rural Health Research Centers	Child Care and Development Block Grant
Rural Telemedicine Grants	Rural Health Outreach and Rural Network Development Program
Development and Coordination of Rural Health Services	Healthy Start Initiative (Targeted Infant Mortality Initiative)
Community Health Centers	
Department of Housing and Urban Development	
Supportive Housing for the Elderly (202)	Community Development Block Grants/Economic Development Initiative (Section 108)
Community Development Block Grants/Small Cities Program	Rural Housing and Economic Development
Community Development Block Grant/Special Purpose Grants/Technical Assistance Program	Community Outreach Partnership Center Program
Opportunities for Youth, Youth Build Program	Community Development Work Study Program
Empowerment Zones Program	
Department of Interior	
Wildland Urban Interface Community and Rural Fire Assistance	Landowner Incentive Program
Historic Preservation Fund Grants-in-Aid	Acid Mine Drainage Reclamation Program
Outdoor Recreation Acquisition, Development and Planning (Land and Water Conservation Fund Grants)	Partners for Fish and Wildlife Program
Rivers, Trails and Conservation Assistance (RTCA)	Cooperative Endangered Species Conservation Fund
Department of Labor	
Welfare-To-Work Grants to States and Localities	Youth Opportunity Grants (YOG)
National Endowment for the Arts, National Foundation on the Arts and Humanities	
Promotion of the Arts Grants to Organizations and Individuals	Promotion of the Humanities Public Programs
Promotion of the Arts Partnership Agreements	Promotion of the Humanities – Extending the Reach Grants to Underserved Areas
Promotion of the Arts Leadership Initiatives	
Institute of Museum and Library Sciences	
Institute of Museum and Library Services (General Operating Support)	

Table 3. Continued

Small Business Administration	
Management and Technical Assistance	Women’s Business Ownership Assistance
Small Business Investment Companies (SBIC; SSBIC)	Veterans Entrepreneurial Training and Counseling (VET Program)
Small Business Loans (Regular Business Loans 7 (a) Loans)	
Department of Transportation	
Recreational Trails Program	Public Transportation for Nonurbanized Areas (Nonurbanized Area Formula Program)
Transportation Equity Act for the 21 st Century Funding Programs (TEA-21)	
Corporation for National and Community Service	
Learn and Serve America School and Community-Based Programs	Americorps
Learn and Serve America Higher Education	Planning and Program Development Grants
National Fish and Wildlife Foundation	
Southern Rivers Conservation	

What are the greatest opportunities?

In addition to challenges, there are also several economic assets associated with creating an integrated restoration industry in the Highlands, including:

- Located near one of most densely populated areas of the US
- Natural beauty and rural amenities of the Highlands can drive capital investment
- Labor force in the mining sector – skills transferable to environmental restoration (Figure 3)
- Available low-cost inputs (material, personnel, resources)
- There are educational institutions in the Highlands with a restoration focus
- The Highlands has high quality natural systems that can be enhanced with restoration of other systems along stream corridors or by decreasing forest fragmentation.

A nominal process was also used to answer this question. The top ranked opportunities identified were:

- Mitigation associated with development in many areas of the Highlands can be used to focus strategic approaches for integrated restoration.
- Restoration & revitalization can occur in the same area.
- Institutional and support framework already exists for integrated restoration.

Challenges and opportunities for integrated restoration have, in part, been identified.

Where should we start?

Economists indicate that the desired attributes of any competitive industry include:

- Integrated within local economy
- Creates desirable jobs
- Develops markets outside the region
- Sustains long-term competitiveness of the area
- Has minimal leakage (e.g., buys supplies locally and uses local labor force)
- Garners a large market share (e.g., exports goods to other areas)
- Results in businesses diversifying by spinning off other businesses.

The attributes desired by a restoration industry reflect most of the same attributes associated with any competitive industry, but also include:

- Reliable markets (demand for services)
- Access to markets
- Access to low-cost inputs
- Trained / trainable labor
- High productivity
- Innovative ideas
- Ability to grow
- Ability to attract the best workers

There are places to start growing an integrated restoration industry throughout the Highlands.

