AN ECONOMIC BENEFIT ANALYSIS FOR ABANDONED MINE DRAINAGE REMEDIATION IN THE WEST BRANCH SUSQUEHANNA RIVER WATERSHED, PENNSYLVANIA

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ABBREVIATIONS

AMD	abandoned mine drainage
AML	abandoned mine land
CVM	contingent valuation method
GIS	geographic information system
LM	Lagrangian Multiplier
NA	not available
O&M	operation and maintenance
OSMRE	Office of Surface Mining, Reclamation and Enforcement
PADCNR	Pennsylvania Department of Conservation and Natural Resources
PADEP	Pennsylvania Department of Environmental Protection
PAFBC	Pennsylvania Fish and Boat Commission
RPC	regional purchase coefficient
SRBC	Susquehanna River Basin Commission
SWI	surface water influence
TMDL	total maximum daily load
TU	Trout Unlimited
USFWS	United States Fish and Wildlife Service
WBSR	West Branch Susquehanna River
WTP	willingness-to-pay

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The photos in this report were provided by Amy Wolfe, Rebecca Dunlap, and Michael Smith. Photo credit for front cover: Rebecca Dunlap.

1. INTRODUCTION

Streams across the West Branch Susquehanna River (WBSR) watershed, which encompasses about 7,000 square miles in central Pennsylvania, are still polluted from abandoned mine drainage (AMD) from old coal mines (Figure 1). Cleaning up these impaired waters will cost millions of dollars, but these expenditures will provide a tremendous boost to the largely rural local economy. This report describes and quantifies the local and statewide economic benefits stemming from remediation of the WBSR watershed.

Green-collar Jobs

Among other economic benefits, remediating AMD in the WBSR watershed will create numerous green-collar jobs, in which local residents design, build, and maintain treatment systems.

Green-collar jobs are "well paid, career track jobs that contribute directly to preserving or enhancing environmental quality."

"Green-collar jobs tend to be local because many involve work transforming and upgrading the immediate built and natural environment."

"Green-collar jobs are in construction, manufacturing, installation, maintenance, agriculture, and many other sectors of the economy."

"…[S]purring the creation of green-collar jobs… means building a sustainable economy, where environmental goals go hand in hand with social and economic goals." (Apollo Alliance and Green For All, 2008, p. 2)

Picture 1: The West Branch Susquehanna River

Photo credit: Amy Wolfe.

The WBSR Task Force plays a leading role in working toward the remediation of the region's AMD. The Task Force is composed of state, federal, and regional agencies, Trout Unlimited (TU), and other conservation and watershed organizations. Soon after its inception in 2004, the Task Force published a state of the watershed report (WBSR Task Force, 2005). The Task Force has also played a key role in the recent AMD remediation strategy (SRBC, 2008) and has provided valuable data for this local economic benefit analysis.

Trout Unlimited's Role

In 1998, TU—a national non-profit organization whose mission is to conserve, protect, and restore North America's trout and salmon fisheries and their watersheds—acknowledged the significance of AMD problems in the Kettle Creek watershed in Clinton County as a component of its nationally renowned Kettle Creek Home Rivers Initiative. In 2004, TU took its AMD remediation work to the next level and launched the West Branch Susquehanna Restoration Initiative, which is aimed at the restoration of coldwater streams and the ultimate recovery of the WBSR.

As the lead nonprofit organization for this initiative, TU is working with numerous local, state, and federal government and non-government partners on a coordinated, strategic, and cost-effective AMD cleanup approach for the entire river basin. TU is also providing organizational support to the West Branch Susquehanna Restoration Coalition, a group that represents the collective efforts of watershed groups, TU chapters, county conservation districts, businesses, and others that are working to address AMD problems throughout the WBSR watershed.

Building upon the initial efforts of the WBSR Task Force, the Susquehanna River Basin Commission (SRBC) predicts a range of costs for remediating the numerous AMD sources in the WBSR watershed (SRBC, 2008). Based on SRBC's recent calculation, full remediation of AMD pollution in the WBSR watershed may require one-time capital investments of between $110 and $453 million, along with annual operation and maintenance (O&M) costs of up to $16 million.[1] The high end of this range could ultimately be reduced if re-mining or reclamation projects are successfully implemented. Savings can also be found if further analysis demonstrates that the watershed can recover without remediating every small pollution source. Additional costs would be incurred to fully restore non-AMD issues at AMLs.

To make the most informed decisions possible, policymakers must consider not just the costs, but also the benefits from making investments to protect and restore watersheds (Schueler, 2000). In fact, assessments of local economic benefits are becoming more common. As detailed in the box below, recent analyses have calculated the local benefits of efforts as large as restoring

[1] SRBC estimates that remediating the 40% of the watershed for which sufficient data are available would require capital construction investments of between $43 and $165 million dollars (SRBC, 2008). Additional communications with SRBC staff clarify that this range is based on the use of passive or active treatment technologies at different sites. Additional site-specific analyses will be required to choose the most appropriate technologies for each site. For the purpose of this report, capital expenditures of between $110 and $453 million are assumed to be required to remediate AMD across the entire watershed. This estimate is broadly consistent with the 2005 estimate from the WBSR Task Force, which suggested a need for capital investments of between $279 and $464 million (WBSR Task Force, 2005). SRBC estimates O&M costs of between $5 and $8 million per year to remediate 40% of the watershed (SRBC, 2008). Based on further communications with SRBC, O&M costs across the entire watershed might total up to $16 million per year, depending on the choice of passive or active technologies at each site. This estimate is somewhat lower than the WBSR Task Force's 2005 estimate of between $22 and $55 million (WBSR Task Force, 2005).

the Great Lakes (Austin et al., 2007a and b), to efforts as small as remediating AMD-impaired watersheds in West Virginia (Schrecongost and Hansen, 2005; Williamson et al., 2007).

The most obvious benefit of AMD remediation to the local community is that funds are pumped into the local economy to design, build, and maintain treatment systems. Many goods and services are provided by local businesses, jobs are created, and these dollars circulate through the economy as workers spend their paychecks on other local goods and services. A restoration economy with "green-collar" jobs is then created in which people work toward environmental restoration that supports local communities over the long term.

Remediation of AMD streams leads to a host of other benefits for local communities and those outside the watershed. Inside the watershed, property values that have been depressed near AMD-impaired streams should rise once remediation is accomplished. Drinking water supply options, now limited or more expensive due to AMD, will expand or become cheaper with cleaner source water. Remediation of polluted streams improves recreational opportunities for local residents and will lead to increased recreational spending by tourists. Finally, remediation improves the aquatic habitat of streams in the watershed, leading to environmental improvements about which many citizens feel passionately.

Economic Benefit Analyses

Economic benefit analyses, like the one performed in this report, have been completed for other watershed improvement efforts, both large and small.

For example, a recent analysis of $26 billion of proposed water pollution control investments in the Great Lakes region estimates a return of more than $50 billion in long-term benefits. These benefits include dollars from tourism, fishing, and recreation; increased property values; and other harder-to-quantify benefits. An additional $30 and $50 billion in short-term multiplier benefits would also be expected (Austin et al., 2007a and b).

At a much smaller scale, an analysis in the Deckers Creek watershed in north-central West Virginia calculates that about $10 million of investments in AMD remediation would generate more than $14 million in economic benefits to local businesses and workers from spending outside funds on remediation projects. Additional annual benefits of more than $2 million per year would be realized through local expenditures by visitors and by increased non-market quality-of-life value (Schrecongost and Hansen, 2005).

In the nearby Cheat watershed, also impaired by AMD, a recent study estimated willingness-to-pay for remediation, and found that properties located near restoration sites would benefit by $1.7 million (Williamson et al., 2007).

Table 1 describes each of these types of local economic benefits, and Sections 3 through 6 provide detailed analyses. Section 7 expands this analysis to estimate the benefits that all Pennsylvania residents—both inside and outside the WBSR watershed—receive from remediating AMD in the WBSR watershed. These benefits are based on a willingness-to-pay (WTP) study and provide a broader estimate that includes portions of those benefits quantified elsewhere, as well as other benefits not quantified in Sections 3 through 6.

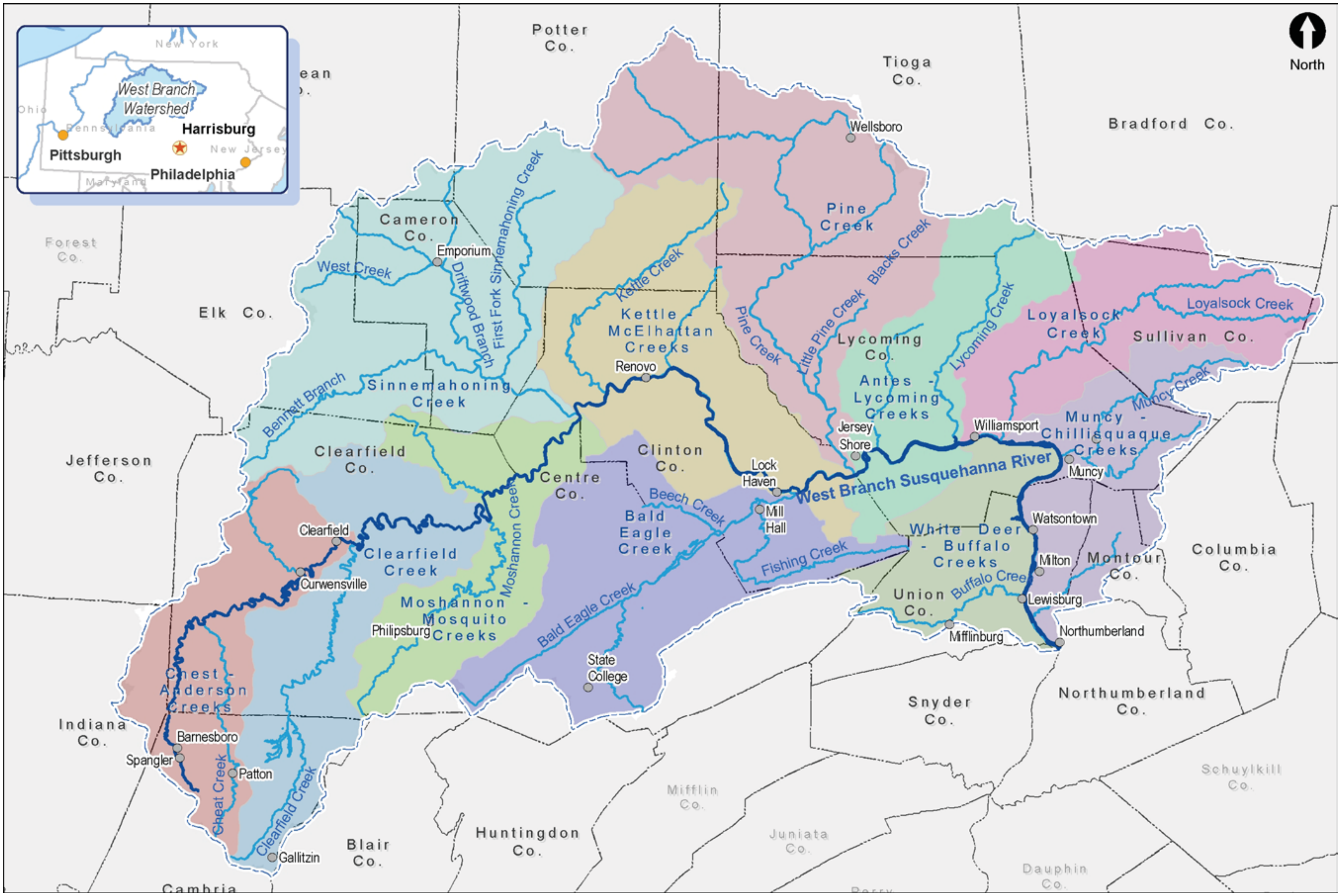
Table 1: Types of local economic benefits addressed in this report

Type of benefit	Description
Money spent locally on remediation	To build remediation projects, money is spent on engineers and contractors, alkaline materials and construction equipment. Local demand for these goods and services stimulates the local economy, strengthening businesses and creating jobs, which in turn become a new source of local purchasing power.
Increased recreation spending	Cleaner streams mean more recreation spending. In the watershed, remediation of AMD-impacted streams will result in increased sport fishing revenues of $22.3 million. Benefits over and above sport fishing revenues are not calculated but would add to this total.
Higher property values	Property values near AMD-impacted streams are depressed and will increase if AMD is remediated. In Clearfield County alone, the total value lost by owners of the 2,734 parcels within 200 feet of AMD-impacted streams is estimated at more than $4 million, for an average of more than $2,500 per acre or almost $1,500 per parcel.
More options for cleaner, cheaper drinking water	Government agencies have already spent more than $11 million in the watershed on waterline extensions to correct private drinking water problems cause by AMD. Clean streams also provide new options for future public water supplies.
Environmental improvement (WTP)	People living within and outside the watershed are willing to pay for environmental improvements. People value clean water for a range of reasons, including those listed in this table and other non-use values such as aesthetics. Pennsylvania residents both inside and outside the watershed are willing to pay $73.6 million for environmental improvements, with a range from $18.1 to $171.4 million.

If funds spent to remediate AMD in the watershed originate largely from outside the watershed—from fees on mined coal or from federal or state taxes, for example—then the local economic benefits are most clearly evident. But even if remediation funds originate within the watershed, several kinds of local economic benefits like those described in this report are realized.

It is only by considering both the costs and benefits that policymakers and local stakeholders can make the most informed choices possible as they consider their priorities and funding options for such a large and comprehensive remediation project.

Figure 1: The West Branch Susquehanna River watershed



2. BACKGROUND

2.1 The West Branch Susquehanna River watershed

While the WBSR watershed includes several developed areas, forests cover about 83% of the land, and agricultural land makes up about 10%. Most abandoned mine lands (AMLs) are found on the remaining 7% of the land, which includes developed and disturbed land (SRBC, 2008).

Public lands are significant. Of the roughly 4.5 million acres in the watershed, more than 1.4 million are in state forests, more than 250,000 are in state game lands, and more than 29,000 are in state parks (SRBC, 2008). The watershed also overlaps considerably with the Pennsylvania Wilds region, the focus of a major push toward ecotourism and outdoor recreation–related economic opportunities in central and north-central Pennsylvania..

AMD impacts the watershed's fisheries. As shown in Figure 2, brook trout populations in some subwatersheds have been depressed or even extirpated. But despite these impacts, trout streams are abundant. Most AMD-impacted streams in the watershed that have been assessed have the potential to support stocked or naturally reproducing trout. In fact, above AMD impacts, most headwaters streams are classified as Class A wild trout fisheries (WBSR Task Force, 2005).

Picture 2: Fishing on Kettle Creek above abandoned mine drainage

Photo credit: Rebecca Dunlap.

Across the watershed, 1,249 miles of Exceptional Value streams receive the highest level of protection from future degradation. High Quality streams include 5,229 miles of Cold Water

Fisheries and 73 miles of Trout-Stocked Fisheries. An additional 3,971 miles of Cold Water Fisheries, 359 miles of Trout-Stocked Fisheries, and 1,208 miles of Warm Water Fisheries are located within the watershed (WBSR Task Force, 2005).

About 2,400 stream miles in the WBSR watershed have been documented to have wild trout reproduction, and the watershed also includes approximately 660 miles of Class A trout streams (SRBC, 2008). According to the Pennsylvania Fish and Boat Commission (PAFBC), these streams support populations of naturally reproducing trout of sufficient size and abundance to support a long-term and rewarding sport fishery. About 250 miles of Wilderness Trout streams are also found in the watershed (SRBC, 2008). Many more undocumented, reproducing wild trout streams may exist, but have not yet been documented (SRBC, 2008).

2.2 Abandoned mine drainage pollution

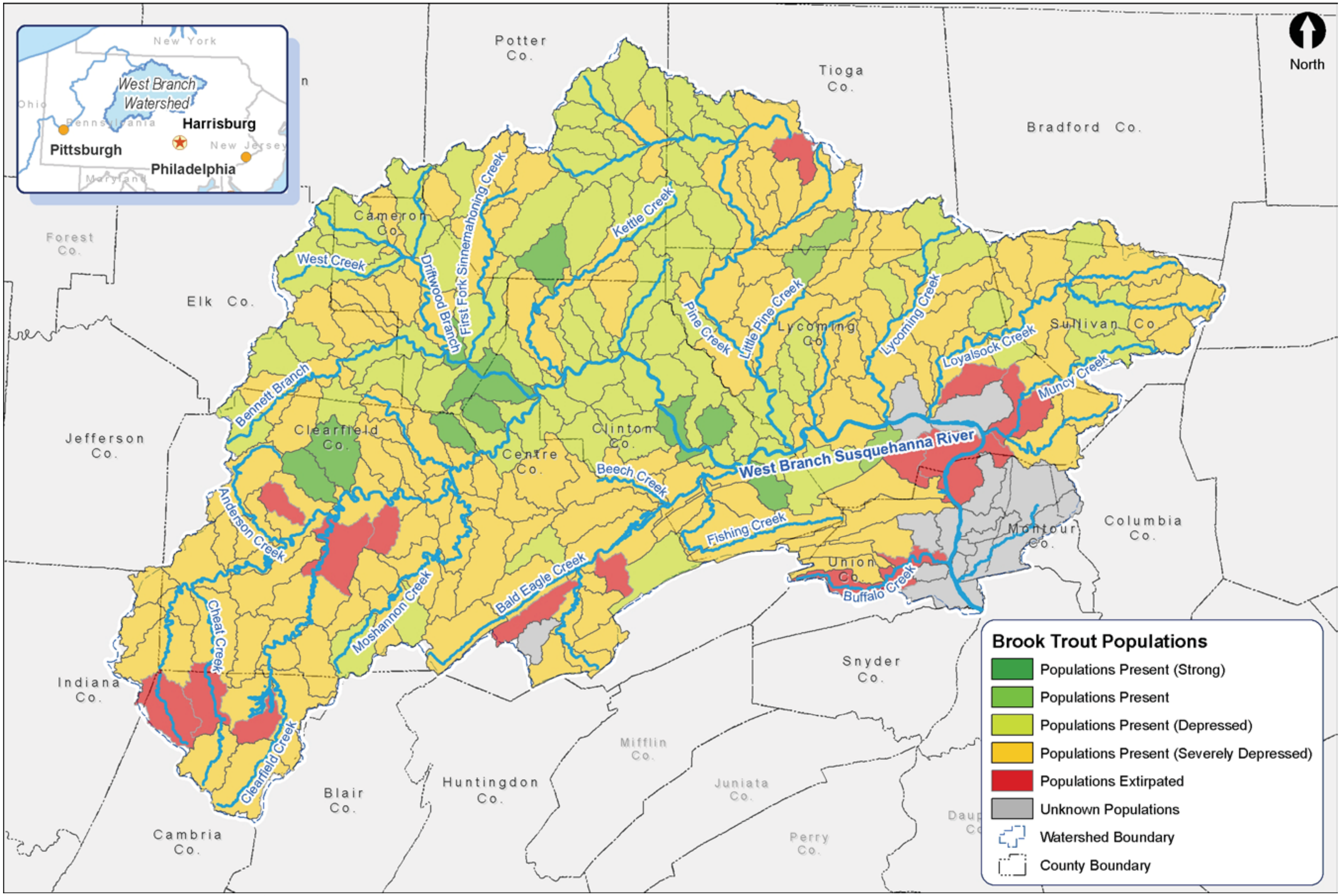
AMD is the number one source of pollution to Pennsylvania's waterways. According to the Pennsylvania Department of Environmental Protection (PADEP), 5,584 stream miles are polluted by AMD across the Commonwealth (PADEP, 2008). More than 20% of Pennsylvania's AMD-polluted streams—1,205 stream miles—lie within the WBSR watershed (SRBC, 2008).According to the WBSR Task Force (2005), physical stream habitat across the watershed is in relatively good condition, and AMD pollution is the most significant cause of water quality impairments.

These impairments are caused by AMLs. The 42,062 acres of un-reclaimed AMLs in the WBSR watershed represent almost 23% of those within the entire Commonwealth (SRBC, 2008).

Funds for remediating AMD from AMLs may come from a variety of sources, including Title IV Abandoned Mine Land Fund allocations to Pennsylvania, the Growing Greener program, and Clean Water Act Section 319 Nonpoint Source grants. Other government programs can also allocate funds toward remediation. Dedicated federal, state, or local government funds may ultimately be needed as well.

Across the WBSR watershed, many AMD remediation projects have been installed, and additional AMD-focused remediation plans have been completed or are in progress, as shown in Table 2. In addition, more than 50 total maximum daily loads (TMDLs) have been approved for AMD-impaired streams in the WBSR watershed, and additional TMDLs are under development (SRBC, 2008).

Figure 2: Brook trout classifications in the West Branch Susquehanna River watershed



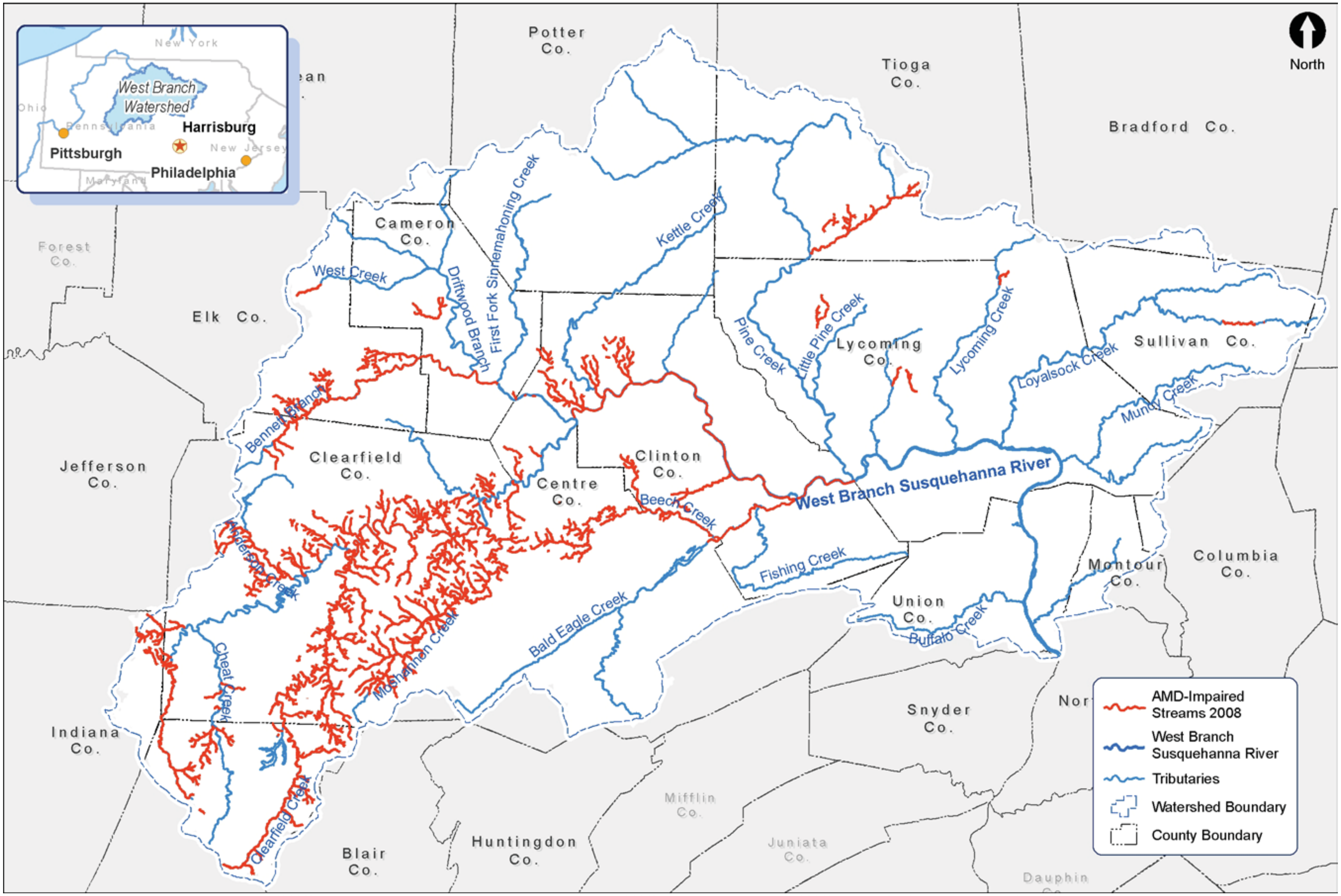
Source: Eastern Brook Trout Joint Venture (Undated).

Picture 3: Moshannon Creek entering the West Branch Susquehanna River

Photo credit: Michael Smith.

Although many remediation projects have already been built across the watershed, a tremendous amount remains to be completed (Figure 3). It is still too early to know which technologies will be used where.

Figure 3: Abandoned mine drainage–impaired streams in the West Branch Susquehanna River watershed



Source: AMD-impaired streams from PADEP (2008) as provided by Pennsylvania Spatial Data Access (2008). According to PADEP (2008), the WBSR from Moshannon Creek downstream has not been assessed; however, data suggest this reach is impaired by pH and metals from AMD.

Table 2: Abandoned mine drainage–focused remediation plans in the West Branch Susquehanna River watershed

Plan	Watershed	County	Year completed	Completed by	Completed for
WBSR Headwaters AMD Assessment and Restoration Plan	WBSR	Cambria	2002	Vapco Engineering	West Branch Susquehanna Rescue
WBSR Headwaters AMD Assessment	WBSR	Cambria	2006	Hedin Environmental	West Branch Susquehanna Rescue
Chest Creek Assessment and Restoration Plan	Chest Creek	Cambria, Clearfield	In progress	Cambria County Cons. Dist.	Chest Creek Watershed Alliance
Bear Run Restoration Plan	WBSR	Indiana, Clearfield	2006	Indiana County Cons. Dist.	Indiana County Cons. Dist.
Clearfield Creek Watershed Assessment Phase I and II	Clearfield Creek	Cambria, Clearfield	2004	Melius and Hockenberry Environmental Services Inc.	Clearfield Creek Watershed Assoc.
Morgan Run Assessment and Restoration Plan	Clearfield Creek	Clearfield	2006	New Miles of Blue Stream	Clearfield Cons. Dist., Morgan Run Watershed Group
Restoration Plan for Little Laurel Run, Cambria County, PA	Clearfield Creek	Cambria	2005	Arthur W. Rose	Clearfield Creek Watershed Assoc.
Anderson Creek Watershed Assessment, Restoration, and Implementation Plan	Anderson Creek	Clearfield	2006	Western Pennsylvania Conservancy	Anderson Creek Watershed Assoc.
Hartshorn Run Assessment	WBSR	Clearfield	In progress	Clearfield County Cons. Dist.	Clearfield County Cons. Dist.
Montgomery Creek 319 Watershed Implementation Plan	WBSR	Clearfield	In progress	Clearfield County Cons. Dist., Montgomery Run	Clearfield County Cons. Dist., Watershed Assoc.
Lick Run Cold Water Assessment and Restoration Plan	WBSR	Clearfield	2005	Allegheny Mountain Chapter of TU	Allegheny Mountain Chapter of TU
Deer Creek Assessment	WBSR	Clearfield	In progress	Clearfield County Cons. Dist.	Clearfield County Cons. Dist., Deer Creek Watershed Assoc.
Moravian Run Assessment	WBSR	Clearfield	In progress	Clearfield County Cons. Dist.	Clearfield County Cons. Dist.
Upper Alder Run Assessment	WBSR	Clearfield	In progress	Alder Run Engineering Inc.	West Branch Sportsman's Association
Hubler Run Implementation Plan	WBSR	Clearfield	2007	Alder Run Engineering Inc.	West Branch Sportsman's Association
Emigh Run Assessment and Restoration Plan	Moshannon Creek	Clearfield	2004	New Miles of Blue Stream	Emigh Run Lakeside Watershed Assoc.
Trout Run Assessment and Restoration Plan	Moshannon Creek	Centre	2006	New Miles of Blue Stream	Moshannon Creek Watershed Coalition
Headwaters of Moshannon Creek Assessment	Moshannon Creek	Clearfield, Centre	In progress	New Miles of Blue Stream	Moshannon Creek Watershed Coalition
Shimel Run Restoration Plan	Moshannon Creek	Centre	In progress	New Miles of Blue Stream	Moshannon Creek Watershed Coalition
Moshannon Creek Water Quality Data Clearinghouse	Moshannon Creek	Clearfield, Centre	2006	New Miles of Blue Stream	Moshannon Creek Watershed Coalition
Moshannon Creek Cold Water Assessment and Restoration Plan	Moshannon Creek	Clearfield, Centre	In progress	Clearfield County Cons. Dist.	Clearfield County Cons. Dist.
Bennett Branch Watershed Assessment and Restoration Plan	Bennett Branch, Sinnemahoning Creek	Clearfield, Elk, Cameron	2003	Gannett Fleming Inc.	Bennett Branch Watershed Assoc.