These attributes, along with several others, formed the basis for a statistical analysis to determine which counties in the Highlands had the greatest likelihood of creating and sustaining a restoration industry. The most likely counties were those surrounding Pittsburgh, PA and those on the eastern border of the Highlands in the Philadelphia region. These areas had both the greatest need and the greatest opportunities for integrated restoration.

Conference participants identified three criteria for selecting places to start or initiate a restoration industry in the Highlands, along with some examples:

- Areas where the greatest challenges and opportunities overlap (e.g., funding, AMD, political will, partners, mining such as the Monongahela River Valley Basin)
- Potential for creating an Environmental Restoration Zone through a collaborative relationship with the local community (e.g., Richwood, WV)
- Cost/benefit analyses show integrated restoration is feasible and champions have been identified.

Who is going to make sure it happens throughout the Highlands?

The U.S. Environmental Protection Agency Region 3 is committed to the Highlands Action Program. However, R. Pomponio, EPA Region 3, clearly stated at the Conference that EPA cannot do this alone. It absolutely requires collaborative partnerships with the states of Maryland, Pennsylvania, Virginia, and West Virginia, civil society institutions such as the Canaan Valley Institute, academia, local communities, local governments, other federal agencies, and private businesses. There are roles for everyone interested in improving the quality of life, revitalizing local communities, and improving environmental stewardship.

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	2	0	0	0	2
Masters	1	0	0	0	1
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	3	0	0	0	3

Notable Awards and Achievements

Publications from Prior Projects

- 2003WV11B ("WRI 40 = Aquaculture Waste Control and Optimizing Nutrient Utilization through Diet Composition and Feeding Strategies") - Articles in Refereed Scientific Journals - 1. Two Manuscripts titled "The Impact of Feeding Strategy, Dietary Phosphorus and Varying Protein/Fat Contents on Juvenile Rainbow Trout Performances and Waste Output" and "Comparison of the effects of various sources of zeolites on growth, body composition and waste output in trout rearing systems" are being prepared and the manuscript will be submitted for publication to "Aquaculture" and "Journal of the World Aquaculture Society".
- 2002WV6B ("WRI47-Establishing Biological and Water Quality Criteria for Water Resource Management in Mining Impacted Watersheds") - Conference Proceedings - 1. Petty, J. Todd and J. Barker. 2004 Water quality variability, trace metals, and implications for restoring a mined Appalachian watershed. Proceedings of the American Society of Mining and Reclamation 21:1484-1504
- 2002WV5B ("WRI48-Impact of Longwall Mining on Headwater Streams in Northern West Virginia") - Conference Proceedings - 1. Impacts of longwall mining on the diversity, longevity and functionality of benthic macroinvertebrate communities in central Appalachian headwater streams. Presented at the 51st annual meeting of the North American Benthological Society, Athens, GA.
- 2002WV5B ("WRI48-Impact of Longwall Mining on Headwater Streams in Northern West Virginia") - Other Publications - 2. Longitudinal profiling of headwater streams; pg. 76-94 in Functions of Headwater Stream Systems. Technical information workshop, North American Benthological Society, Athens, GA. Newspaper article: Charleston Gazette Friday, May 10, 2002. "WVU to study stream standards".
- 2002WV6B ("WRI47-Establishing Biological and Water Quality Criteria for Water Resource Management in Mining Impacted Watersheds") - Other Publications - 2. Petty, J. Todd, and J.E. Bark. In preparation. Relationship between stream ecological condition and specific water quality characteristics in a mined Appalachian watershed. To be submitted to: Environmental Management.

6. 2002WV6B ("WRI47-Establishing Biological and Water Quality Criteria for Water Resource Management in Mining Impacted Watersheds") - Other Publications - 3. Newspaper article: Charleston Gazette Friday, May 10, 2002. "WVU to study stream standards".