Table 2: Abandoned mine drainage–focused remediation plans in the West Branch Susquehanna River watershed (continued)

Plan	Watershed	County	Year completed	Completed by	Completed for
Dents Run Watershed Ecosystem Restoration	Bennett Branch, Sinnemahoning Creek	Elk	2001	US Army Corps of Engineers	Bennett Branch Watershed Assoc.
Sterling Run Assessment and Restoration Plan	Driftwood Branch, Sinnemahoning Creek	Cameron	2004	Gannet Fleming Inc.	Cameron County Cons. Dist.
Lower Kettle Creek Restoration Plan	Kettle Creek	Clinton	2000	Hedin Environmental	TU, Kettle Creek Watershed Assoc.
West Side of Lower Kettle Creek AMD Remediation Master Plan	Kettle Creek	Clinton	2007	Hedin Environmental	Kettle Creek Watershed Assoc. & TU
Huling Branch Mine Complex: Investigation of AMD and Recommendations for Remediation	Kettle Creek	Clinton	2004	Hedin Environmental	TU, Kettle Creek Watershed Assoc.
Twomile Run Watershed AMD Remediation Master Plan	Kettle Creek	Clinton	2007	Hedin Environmental	Kettle Creek Watershed Assoc. & TU
Rapid Watershed AMD Assessment for Sandy Run, Woodley Draft, and Stony Run	Drury Run	Clinton	2006	Hedin Environmental	Western PA Coalition for Abandoned Mine Reclamation
Loop Run Restoration Plan	WBSR	Clinton	2004	New Miles of Blue Stream	Rocky Mountain Elk Foundation
Tangascootack Creek Watershed Assessment	WBSR	Clinton	1998	PADEP Moshannon District Mining Office	Clinton County Cons. Dist.
Acid Mine Drainage Restoration Plan for the Beech Creek Watershed	Beech Creek	Clinton, Centre	2006	Hedin Environmental	Beech Creek Watershed Assoc.
Jonathon Run Restoration Plan	Beech Creek	Centre	2003	Hedin Environmental	Beech Creek Watershed Assoc.
Jonathon Run Site Evaluation	Beech Creek	Centre	2006	GAI Consultants	Penn DOT
Contrary Run and Butts Run Assessment	Beech Creek	Centre	2004	Bucek & Associates	Beech Creek Watershed Assoc.
Lycoming Acidification Assessment	Lycoming Creek	Lycoming	2007	Hedin Environmental	Lycoming Creek Watershed Assoc.

Source: Copied from SRBC (2008), Table 2. Plans are listed from upstream to downstream.

3. JOBS AND ECONOMIC ACTIVITY

Local economic benefits from AMD remediation accrue to a community or region in various ways. This analysis estimates the regional economic impacts in terms of local wages, contracts, and purchases that would be generated from the remediation project expenses.[2]

Input-Output Analysis

Input-Output Analysis, like that described in this section, is a means of examining relationships within an economy, both between businesses and between businesses and consumers. It captures money market transactions for consumption in a given time period. The resulting mathematical models allow examination of the effects of change in an economy (Minnesota IMPLAN Group, 2004).

As described in Section 1, site-specific analyses will be required to choose the most appropriate treatment technologies at each site across the watershed; however, one-time capital costs may range between $110 and $453 million and annual O&M expenditures may be up to $16 million. The focus of this section is to calculate the financial benefits to businesses and families in the WBSR watershed and in Pennsylvania, should these expenditures be made.

A computer tool called IMPLAN estimates how expenditures benefit an economy by tracking the way they circulate through the regional economy from the purchase of locally produced inputs and provision of local employment. For example, a dollar spent to remediate AMD circulates in the regional economy approximately 1.5 times—this is called the “multiplier.” The multipliers from this analysis actually range from 1.36 to 1.87, depending on the scenario. Multipliers are higher if the goods and services required to complete the remediation are available locally, and smaller if the goods and services must be brought in from elsewhere to accomplish the work.

More specifically, the IMPLAN model uses real economic data from the study area to estimate how funds spent in various economic sectors are used to purchase additional goods and services and to what degree those purchases are likely to be local. For example, a construction firm may receive a contract to grade and prepare land on a site. Based on business data collected in the central Pennsylvania counties, regional construction firms are expected to spend set portions of those funds to purchase local labor and gasoline, rent equipment, and buy grass seed. Workers on the project then spend portions of their wages locally to purchase daycare, food, and other household items. The expenditures circulate through the local economy in that way until they are eventually used to purchase goods and services from outside the study area (e.g., surveying equipment from Ohio, imported clothes, or a vacation to Las Vegas).

Another way to consider this concept is that for every $1 of external funds spent on local AMD remediation, local economies actually *receive* $1.36 to $1.87 in local economic activity in addition to healthy streams. In other words, the businesses and workers in the watershed not only gain economically from the cleaner, safer environment; they also receive wages and make purchases from regional businesses that amount to more than the remediation expenditures. New treatment systems create direct green-collar jobs to build and maintain the systems, as well as

[2] The estimates in this section represent gross, not net benefits from remediation. The funds for remediation expenditures are assumed to come from outside the watershed; therefore, the corresponding economic losses due to taxation needed to generate these remediation funds are not included in this analysis.

indirect jobs based on the cycled or multiplied spending of wages and the secondary purchase of necessary inputs.

From a local government perspective, that also means that additional tax revenue would be generated from the restoration economy. Each business or worker that receives payment for remediation work will pay taxes as the investment dollars circulate through the local economy from construction firm income, to employee paycheck, to daycare, and so on. This boost in local tax revenue would be a timely and significant boost to county and local governments hoping to build parks, greenways, or other kinds of recreational support networks to help people take advantage of newly restored streams and land.

IMPLAN can also be used to estimate the economic benefits from increased tourism, increased recreation expenditure, and other benefits derived from newly restored environmental amenities (Prato, 2006; Weisskoff, 2000; Minnesota IMPLAN Group, 2004). For the West Branch analysis, these other benefits were estimated with different methodologies and IMPLAN was used only for estimating the benefits from increased restoration expenditures in the study area.

3.1 Methodology

We based this analysis on the range of estimated remediation costs for the entire WBSR watershed, as described above.

IMPLAN was used at two levels. At the watershed scale, IMPLAN estimates a multiplier based on the structure of the economies of the 13 main watershed counties.[3] IMPLAN was used a second time to estimate the benefits to the entire state. Regional purchase coefficients (RPCs)—the percentage of the initial direct demand that is supplied within the modeled region—were based on the model's assumptions.[4] "Regional" is defined by the 13-county watershed area in the first case, and by the state of Pennsylvania in the second case.

For the state-level analysis, the model-derived RPCs are higher, resulting in additional overall benefits to the entire state. This occurs because some materials not likely to be supplied in the WBSR watershed would be found elsewhere in the state, ensuring that more expenditures benefit the state economy.

The cost data and descriptions used in the IMPLAN analysis were based on the SRBC (2008) report and communications with two principal authors of this report (Clark, 2008a and b; Rightnour, 2008a and b). Cost estimates for that report were developed using water quality monitoring data with AMDTreat[5] and the Watershed Restoration Analysis Model.[6]

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[3] Cambria, Cameron, Centre, Clearfield, Clinton, Elk, Indiana, Lycoming, Montour, Potter, Sullivan, Tioga, and Union Counties are included in the watershed-scale IMPLAN analysis.
[4] For each category, IMPLAN assumes that some portion of direct demand would be supplied within or outside of the area of interest.
[5] AMDTreat is a software package that estimates abatement costs for AMD using a variety of passive and chemical treatment types (OSMRE, 2008).
[6] The Watershed Restoration Analysis Model was developed by Water's Edge Hydrology Inc. and was used by SRBC (2008) to simulate active and passive AMD treatment systems and costs in the WBSR watershed.

Picture 4: Examples of active and passive treatment systems

Note: Active system on left shows lime dosers on Porcupine Run in the Bennett Branch watershed. Passive system on right is on Middle Branch in the Kettle Creek watershed. Photo credits: Amy Wolfe.

Specific budgets, estimated with AMDTreat for projects within the study area, were evaluated. Expenditures for the budgets were categorized by percentage in each distinct North American Industry Classification System code. After detailed sectors were combined into the more general sectors used in IMPLAN, the budgets demonstrated overall consistency with the expenditure categories and percentages estimated by Rightnour for active and passive projects (2008a and b). As shown in Table 3, expenditures were ultimately classified into four general sectors: construction, engineering, materials, and remediation.

Table 3: Expenditures by category for active and passive treatment

	Percent of capital costs		Percent of O&M costs	
Category	Passive	Active	Passive	Active
Construction	60%	70%	0%	0%
Engineering	10%	10%	0%	0%
Materials	30%	20%	0%	0%
Remediation	0%	0%	100%	100%
Total	100%	100%	100%	100%

Using these percentages, multipliers were then modeled for capital costs and extrapolated to the watershed estimates as a whole.[7] For annual O&M costs, expenditures were classified into the

[7] The IMPLAN model makes a variety of assumptions that allow percentages to simply be applied to total costs without added distortion to results. These assumptions include: constant returns to scale; no supply constraints; fixed commodity input structure; homogenous sector output; and industry-wide uniform technology assumptions. These assumptions are acceptable in this situation because the total amount of spending actually represents a variety of

single category called "Remediation,"[8] given the suite of activities that will be required. Annual costs will likely grow over time, but assuming they grow no faster than the rate of inflation, the estimated value of annual benefits reported here is expressed in 2008 dollars.

Materials were collectively classified as wholesale trade. While actual materials would include soda ash, lime, mushroom compost, and others, the differences among the multipliers for these items was nominal and the percentages of each that are used vary significantly based on site characteristics. The industry/commodity category in IMPLAN for wholesale trade included a variety of chemicals and input materials like lime and wholesale compost. The RPC or estimate of locally supplied demand for this industry was 50.1%, which reflects Rightnour's (2008b) estimate of the actual trends for supply of project materials.

The IMPLAN model chosen as the appropriate multiplier model for this analysis was the Social Accounting Matrix. These multipliers account for direct effects (government contract to engineering firms), indirect effects (engineering firms' purchases of equipment at retail outlets), and induced effects from labor payments that reflect social security and tax withholding, savings, commuting, and other details.

3.2 Results

The results shown in Table 4 are organized by expenditure type and by study area. Estimates are analyzed separately for the WBSR watershed and for the whole state. Ranges are provided based on the high and low estimates of the capital and annual expenditures required to remediate the WBSR watershed.

Table 4: Multipliers, benefits, wages, and jobs resulting from remediation expenditures

	Multiplier	Benefits (million $)	Wages to labor (million $)	Jobs
To WBSR watershed				
Capital	1.36-1.37	151-616	42-168	1,038-4,120
Annual O&M	1.44-1.45	23	5	152-157
To state				
Capital	1.80-1.85	204-817	77-300	1,531-5,892
Annual O&M	1.87	30	9	185-186

Note: Wages to labor are a share of total local benefits.

These results demonstrate the potential gains in economic activity that would accrue to the regional economy from AMD remediation spending. WBSR businesses and families stand to gain significantly—both directly and indirectly—from remediation efforts. Approximately 70% of direct project purchases can be supplied within the watershed, resulting in strong WBSR watershed multipliers for the project of between 1.36 and 1.45.

smaller projects with similar product/service demand patterns. Therefore it is not likely that the scale of total spending would result in a changed structure or the regional economy.

[8] This IMPLAN remediation category includes 107 types of businesses that include, among other things, mine reclamation services and remediation and clean up of mine sites. Even if O&M is performed by watershed associations, this category is the closest to capturing the pattern of expenditures expected for O&M of AMLs.

Expenditures on annual O&M are expected to permanently create between 152 and 157 new jobs within the watershed counties. This is in addition to the short term boost in employment that would occur from initial capital expenditures: between 1,038 and 4,120 jobs, depending on the treatment scenario. About 60% of these jobs are green-collar jobs because they include the people who design, build, and maintain treatment systems.

The Commonwealth of Pennsylvania stands to gain even more. Nearly 93% of the total direct demand is likely to be supplied with goods and services from within the Commonwealth. Benefits from the low estimate of $110 million in remediation expenditures can conservatively be expected to generate $204 million in economic activity, not including the additional benefits that would accrue from restored streams. Benefits from the high estimate of $453 million in remediation expenditures would generate $817 million in additional spending within the Commonwealth.

In terms of employment, about 185 permanent jobs in Pennsylvania would be created based on the annual O&M expenditures. The initial capital expenditures would generate between 1,531 and 5,892 direct and indirect jobs in Pennsylvania. An estimated 52% of these jobs are likely to be green-collar jobs.

3.3 Summary

When money is spent to design, build, operate, and maintain AMD treatment systems, the local region and the state as a whole stand to benefit. Thousands of jobs are created, wages are paid, goods and services are purchased, and money circulates through the local economy, providing an even greater boost.

Local benefits are greatest when funds come from outside of the watershed and outside of the state (as compared with expenditures paid for with local tax revenues). AML Fund dollars, which fund significant amounts of AMD treatment, are allocated to Pennsylvania from the federal government.

The benefits calculated in this section are in addition to the significant benefits discussed in other sections that result from cleaner streams and drinking water sources and revived fisheries.

4. RECREATIONAL SPENDING

Outdoor recreation is an important pastime and an important source of revenue in the WBSR watershed. AMD negatively impacts opportunities for outdoor recreation and therefore reduces the amount of tourism dollars spent in the watershed. This section discusses the benefits from AMD remediation that will accrue based on increased participation in fishing and other outdoor recreation activities in the WBSR watershed.

4.1 Participation in outdoor recreation

Fishing, hunting, and wildlife viewing are popular recreation activities across the United States. In 2006, 13%, 5%, and 10% of the national population 16 years old and older went fishing, hunting, and wildlife viewing (away-from-home), respectively (USFWS, 2007).

In Pennsylvania alone, almost 1 million people fished in 2006, and more than 1 million people hunted and participated in wildlife viewing away from home (Table 5).

Table 5: Participation in fishing, hunting, and wildlife viewing in Pennsylvania in 2006 (thousands)

	Fishing	Hunting
Residents	824	921
Non-residents	158	107
Total participants	982	1,027

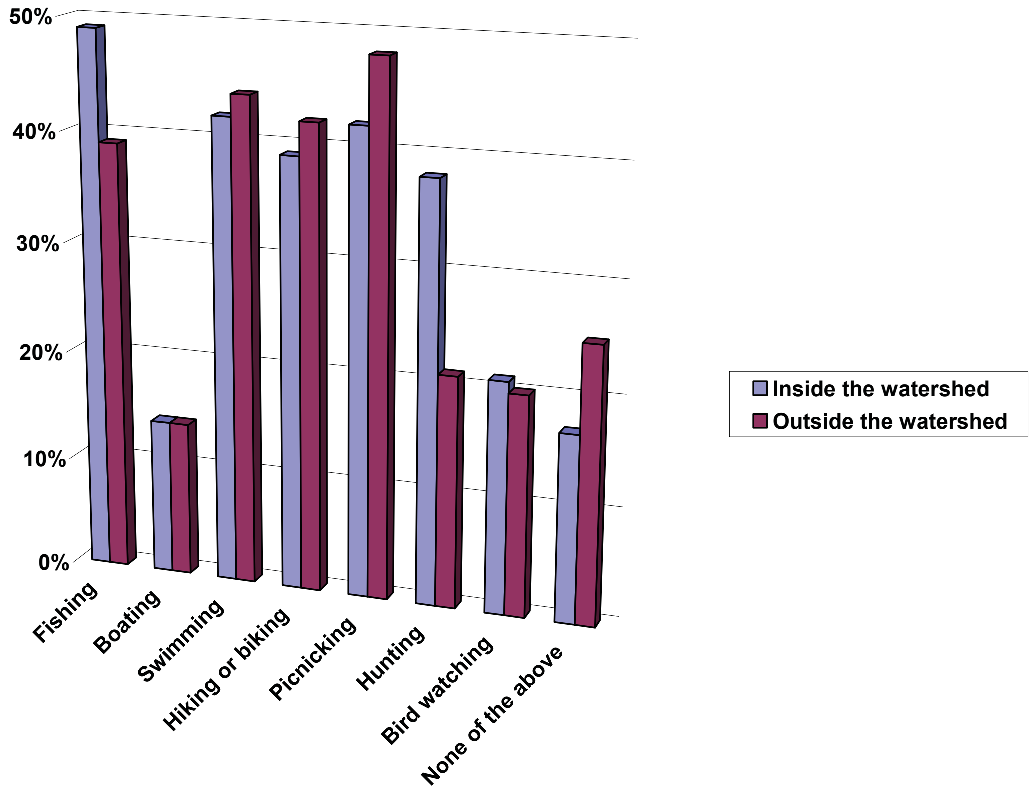
	Wildlife viewing
Around-the-home	3,503
Away-from-home	1,185
Total participants	3,965

Source: USFWS (2007). Includes United States population 16 years old and older.

The USFWS results do not report data for the WBSR watershed; however, the WTP study described in Section 7 included questions about the importance of water quality and outdoor recreation activities undertaken by respondents to a mail survey. Survey responses indicate that many forms of outdoor recreation are important pastimes for Pennsylvania residents both within and outside the WBSR watershed. Of the survey respondents from outside of the watershed, 77% stated that clean water in Pennsylvania's rivers and streams is important to them for water-based recreation, and 85% stated that clean water is important to provide good habitat for fish and wildlife. Inside the watershed, these numbers were very similar: 77% and 86%, respectively.

Further, survey respondents participate in a wide range of outdoor activities, as shown in Figure 4. Survey results also indicate that a large majority of residents in Pennsylvania (about 75% outside the watershed and 82% inside the watershed) participate in some type of outdoor recreation at least once per year.

Figure 4: Percent of respondents who regularly participate in outdoor activities



Source: WTP study conducted for this report. Regular participation is defined in the survey as more than once per year. Boating includes kayaking, canoeing, or rafting. Swimming includes swimming and wading. Hiking, biking, and picnicking is along a river or stream.

Survey respondents were also asked how many visits they had made to the WBSR watershed in the past five years for any of these outdoor recreation activities. As shown in Table 6, people inside the watershed made more trips. A total of 37% of watershed residents took six or more trips for outdoor recreation within the watershed, and 15% of outside-the-watershed respondents did the same.

Table 6: Number of visits to the West Branch Susquehanna River watershed to participate in outdoor recreation

Watershed area	None	1-5	6-20	> 20
Outside	69%	16%	10%	5%
Inside	24%	39%	17%	20%

Source: WTP study conducted for this report. Visits are within the last five years.

Trends suggest that participation in certain outdoor recreation activities is increasing among Pennsylvania residents (Table 7). In fact, recent increases of more than 50% have been recorded for many less traditional outdoor activities such as ice fishing; kayaking; wildlife and bird viewing and photography; road bicycling; horseback riding; snowmobiling; and visiting nature centers, zoos, and nature trails (Fermata, 2005a).

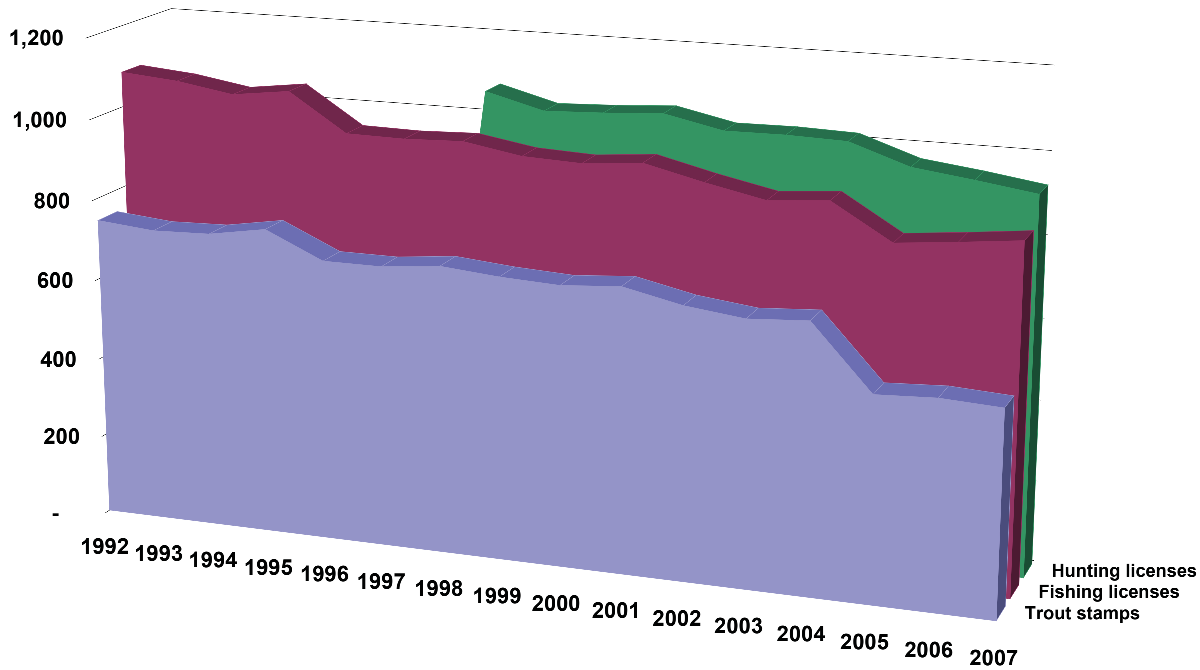
Table 7: Recent trends in participation in outdoor activities in Pennsylvania

	Number of participants in 2004 (thousand)	Trend (1995-2004)
Canoeing	882	39%
Coldwater fishing	1,600	26%
Warmwater fishing	1,832	30%
Ice fishing	175	157%
Kayaking	223	340%
Swimming in streams, lakes, or oceans	3,965	7%
Viewing, identifying, or photographing fish	2,327	133%
Visit other waterside (besides beach)	2,414	6%
Big game hunting	1,212	70%
Small game hunting	824	46%
Migratory bird hunting	155	23%
Viewing, identifying, photographing wildlife	4,828	59%
Viewing, identifying, photographing birds	3,490	53%
Bicycling (mountain)	2,036	NA
Bicycling (road)	3,441	52%
Cross-country skiing	281	-7%
Day hiking	2,869	41%
Driving off-road	1,726	37%
Driving for pleasure	5,458	7%
Hang gliding		NA
Horseback riding	669	52%
Orienteering	233	4%
Sightseeing	5,225	-4%
Sledding	2,181	40%
Snowmobiling	562	68%
Snowshoeing	49	NA
Visit wilderness	2,840	NA
Visit nature center, zoo, nature trail	5,089	1,260%

Source: Fermata, (2005a). Participants are 16 years old and older. NA=Not applicable.

The positive trends for hunting and fishing reported in this survey and summarized in Table 7, however, contradict the declining trends in the sale of hunting and fishing licenses in Pennsylvania (Figure 5). Whether or not hunting and fishing are becoming more popular, participation in other outdoor recreation activities is increasing significantly, signaling a diversification of outdoor activities across the state.

Figure 5: Recent trends in hunting and fishing licenses in Pennsylvania (thousands)



Source: Hunting licenses are total general hunting license sales from Pennsylvania Game Commission (2008). Fishing licenses are total fishing license sales from PAFBC (2008). Trout stamps are trout/salmon stamps from PAFBC (2008).

These increases in outdoor recreation have resulted in higher recreational spending. A study contracted by the Pennsylvania Department of Conservation and Natural Resources (PADCNR) showed that Pennsylvania outdoor recreation travelers' direct spending grew nearly double the rate of Pennsylvania's total traveler direct spending from 1995 through 1997 (PADCNR, 1997).

Picture 5: Kayaking on the West Branch Susquehanna River

Photo credit: Amy Wolfe.

4.2 Pennsylvania Wilds

The Pennsylvania Wilds Initiative, launched by Governor Rendell in 2004, seeks to boost ecotourism and outdoor recreation–based economic opportunities in central and north-central Pennsylvania. The Pennsylvania Wilds region contains a large portion of the state's natural resources: over two million acres of public lands including 29 state parks, eight state forests, eight wild areas, 27 natural areas named for their scenic and ecological value, and 16,000 miles of flowing waters (Pennsylvania Wilds, 2008).

Fermata (2005b) recently completed a strategic recreation plan for PADCNR lands within the Pennsylvania Wilds region. Fermata compiled data on recreational trends in Pennsylvania and the larger market region—including Pennsylvania and the adjacent five states—and projected the participation in key recreational activities in 2015. This plan also proposes five "brands" for PADCNR lands in the Wilds region: WildsDarkSkies, WildsWaters, WildsLife, WildsWays, and WildsWoods. Each of these brands presents an opportunity for developing recreational activities with potential for growth.

More than three-quarters of the WBSR watershed is located within the Pennsylvania Wilds region, as shown in Figure 6, and one-half of the entire Wilds region is located within the WBSR watershed. Due to this significant overlap, development and growth in these outdoor recreation activities in the Wilds will benefit the WBSR watershed. Additionally, as AMD-impaired waters in the watershed are remediated, even greater opportunities will be available in the Wilds region.

Figure 6: The West Branch Susquehanna and Pennsylvania Wilds regions

Source: Pennsylvania Wilds boundary from PADCNR Bureau of Recreation and Conservation (2008).

4.3 Economic impact of outdoor recreation

Not only is outdoor recreation popular in Pennsylvania and in the WBSR watershed; these activities also have a significant economic impact. As shown in Table 8, fishing, hunting, and wildlife viewing in Pennsylvania generated almost $4 billion per year in 2006 in trip-related costs, equipment, and other items.

Table 8: Expenditures on fishing, hunting, and wildlife viewing in Pennsylvania in 2006 (million $)

	Fishing	Hunting	Wildlife viewing	Total
Food and lodging	110	123	180	413
Transportation	102	122	107	331
Other trip costs	76	22	17	115
Subtotal, trip related	*288*	*267*	*304*	859
Activity-related equipment	130	423	407	960
Auxiliary equipment	36	98	29	163
Special equipment	701	NA	NA	701
Subtotal, equipment	*867*	*882*	*791*	2,540
Other items	98	297	176	571
Total	1,252	1,446	1,270	3,968

Source: USFWS (2007). NA=Not available because sample size is too small to report data reliably. Wildlife viewing expenditures are where spending took place.

A previous study conducted by the Center for Rural Pennsylvania (1997) indicates that the total economic impact and value of fishing and hunting in Pennsylvania might be higher than the USFWS figures outlined above. In this study, questionnaires were sent to Pennsylvania hunters and anglers over a 12 month period in 1995 and 1996. Results showed an economic impact of $4.7 billion from fishing alone, plus an additional $4.8 billion from hunting (Table 9). Economic impact is a measure of how much participants spend on equipment, goods, and licenses and how these purchases affect the economy (direct, indirect and induced). Economic impact was calculated using IMPLAN, the same model used in the previous section of this report.

The Center for Rural Pennsylvania study also calculated net economic values of $3.7 billion for fishing and $3.4 billion for hunting in Pennsylvania. Net economic value is the maximum amount that a participant would be willing to pay to participate in the activity, less direct expenses. Economic value was measured using the travel cost method. A different WTP method was used to calculate the value of AMD remediation in the WBSR watershed, and is described in Section 7 of this report.

Table 9: Economic impact and net economic value of fishing and hunting in Pennsylvania (billion $)

	Fishing	Hunting
Economic impact	4.7	4.8
Net economic value	3.7	3.4

Source: Center for Rural Pennsylvania (1997).

4.4 Economic impact of AMD on recreational spending in the WBSR watershed

Clearly, outdoor recreation is a popular and growing pastime, is diversifying, and is an important source of revenue for Pennsylvania, the Wilds region, and the WBSR watershed. AMD can have a large, detrimental impact on outdoor recreation experiences, specifically angling opportunities. In fact, PAFBC (2007) estimates that $22.3 million in sport fishing revenues was lost in the WBSR watershed due to AMD in 2006. As illustrated in Figure 7, these lost values are concentrated in subwatersheds with large numbers of AMD-impaired streams. (See Appendix A for detailed values for specific streams.)

AMD has a direct and negative impact on fishing opportunities. However, the impact of AMD on other forms of outdoor recreation is not as easy to quantify. While it is clear that AMD negatively affects potential wildlife habitat and the aesthetic value of streams and rivers, it is harder to quantify this impact on hunting, wildlife viewing opportunities, or activities such as hiking in AMD-impacted watersheds. The amount of revenue lost annually for all outdoor recreation activities in the WBSR watershed due to AMD is clearly much larger than the $22.3 million projected loss for fishing; however, quantifying this loss is much more complicated and beyond the scope of this report.

4.5 Summary

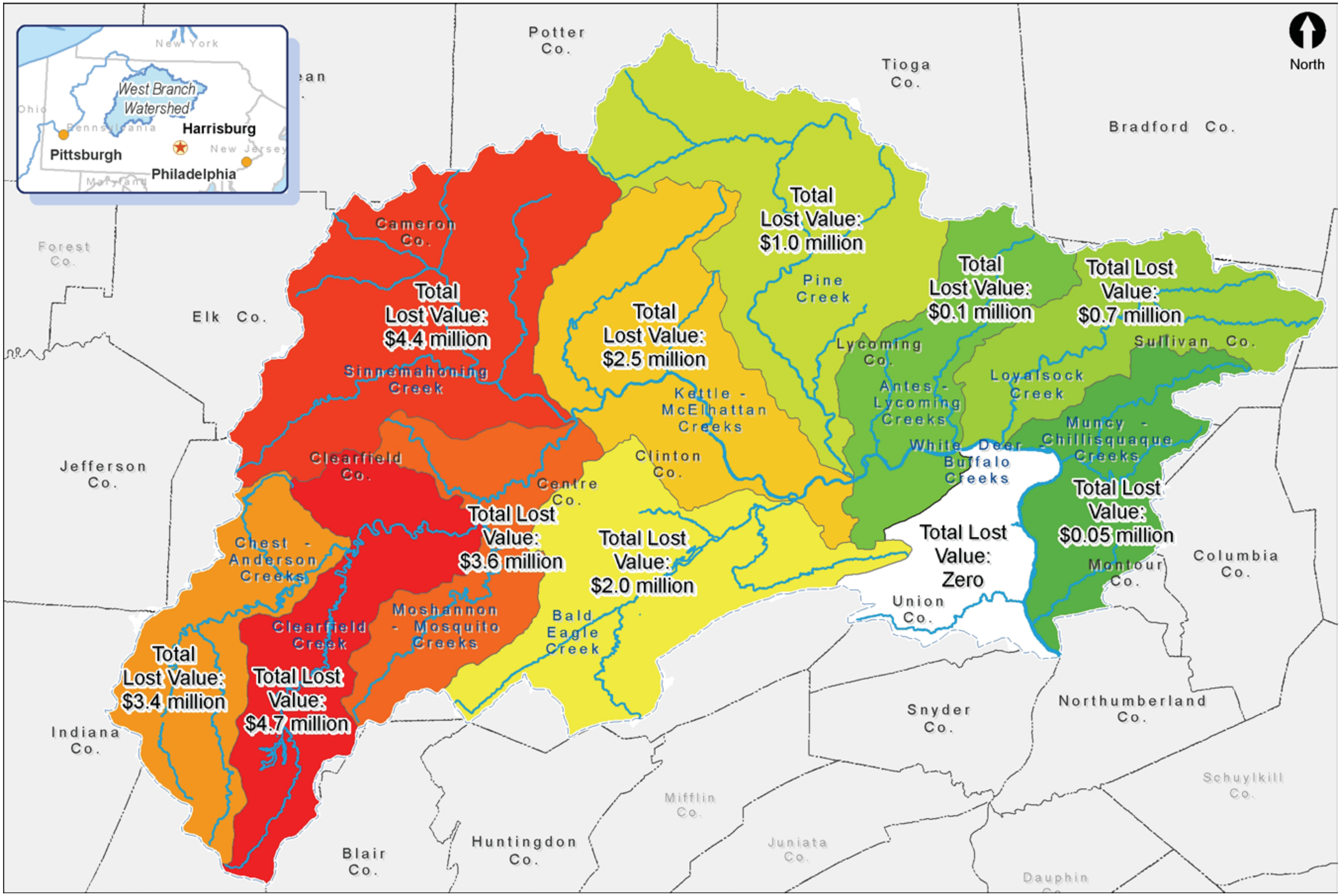
Millions of people participate in outdoor recreation activities in Pennsylvania each year. While traditional activities such as fishing and hunting are still popular and growing, activities are diversifying as participation in kayaking, wildlife and bird viewing and photography, and other activities are increasing rapidly.

While this study does not quantify outdoor recreation rates within the WBSR watershed, the WTP survey discussed in Section 7 indicates that survey respondents use the watershed for recreation, and people who live within the watershed use it more often. Fishing, swimming, hiking, biking, picnicking, and hunting are all popular outdoor activities within the watershed.

To participate in these activities, people spend money on food and lodging, transportation, and equipment. In Pennsylvania, almost $4 billion was spent on fishing, hunting, and wildlife viewing in 2006. Even more money was spent by people engaging in other outdoor activities.

It is beyond the scope of this report to quantify all of the increases in recreation spending across the watershed that could be expected after AMD is successfully remediated. Still, for fishing alone, the watershed could be expected to generate $22.3 million in sport fishing revenues per year with AMD remediation.

Figure 7: Sport fishing revenue lost annually due to abandoned mine drainage in the West Branch Susquehanna River watershed



Source: PAFBC (2007). See detailed figures in Appendix A. The lost value for the Pine Creek watershed includes figures for Babb Creek and other nearby waters that are no longer significantly impaired due to successful AMD remediation.

5. PROPERTY VALUES

> **Hedonic Property Price Analysis**
>
> Unlike marketed goods, environmental quality is typically not bought and sold in observable markets. Therefore, values for these non-market goods must be estimated through other techniques. One such technique is referred to as hedonic estimation or hedonic property price analysis.
>
> This method assumes that when consumers purchase some observable good such as a house, they are implicitly also paying for the attributes associated with this good. Attributes might include the size, location, schools, neighborhood, and environmental quality. By analyzing the price of the house and the levels of its attributes, we can extract the contribution of each attribute—including environmental quality—to the price of the entire market good.

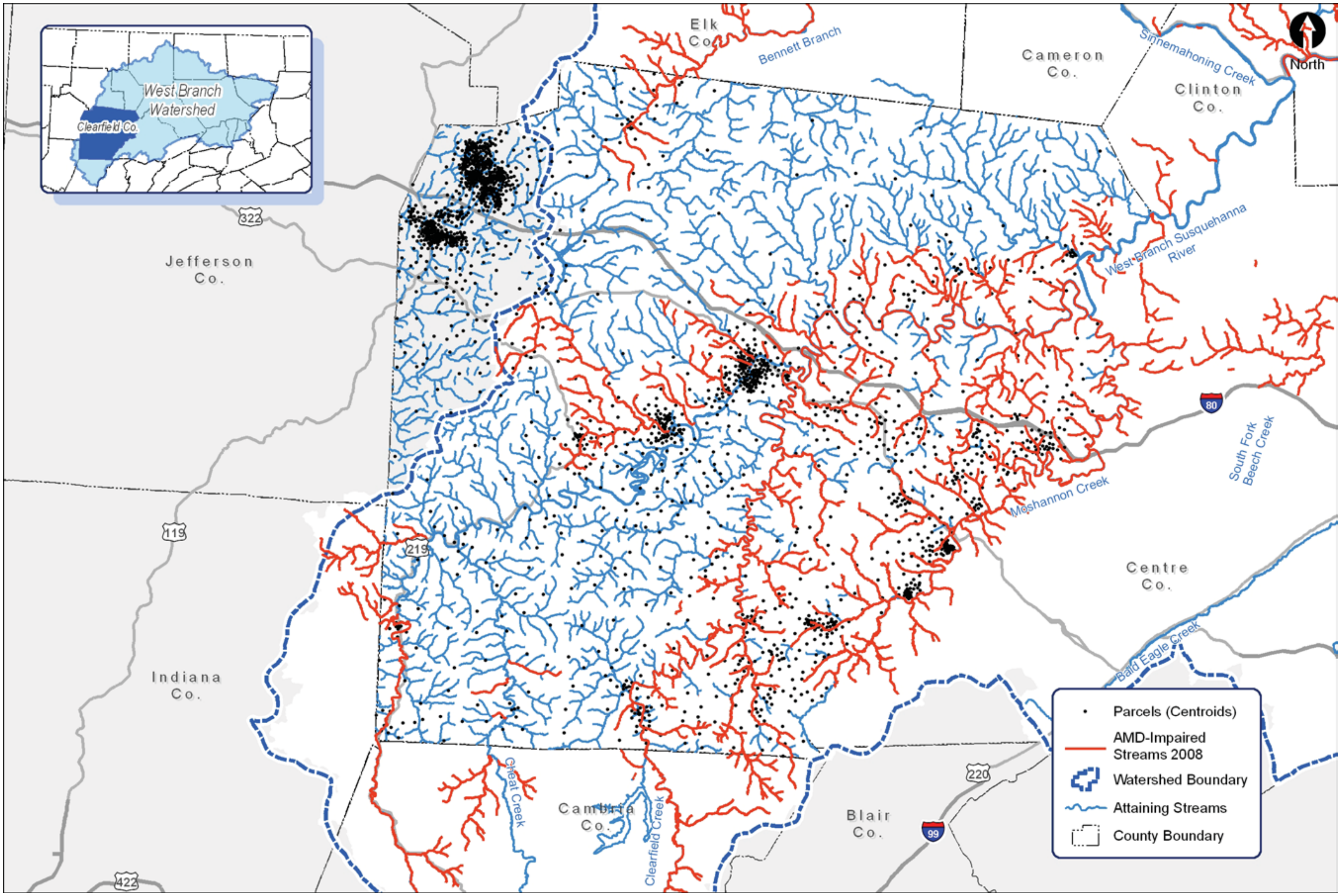
In this section, we focus on the economic impact that AMD-impaired streams have on residential property prices. AMD lends itself particularly well to property value analysis because its effects are often very noticeable in contaminated streams. Aesthetic impacts of AMD include discoloration of the water and stream bed from the precipitation of metals, and the loss of aquatic life due to acid and metals. Streams severely affected by AMD tend to be significantly discolored and often support little to no aquatic life.

This section uses a hedonic property price analysis to estimate the impacts of AMD on residential property prices in Clearfield County, Pennsylvania. The analysis includes market residential sales data collected from 2002 through 2006, along with a geographic information system (GIS) database of environmental characteristics of each study parcel. Results show that a significant relationship does exist between property price and distance from AMD-impacted streams. These results imply that remediation of affected streams will create a benefit of improved property values to the owners of residential properties located within 200 feet of AMD streams.

5.1 Study area

Clearfield County is situated in the center of the state (Figure 8), and is almost completely within the WBSR watershed. This rural county's population of around 82,000 resides primarily in several towns and small scattered rural areas. The largest city, DuBois, has a population of around 8,000, and is located outside of the WBSR watershed (US Census Bureau, 2000). The county boasts branches of two state universities, a new industrial park, and a large retail distribution center (Clearfield County, 2008). Household incomes, however, are lower than the national average—four municipalities within the county are classified as persistent poverty municipalities by the Census Bureau—and out-migration is depleting the county's intellectual base (US Census Bureau, 2000; The Center for Rural Pennsylvania, 2005). Furthermore, historic booms and busts of the coal and timber industries have left their marks on the landscape through logging roads and mine-scarred lands (The Center for Rural Pennsylvania, 2003).

Figure 8: Clearfield County abandoned mine drainage–impaired streams and parcels



Source: AMD-impaired streams from PADEP (2008) as provided by Pennsylvania Spatial Data Access (2008).

Clearfield County is ideal for a hedonic analysis of AMD impacts. Most of the county lies within the WBSR watershed, and stream quality is quite variable across the county. This allows us to examine property prices near AMD-impaired and unimpaired streams. Clearfield County also contains a large quantity of privately-owned residential parcels. Compared with other counties in the WBSR watershed, relatively little land is in public ownership. Also, parcel-level transaction, tax, and GIS data are available for the entire county, allowing us to efficiently obtain property assessments and calculate detailed numbers for parcels' environmental characteristics.

5.2 Data and methods

The empirical model developed in this study is based on cross-sectional data that includes 1,577 arms'-length transactions[9] of residential properties that took place between January 2002 and December 2006. These parcels are shown as black dots in Figure 8. This information was obtained from the Clearfield County Assessment Office and included the GIS shapefile for parcels in the entire county, assessed values for the land and structures on properties, lot sizes, and land use classifications. Residential properties, as defined by the land use classification, do not exceed 10 acres in area and potentially contain a housing structure.[10]

Landscape attributes of parcels in Clearfield County come from several sources of GIS data. A Digital Elevation Map was used to derive slope, and polygon shapefiles of designated populated places and urban areas were obtained from the United States Census Bureau. Vector layers of streams—including the variable of interest, AMD-affected streams—and major roads in the county were obtained from PADEP.

The value of a residential property is assumed to be affected by both its location and its structure. Most hedonic price models include both locational and structural variables as independent variables to separate out locational impacts from the values of the structures. However, structural data such as square footage and number of rooms were not available in this dataset. Therefore, the dependent variable in the analysis, land price per acre, is calculated by subtracting the assessed value of the structure from the total sale price of the parcel and dividing by the acreage, presumably resulting in the residual land price per acre.

The model characterizes eight variables' roles in the per-acre sale prices of residential parcels. As shown in Table 10, these variables include lot size, perimeter, value of improvements, location within an urban area, location on unsuitable soil, presence of a stream within 200 feet, distance from nearest AMD-impacted stream, and an interaction term of stream presence and distance to an AMD-impacted stream. An additional variable—the location within a floodplain—was found not to affect property values in this dataset and was not included in the model.

Tables 10 and 11 provide descriptions and summary statistics of all variables; Appendix B describes the details of the statistical model and results. The variable coefficients derived from

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[9] Arms' length transactions are those entered into by unrelated parties, each acting in their own best interest. It is assumed that in this type of transaction, the prices paid are the fair market values of the properties being transferred in the transaction.
[10] Parcels are assumed to contain a house if the market value of improvements is greater than or equal to $5,000.

the statistical model are applied to the set of all affected residential parcels in Clearfield County to estimate the aggregate impact of AMD proximity on property values.

Table 10: Variables used in the property value model

Variable name	Description
Dependent variable	
PPACRE	Land price per acre, in 2006 dollars
Independent variables	
LOT_SIZE	Area of parcel, in acres
PERIMETER	Perimeter of property, in feet
STRUCT_VALUE	Market value of structural improvements on the property, in dollars
INURBAN (0,1)	Parcel located within boundaries of US Census urban area
BAD_SOIL (0,1)	Parcel is located on soil classified as "very limited" for dwellings with basements (includes slope)
STREAM_200FT (0,1)	Stream within 200 feet of property.
AMD_DISTANCE	Distance in feet from nearest AMD-impaired stream (305(b) impairment source)
STR200XAMD	Interaction term (STREAM_200FT * AMD_DISTANCE); distance to nearest AMD stream for those parcels located within 200 feet of any stream

Table 11: Summary statistics for the property value model dataset

Variable Name	Average	Median	Maximum	Minimum
PPACRE	87,798	51,116	1,346,409	479
LOT_SIZE	1.03	0.42	9.90	0.04
PERIMETER	820	585	11,280	165
STRUCT_VALUE	58,327	45,314	313,775	5,053
AMD_DISTANCE	3,243	1,901	27,103	0

5.3 Results of the statistical model

The per-acre land price increases as parcels are situated farther away from an AMD-impacted stream. Analysis of model predictions indicates that the zone of influence on property values extends to about 200 feet from the center of the stream. This zone may be based on sight distance, implying that visual quality may be the characteristic of AMD streams that causes loss in property value. AMD has little impact on property value beyond 200 feet.

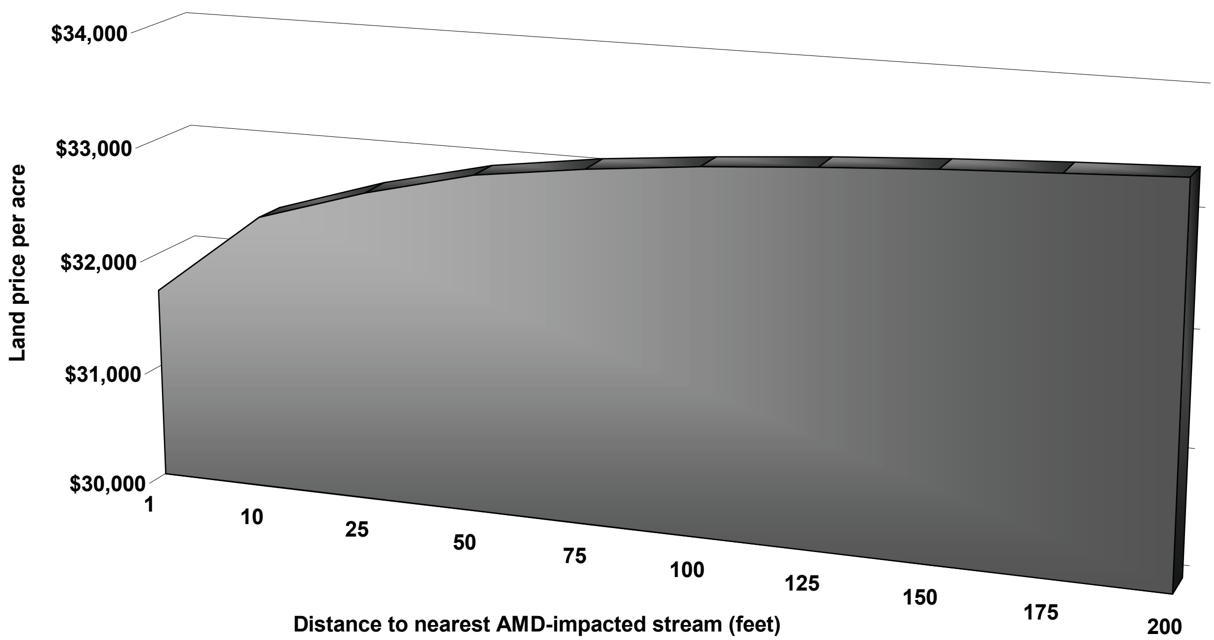
As shown in Figure 9, a representative one-quarter acre parcel with a $50,000 house on good soil outside urban boundaries decreases in property value from $33,395 to $31,672 per acre as it is moved closer to an AMD-impacted stream. Figure 10 quantifies the lost value at various distances from the stream. According to the model, this property would lose over 5% of its value if it were moved from the outer edge of the zone of influence—200 feet from the stream—to a location immediately adjacent to the stream.[11]

Picture 6: Homes near Mill Run in Clearfield County

Photo credit: Amy Wolfe.

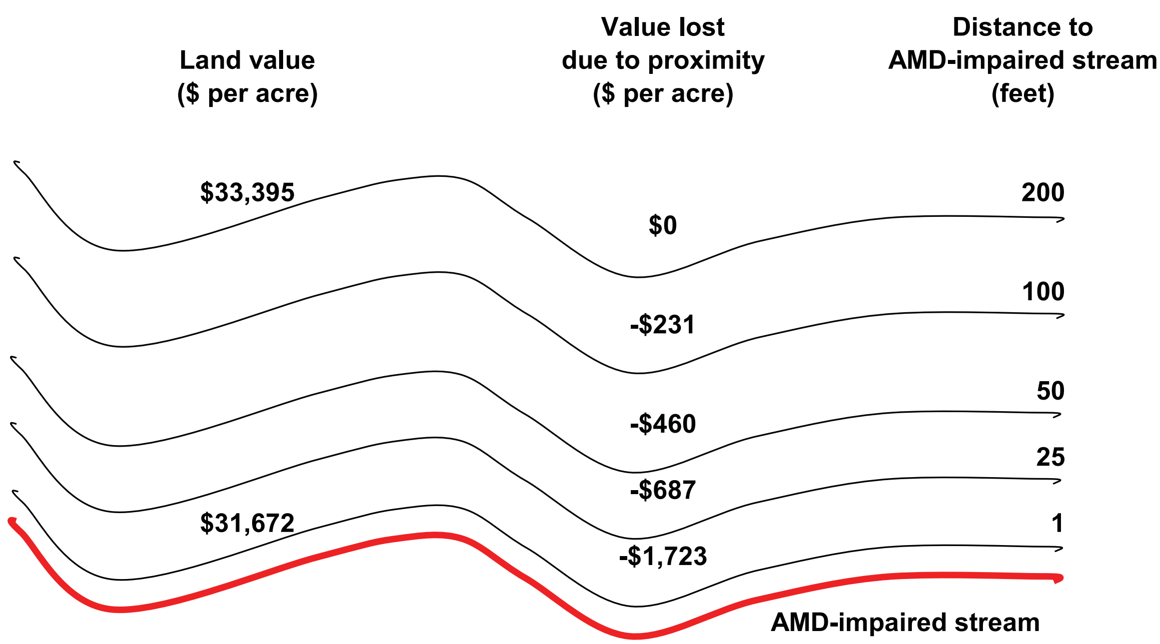
[11] Note that the distance referred to here is not the distance from the house to the stream, but rather the distance from the edge of the parcel to the AMD-impacted stream.

Figure 9: Land value changes near an abandoned mine drainage–impacted stream



Source: Hedonic property price analysis conducted for this study. Figures are based on a one-quarter acre residential parcel with a $50,000 house, situated on good soil outside urban boundaries. Values are in 2006 dollars, adjusted by the Consumer Price Index.

Figure 10: Lost land value near an abandoned mine drainage–impacted stream



Source: Hedonic property price analysis conducted for this study. Figures are based on a one-quarter acre residential parcel with a $50,000 house, situated on good soil outside urban boundaries. Values are in 2006 dollars, adjusted by the Consumer Price Index.

5.4 Aggregate impact of abandoned mine drainage on property value

The next step in the analysis is to apply the results from the property value model to all affected developed parcels in Clearfield County. The reduction in property value for each parcel due to AMD-impacted streams is estimated as the difference between the parcel's actual value based on its distance from an AMD-impacted stream, compared with a projected parcel value located 200 feet from an AMD-impacted stream. When AMD remediation is completed, the residential property values along AMD-impacted streams are projected to rise to this projected parcel value at 200 feet.

The total value lost by owners of the 2,734 parcels situated within the 200-foot zone of influence is $4,077,682, for an average of $2,587 per acre or $1,491 per parcel. Ninety-four percent of that loss ($3.8 million) is experienced by homeowners with parcels within 50 feet AMD-impacted streams. The location of parcels within floodplains was found not to affect property values.

These numbers suggest that there is a positive WTP to live farther away from AMD-impacted streams. For homeowners situated within the zone of influence, AMD remediation projects could provide significant property value improvement. For Clearfield County as a whole, AMD remediation could, by way of property value increases, expand the tax base of the county.

5.5 Summary

Streams polluted by AMD markedly reduce property values of nearby landowners in Clearfield County, particularly those situated within 50 feet of affected streams. This study reports a property value loss of over $4 million for the owners of 2,734 single-family residences on parcels located within 200 feet of AMD-impacted streams. While this study focused only on Clearfield County, similar losses can be expected for property owners located near other AMD-impacted streams throughout the WBSR watershed. This analysis documents property value losses from proximity to AMD; however, these losses could be converted to property value gains if AMD is remediated.

6. DRINKING WATER

AMD pollution affects the availability of clean, affordable drinking water. As described in this section, both public and private drinking water sources in the WBSR watershed have been impacted by AMD. In addition, new industries and large water users may avoid areas in which clean water supplies are not available. While difficult to quantify, AMD remediation is likely to open up cheaper options for future public water supplies and to prevent the need for future waterline extensions.

6.1 Impacts on public water supplies

The impact of AMD on public water supplies was researched by conducting interviews of drinking water treatment facility operators within the WBSR watershed. To locate appropriate operators for interviews, a public database of Pennsylvania drinking water systems was queried (PADEP, 2007).[12] Information about all active public water systems was collected; each active system included one or more types of withdrawals.[13] Locations of each withdrawal were then plotted using the provided latitude and longitude using GIS. Only those withdrawals within the boundaries of the WBSR watershed were included in the analysis. As shown in Table 12, active public water systems withdraw from more than 1,000 locations across the watershed.

Table 12: Withdrawals by active public water systems in the West Branch Susquehanna River watershed

Type of system	Permanent	Reserve	Emergency	Seasonal	Interim	Total
Surface	62	6	3	1	0	72
Ground	780	51	17	0	3	851
Ground under SWI	48	10	3	9	0	70
Purchased surface	10	0	1	0	0	11
Purchased ground	9	4	1	0	0	14
Total	909	71	25	10	3	1,018

Source: PADEP (2007). SWI=surface water influence.

This database was further refined to include only those permanent withdrawals that were not abandoned. These 747 withdrawals are categorized below in Table 13. A map of these withdrawals was then overlaid onto streams in the WBSR watershed. Streams were characterized as AMD-impaired or non-AMD-impaired, to determine which permanent, non-abandoned public water withdrawals are most likely to be impacted by AMD.

12 The following 13 counties were included: Cambria, Cameron, Centre, Clearfield, Clinton, Elk, Lycoming, Montour, Northumberland, Potter, Sullivan, Tioga, and Union.

13 Some active *systems* included abandoned *withdrawals.*

Table 13: Permanent, not abandoned withdrawals by active public water systems in the West Branch Susquehanna River watershed

Type of System	Number
Surface	51
Ground	639
Ground under SWI	45
Purchased surface	7
Purchased ground	5
Total	747

Source: PADEP (2007). SWI=surface water influence.

Of the 51 surface water withdrawals, we then chose eight located on or very close to AMD-impaired streams. These eight systems were targeted for interviews.

In addition, we identified systems with groundwater withdrawals near AMD-impacted streams and near non-AMD-impacted streams, as well as surface water withdrawals on non-AMD impaired streams. These systems were chosen at random; however, priority was given to municipalities with multiple withdrawals in order to maximize the amount of information attained during the interview process.

Individual systems typically withdraw water from multiple sources. A total of 16 systems with 56 sources were targeted for interviews (Table 14). These sources included abandoned, permanent, and reserve sources, as we wanted to gain information on past, present, and potential future withdrawals.

Table 14: Public drinking water sources targeted for interviews

	Surface	Ground	Total
On or near AMD-impacted streams	8	13	21
On or near non-AMD-impacted streams	9	9	18
Reserve	5	6	11
Abandoned	0	6	6
Total	22	34	56

Introductory letters were sent to all 16 systems. We then called and made appointments for phone interviews. Interviews were conducted with a total of nine of the 16 targeted systems in November 2007. These included all eight systems we believed to be withdrawing surface water from AMD-impacted streams, plus one system with only groundwater withdrawals near AMD-impacted streams. These nine systems had a total of 36 water sources. The systems we spoke with and their corresponding withdrawal sources have been assigned letters A through I to preserve confidentiality. The sources used by these nine systems are listed in Table 15 and have been updated from the original database using information gathered in the interviews.

Table 15: Types of sources and volume withdrawn for the systems that participated in drinking water interviews

System	Source	Type	Volume withdrawn (million gallons/ year)	AMD impacted?	Other pollutants?	Notes
A	A1	Ground SWI	2.6	No	No	This source will not be available soon, system looking at options
A	A2	Ground SWI	Abandoned	NA	NA	
B	B1	Ground SWI	4	No	Yes	Variable pH from acid precipitation, going offline soon
B	B2	Ground	0	Yes	No	Will be online in near future, treatment costs will go up
B	B3	Ground	Reserve	No	Unknown	
C	C1	Ground	9.2	No	Yes	High iron and manganese due to rock formations
C	C2	Ground SWI	21	No	No	High alkalinity and hardness
C	C3	Ground	Reserve	No	Unknown	
C	C4	Ground	Abandoned	NA	NA	Too shallow
D	D1	Surface	118	No	No	
D	D2	Ground	136	No	No	
D	D3	Ground	75	No	Yes	High iron due to rock formation, increased treatment costs
D	D4	Surface	Reserve	Yes	No	Do not use due to AMD
D	D5	Ground	113	No	No	
D	D6	Surface	0	NA	NA	
D	D7	Surface	Reserve	Yes	No	Do not use due to AMD and water restrictions on creek
E	E1	Surface	272	No	No	
E	E2	Surface	2	No	No	
E	E3	Ground	5	No	No	
E	E4	Ground	Abandoned	NA	NA	
E	E5	Surface	Reserve	Yes	No	Do not use due to AMD
E	E6	Ground	Abandoned	NA	NA	
F	F1	Ground	Abandoned	NA	NA	
F	F2	Surface	219	No	Yes	Acidic due to rock formations
F	F3	Surface	Emergency	Yes	No	Do not use due to AMD, becoming more complicated due to drought conditions
G	G1	Surface	Unknown	Yes	No	Drinking water portion of withdrawal is minuscule compared to total withdrawals
H	H1	Surface	25.6	Yes	No	Tributaries here are orange, but WBSR is not
H	H2	Surface	6.4	Yes	No	Increased treatment requirements and costs
H	H3	Ground	Abandoned	NA	NA	
H	H4	Surface	Reserve	Yes	No	
H	H5	Surface	Reserve	Unknown	Unknown	
I	I1	Ground	13	No	No	
I	I2	Ground	12	No	No	
I	I3	Ground	11.5	No	No	
I	I4	Ground	10	No	No	
I	I5	Ground	15.5	No	No	

Note: Sources with reported AMD impacts are highlighted gray. NA=Not applicable.

6.1.1 Systems now affected by AMD

Of these nine systems, only Systems G and H are actively withdrawing surface water from AMD-impacted streams. System G is described below in Section 6.1.3 because it is not using its water primarily for drinking water.

System H explained that due to the high iron and manganese levels in their surface water, they need to use more potassium permanganate and coagulant to oxidize and then settle out the metals. This increase in oxidants and coagulants along with sludge removal (about 2-3,000 gallons/year) increases treatment costs, especially in the summer when manganese concentrations are higher due to lower flows. System H also explained that they have less water for consumption because they have to backwash their system more frequently due to the build-up of metals on their filters. This reduces the capacity of their plant and increases their costs.

6.1.2 Systems likely to be affected in the future by AMD

System B will be withdrawing water from AMD-impacted groundwater in the near future, and Systems D, E, and F have reserve or emergency surface water sources that are impacted by AMD. These systems do not currently withdraw from these sources due to the severity of the AMD impairment and associated increases in treatment costs. According to the interviews, these three systems will most likely need to withdraw from these AMD-impaired sources in the future due to drought conditions, failing or contaminated wells, or population expansion.

System B is a small system currently withdrawing from a spring with generally good water quality. This spring's variable pH levels can be low due to acid precipitation, and the spring was recently condemned by PADEP because it is technically a surface water source. System B cannot afford the treatment facility required for treating surface water; therefore, they are being forced to move to a groundwater source that is impacted by AMD. This will raise their annual costs due to an increase in potassium permanganate use, more frequent backwashing, and increased operator hours. They estimate that operator hours will increase from one to six hours and that electricity will increase from $10 to $100 per month. The operator of the system stated that streams in their area are heavily impacted by AMD and that the quality of their surface water is limiting drinking water operations. He also explained that the initial purchase cost for developing a treatment system for surface water withdrawals is high, but in the long run, it is cheaper if the streams are clean. He felt that his system could greatly benefit from AMD remediation in the area.

System D currently has a groundwater source with high levels of iron due to the rock formations from which they withdraw. This operator also stated that this increases their treatment costs due to an increase in the chemicals needed to remove the iron. Due to drought conditions and population expansion, this system is exploring options for withdrawing from their reserve sources. Two of these sources are heavily impacted by AMD. The operator explained that treatment costs would go up to remove the metals from the AMD for these sources, but he could not estimate the cost. Similar to System B, he did state that it is more cost-effective to use surface water to save on electricity costs, but that there are more strict treatment requirements for surface water withdrawals compared with groundwater.

System E also has a reserve surface water source impacted by AMD; however, this system currently has enough clean water to withdraw that they are not looking to use their reserves in the immediate future. This operator did state that there would be increased requirements and costs for treating AMD-impacted water, but that he did not have an estimate for that increase. He is concerned about AMD, iron, and sulfur in the area's waters, but he does not believe that AMD problems are currently impacting expansion plans for his system.

System F is currently withdrawing from a reservoir that is slightly acidic due to the area's rock formations. However, due to current drought conditions, the system is being forced to consider withdrawing from a reserve surface water source heavily impacted by AMD in the near future. The operator stated that this source has a pH of about 5 on a good day, and between 3 and 3.5 on a bad day. He also explained that it is high in iron and manganese. In order to use this source, his system will need to use more potassium permanganate and chlorine, increase their electricity use, and remove more sludge. He estimates that his treatment cost will rise by approximately one-half, from $2.10 per 1,000 gallons to $3.10 per 1,000 gallons. The operator adamantly believes that if AMD were cleaned up, his treatment requirements and costs would be reduced and that AMD is reducing the possibility of his system expanding, especially in times of drought. He further explained that his system tried using wells in the early 1980s and 1990s, but that the elevation was too high. Therefore, they are forced to use surface water sources and he strongly believes that AMD has a big influence on water quality and drinking water treatment costs in his area.

6.1.3 Other systems

System A is a small system in quite a predicament. They currently withdraw out of a deep mine with excellent water quality through a gravity system. However, due to current drought conditions, fire trucks have brought in water for the last month-and-a-half to supplement their water supply. To further complicate issues, a coal company wants to open a strip mine which will take away this water source. The operator claims that they need an entirely new distribution system, and they are currently exploring options for the future. The options include paying for drinking water from a neighboring system approximately three miles away, getting a new water system, and using nearby streams. However, the operator explained that although nearby surface water sources have more than enough water for the whole town, they cannot afford to treat them because they are heavily impacted by AMD. He was very much aware of the increased treatment requirements and costs for using surface water impacted by AMD. He also stated that a PADEP engineer estimated it would cost about $35,000 per year to treat the iron and manganese from a nearby surface water source.

System C withdraws groundwater only and is located near the headwaters of the WBSR watershed. They deal with high iron and manganese levels from one of their sources; however, this is due to the rock formations from which they withdraw. The treatment requirements for this water are similar to that for AMD-impacted waters in that they must increase the amount of oxidants and coagulants used, increase the backwash rates, and increase ozone rates. The operator explained that an AMD-impaired stream runs through town, but that there is not enough water in the stream to use it as a surface water withdrawal. He further explained that because they are located in the headwaters, AMD is not much of an issue, but that it may be a problem further downstream in the watershed.

System G withdraws directly from the WBSR. The person we spoke with stated that the river here is impacted by AMD. While the mainstem is not orange, several nearby tributaries are. She explained that the amount of water they withdraw for drinking water is miniscule compared to the amount they withdraw for industrial purposes. The water is treated before use at the facility, and is therefore treated for consumption, but she could not separate the two and was not aware of different treatment requirements for treating clean water versus AMD-impacted water.

System I uses five groundwater sources of excellent quality. The only issue they deal with is the hardness of their water. They disinfect with chlorine and use a softener. The operator explained that the streams in their area are impacted by AMD, but that their flows are too small to be used as drinking water withdrawals, especially with the current drought conditions. In fact, he stated that three of his groundwater sources have slowed 80% due to the current drought. All in all, he explained that his system is not impacted by pollution in general or AMD specifically.

6.1.4 Summary

Results from this interview process indicate that there are increased treatment requirements and costs associated with using AMD-impacted water for drinking water. Increased costs result from using more chemicals (potassium permanganate) to oxidize iron and manganese, using more coagulants, backwashing filters more frequently, and disposing of larger quantities of sludge. Labor costs also increase. Due to current drought conditions and expanding populations, several systems in the WBSR watershed are entertaining the idea of using reserve and emergency sources that are impacted by AMD. These systems would benefit from nearby AMD remediation projects.

Unfortunately, we were not able to ascertain the actual costs associated with using clean surface water versus AMD-impacted surface water. We did, however, compile information on treatment costs, when such information was provided during the interview process (Table 16). It is important to note that not all systems reported costs in the same manner. Some systems reported costs for chemicals only, some for the entire plant operation, and some for combinations of costs in between. Also, three systems were not able to estimate treatment costs for any aspect of their systems.

Table 16: Total volume withdrawn and treatment costs for the systems that participated in drinking water interviews

System	Volume withdrawn (million gallons/ year)	Treatment cost		Current pollutants	Source of pollutants	Cost estimate
		$/million gallons	$/year			
A	2.6	Not calculated	35,000	N/A	AMD	PADEP estimate to treat AMD
B	4	3,000	12,000	Low pH	Acid precip.	Chemicals only
D	443	87	38,541	Iron	Rock form.	Chemicals only
E	279	1,390	387,810	None	N/A	Total treatment
F	219	2,100	459,900	Low pH	Rock form.	Staff, utilities, chemicals
H	32	2,500	80,000	Yes	AMD	Entire facility

Note: For System A, treatment cost/million gallons not calculated because cost estimate from PADEP does not reflect current treatment costs. System B operator stated that treatment cost was a little high. System C is not included in this table because cost data provided by operator is not considered to be reliable. System D volume withdrawn differs from sum of sources due to rounding. For System H, cost estimate includes chemicals, wages, utilities, repairs, lab fees, and insurance. No cost data were received from Systems G and I.

6.2 Impacts on water supplies for homes and businesses

Private water supplies are also impacted by AMD. In this section we investigate these impacts by cataloging publicly-financed water line extensions for private water supplies in the WBSR watershed.

The Title IV Abandoned Mine Land Fund collects fees on each ton of coal mined and allocates funds back to states to remediate coal mines abandoned before 1977. Among other things, these funds are used to pay for waterline extensions when drinking water has been polluted. As shown in Table 17, 18 such projects have been completed or were under construction as of May 2007. These projects cost over $11 million, and provided clean drinking water to 689 residences and 4 businesses. Over 320,000 feet of waterline extensions were involved in these projects. Water pollution from coal mines justified 16 of these projects. In at least 11 of these projects, a reduction in water quantity was also recorded.

In all but two of the projects, private wells were replaced with public waterline extensions. In one project, the well was replaced with another well, but was subsequently replaced with an extension to a public water supply after this effort failed. In the final project, a public water supply threatened by contamination via subsidence was restored. In many cases, the financial responsibility of connecting to the public water line extension was left up to individual residents, although public funds were used for the actual extension project.

Table 17: Water supply replacements projects in the West Branch Susquehanna River watershed funded by Title IV Abandoned Mine Land Fund

Project name	Project number	Cost ($)	Water quality impact?	Water quantity impact?	No. resi-dences	No. busi-nesses	Waterline distance (feet)
Public waterlines							
Needful West	OSM 17 (0084)103.1	367,482	Yes	Yes	4	0	6,000
Scotch Hollow Southeast	OSM 17 (0091)101.1	30,865	Yes	No	2	0	4,150
Muddy Run West (Glendale Cont)	BF 354-102.1	78,395	Yes	No	2	0	1,700
Cherry Run	OSM 24 (0512)101.1	62,196	Yes	No	8	0	1,781
Belsena Mills	OSM 17 (1405)101.1	345,768	Yes	No	13	0	12,148
Mock Hill (Refund)	OSM 17 (1417)101.1	109,376	Yes	Yes	26	1	13,450
Spring Valley/Salem-1	OSM 17 (1941)101.1	1,329,747	Yes	Yes	135	0	30,190
Spring Valley/Salem-2,3 & 4	OSM 17 (1941)102.1	1,952,795	Yes	Yes	163	0	66,779
Sanbourn	OSM 17 (1942)101.1	1,939,674	Yes	Unknown	83	0	69,500
Drane	OSM 17 (1946)101.1	3,482,229	Yes	Yes	133	0	65,000
Madera West	OSM 17 (2570)101.1	90,072	Yes	No	1	0	3,300
Barr Twp.	OSM 17 (2813)101.1	41,212	No	Yes	70	0	N/A
Kettle Spring Run (Pinchy Road)	OSM 17 (6404)101.1	102,081	Yes	Yes	10	0	3,750
Bigler Northeast	OSM 17 (7072)101.1	65,455	Yes	Yes	4	0	2,600
Blue Ball East	OSM 17 (7085/7086)101.1	1,100,000	Yes	Yes	13	0	22,000
McDowell Mountain South	OSM 17 (7163)102.1	189,786	No	Yes	3	0	4,568
Graham West	OSM 17 (7500)101.1	243,474	Yes	Yes	18	3	13,600
Well							
Needful West	OSM 17 (0084)101.1	15,646	Yes	No	1	0	N/A
Total		11,546,253			689	4	320,516

Note: Information gathered from problem area descriptions, general environmental assessments, and other project information sources. Projects are as of as of May 2007. Growing Greener paid $941,235 toward Spring Valley/Salem-1 and $877,151 toward Spring Valley/Salem-2,3 & 4. Blue Ball East is in design phase, cost and extension distance is an estimate.

Two additional waterline extension projects are in the early stages of planning, and no designs or cost estimates are yet available. These projects are not included in Table 17.

A standard justification for funding for these projects is exhibited by the following excerpt from the General Environmental Assessment report for one of the sites:

> "These past coal mining operations have interrupted or adversely affect the quality of the local aquifers resulting in a lack of potable water for many of the local residences and businesses. The lack of a potable water source adversely affects the quality of life for the local residents and could have potential adverse health effects for persons who are presently consuming the degraded water. Individual water supplies were sampled and analyzed and do not meet safe drinking water standards. Most water supplies have elevated levels of iron, manganese and sulfates along with low pH values." (PADEP, 1994a, p. 1)

Many residents have experienced years or even decades of hardship in dealing with water supply issues related to abandoned mining activities, such as the following resident who waited from an initial investigation in 1981 until 1994 before any assistance was received in restoring his water supply:

> "BMR investigated the water supply problem in 1981 and 1982 in response to a complaint by Mr. [W.]. Department hydrogeologist, [J.], found Benjamin Coal Company

responsible for the spring degradation in his October 19, 1982 report. Benjamin was issued a Departmental order for a water supply replacement, which Benjamin subsequently appealed. Benjamin Coal Company became insolvent in 1989 and the [W.] water supply was never replaced." (PADEP, 1994b, No page number)

"Mr. [W.] utilizes a dug well for his bulk water needs, and hauls potable water from his son's house in Madera which is served by municipal water. Although his well supplies water of generally good quality, it is not a reliable supply due to insufficient quantity during the summer months. The Madera Fire Company has filled his well several times as a courtesy for which Mr. [W.] has made contributions. He also collects rain water in a cistern to supplement his supply. He doesn't know how long the fire company will be able to supply him bulk water. He does not feel that he can rely on them for a permanent water supply" (PADEP, 1994b, No page number)

Several water supply or water well replacement projects have also been funded in the WBSR watershed using coal mining company bonds forfeited to PADEP upon inadequate closure of mining operations. Details of these projects are listed in Table 18.

Table 18: Water supply replacement projects in the West Branch Susquehanna River watershed funded by forfeited bonds

Project number	Cost ($)	Water quality impact?	Water quantity impact?	No. residences	No. businesses
Water supply					
BF 217-101.1	$42,224	No	Yes	1	1
BF 261-102.1	$51,870	Yes	No	4	0
BF 34-202.1	$13,681	Yes	No	1	0
Well					
BF 217-103.1	$17,859	No	Yes	1	0
Total	$125,635			7	1

Note: Information gathered from water supply investigation reports, scopes of work, and other project information sources. Replacements as of May 2007.

6.3 Summary

Both public and private drinking water systems have been affected by AMD in the WBSR watershed. Public systems face increased treatment requirements and costs when source water is impacted by AMD. Several systems in the watershed are considering using reserve and emergency sources that are impacted by AMD; these systems would benefit from nearby AMD remediation projects. Private systems have also been impacted by AMD. More than $11 million has been spent on waterline extensions to bring clean water to 696 residences and five businesses within the WBSR watershed.

Remediating AMD across the watershed would open up more plentiful and cheaper source water options for public water systems, and would minimize the need for additional spending on waterline extensions for private residences and businesses.

7. WILLINGNESS-TO-PAY FOR REMEDIATION

> **Contingent Valuation Method**
>
> This method is based upon the simple idea that if you want to know the maximum amount of money that someone would be willing to pay for WBSR remediation, you simply ask them. We used a mail survey to ask such a question of 2,000 households inside and outside the WBSR watershed.

WTP is used to measure the monetary benefits from AMD remediation in the WBSR watershed among the affected general public. People have positive WTP for AMD remediation because of the various improvements associated with property values, recreation, and drinking water quality that were discussed in the previous sections of this report. Other non-use values such as aesthetics also contribute to people's WTP.

To calculate WTP estimates for remediation of AMD damage in the watershed, data were collected from a mail survey of households inside and outside the watershed. From this survey, the total WTP among Pennsylvania residents was calculated. Total WTP helps compare the benefits from AMD remediation with the costs.

The objectives of this mail survey were threefold. First, the survey provides a database from which to derive household-level WTP estimates for cleaning up AMD in the WBSR watershed such that these estimates can be aggregated to the affected population. Second, the survey determines whether in-watershed and out-of-watershed populations have different WTP values. Finally, in addition to WTP questions, this survey included questions to gauge the importance of AMD remediation, attitudes and opinions about water quality, recreational use of water resources, and basic demographic information.

The approach used to estimate WTP was contingent valuation method (CVM). CVM is based upon the simple idea that if an analyst wants to know the maximum amount of money that someone would be willing to pay for an environmental good or service—like watershed restoration—you simply ask them via a constructed or hypothetical market. WTP is estimated as the highest price that a respondent would pay to obtain the environmental good or service. This method is called "contingent" because the dollar values obtained from the survey are contingent upon creation of a market for stream restoration.

The goal of CVM is to construct a question that presents each respondent with a believable market that encourages realistic responses to a WTP question. With AMD pollution, attempting to place a WTP on watershed remediation was complicated by a fairness question: Why should respondents pay to clean up a problem that someone else created (Collins and Rosenberger, 2007)? Thus, the analysis of responses to CVM questions must minimize and/or account for responses that do not reflect respondents' true values (i.e., protest responses).

7.1 <u>Mail survey</u>

A mail survey was used in this study because mail surveys are less expensive than telephone and personal interview contacts. Also, mail surveys can address complex information of watershed restoration. Previous survey instruments utilized in CVM studies for restoration on the Cheat

River (Collins and Rosenberger, 2007) and Opequon Creek (Benson, 2006) watersheds in West Virginia were used as starting points. A draft survey instrument was then reviewed by members of the WBSR Task Force.

Very similar surveys were sent to residents inside and outside the watershed (See Appendices C and D). Section A of the survey included questions on respondents' attitudes, knowledge, and recreational activities related to water resources. Section B included questions about respondents' use and familiarity with the WBSR watershed and its problems. This section also included watershed restoration information, the CVM questions, and follow-up questions. Finally, Section C contained questions about demographic characteristics of the respondents and their households.

The CVM employed in this survey was a referendum question with a modified payment card approach to elicit maximum WTP. CVM included two questions: (1) a referendum question that was patterned after an actual ballot question on the 2006 Pennsylvania statewide election; and (2) a maximum, one-time tax increase question answered by those that did not oppose the referendum. Those who opposed the referendum were referred to a follow-up question that was used to distinguish between actual zero values and protest responses. Protest responses were designated as: "I support clean-up, but I think someone else other than the state should pay for the clean up" and "I support clean-up, but don't support any new taxes." These three questions are presented in Figure 11.

Two populations were identified as potentially affected by restoration in the WBSR watershed. The first population included residents within the watershed. Inside the watershed, the sample population was stratified in order to adequately represent the rural populations in the sample. This stratification included 75% of selected households in less populated zip codes and 25% in more populated zip codes.

The second population consists of all Pennsylvania households with recreational and/or environmental concerns about the WBSR watershed who reside outside the watershed. This population was determined based on recreational visitation rates to the Pennsylvania Wilds region (Sechoka, 2007), which overlaps considerably with the WBSR watershed (See Figure 6). Sixty percent of the outside-the-watershed surveys were sent to the targeted metropolitan areas of Johnstown-Altoona, Pittsburgh, and Philadelphia based on these areas having the highest visitation rates. The remaining 40% of surveys were sent to households throughout the rest of the state.

To create samples from both populations, mailing lists of randomly selected households for each population were purchased from Survey Sampling, Inc. With a target goal of 800 responses (400 per population), 2,000 surveys were mailed to these randomly selected households. Mail surveys were sent in three waves. In early June 2007, 1,000 surveys were sent to each sample population. A week or two later, reminder postcards were sent out. A second mail survey was sent to non-respondents in early July.

Figure 11: Contingent valuation method questions in West Branch Susquehanna River mail survey

B5. One way to provide money for AMD clean up is for the state of Pennsylvania to create a fund through a statewide referendum. Suppose that the following referendum was placed on the next ballot in the state of Pennsylvania:

"Do you favor creation of a fund by the Commonwealth that contains sufficient funds to clean up acid mine drainage in the West Branch Susquehanna River and its stream tributaries?"

How would you vote on this referendum? (Please check one)

____ Yes, I would support a referendum on an AMD clean up fund (Please answer question **B6**)
____ I am unsure how I would vote (Please answer question **B6**)
____ No, I would oppose an AMD clean up fund (Please skip to question **B7**)

B6. In order to pay for the clean-up fund described in question **B5**, funding would be needed. What is the **maximum, one time** tax increase that you would be willing to pay to clean up acid mine drainage in the West Branch Susquehanna River and its stream tributaries? (Please circle the highest amount that you would be willing to pay remembering your household budget)

$0	$5	$10	$15	$20
$30	$40	$50	$75	$100
$125	$150	$200	$300	$500

$1,000 Other (please specify) $_______

B7. If your answer is **NO** to question **B5**, which statement best reflects why you would oppose the referendum to create a fund to clean up acid mine drainage in the West Branch Susquehanna River and its stream tributaries? (Please check one)

____ I support AMD clean-up, but I can't afford to pay any more taxes.
____ I support clean-up, but I think someone else other than the state should pay for the clean up.
____ I support clean-up, but don't support any new taxes.
____ I don't support a clean-up fund because there are higher priorities for spending state money.
____ I don't think acid mine drainage is a problem in the West Branch region.
____ Other, please explain ___________________________

Survey data were entered into Microsoft Excel for tabulation and analysis. Thirty-two surveys were randomly selected to verify that survey coding was correct. These included 12 out-of-watershed and 20 within-watershed surveys. Only three minor coding errors were found.[14] This level of mistakes was deemed small enough to not check all surveys. Coding of all survey responses also was checked for minimum and maximum values on each question, to make sure

[14] A zip code digit was left off one survey. On Question A4 of one survey, the coding was "polluted" when the response was "very polluted." The wrong category was coded for the second part of B3 ("Lack of fish or aquatic life" was coded when the response was "Trash in the river…".

that responses were not coded outside the bounds of the survey responses. Four coding changes were made to address inconsistent responses by survey respondents.[15]

7.2 Survey results

Table 19 contains the statistics on the survey response rates. The return rates were below expectations both inside- and outside-the-watershed. There probably were several factors involved in this low response rate: surveys were sent during the summer; the outside envelope used bulk postage from a non-profit organization rather than a stamp (although the outside envelope was clearly labeled as not being a fund raising letter); and no rewards were included in the mailings. Overall, 271 surveys were returned.

Table 19: Survey response statistics

Watershed area	Surveys sent out	Undeliverables	Net surveys sent out	Surveys returned	Response rate
Inside	1,000	62	938	149	15.88%
Outside	1,000	32	968	122	12.60%
Total	2,000	94	1,906	271	14.22%

7.2.1 Awareness of streams, rivers, and pollution

The survey included questions about people's knowledge of Pennsylvania rivers and streams. This self-reported knowledge was higher among respondents who lived inside the WBSR watershed. A total of 65% of watershed residents report high or medium knowledge, compared with 49% of out-of-watershed residents.

More specifically, the survey asked about respondents' familiarity with the eastern and western portions of the WBSR watershed. Fewer than one-half of in-watershed respondents were familiar with the streams in either portion of the watershed, and only 30% of out-of-watershed respondents were familiar with any streams in the watershed.

Awareness of environmental problems with the WBSR and its stream tributaries can be improved: 31% of in-watershed respondents and 70% of out-of-watershed respondents did not know if environmental problems existed. Most respondents reported they were not aware of how much AMD pollution existed in the WBSR and its stream tributaries prior to receiving this survey (50% in-watershed and 86% out-of-watershed).

[15] Coding for Question B6 was changed from a missing value to zero when the respondent said yes to Question B5 but indicated that s/he supported AMD clean-up but could not afford any more taxes. Changes were made on six surveys. Coding for Question B1 was changed when a respondent indicated they were familiar with one portion yet checked "I am not familiar…". The coding on the "I am not familiar…" response was changed to zero indicating that four such respondents were familiar with some part of the watershed. Coding for Question B3 was changed from a missing value to "Yes" when the respondent indicated problems on the West Branch in the second part of B3, yet did not answer Question B3 itself. This change was made on four surveys. Coding for Question B5 was changed from a missing value to "I am unsure how I would vote" when the respondent skipped Question B5 but responded with a positive value for Question B6. This change was made on three surveys.

Picture 7: Huling Branch Kill Zone in the Kettle Creek watershed

Photo credit: Amy Wolfe.

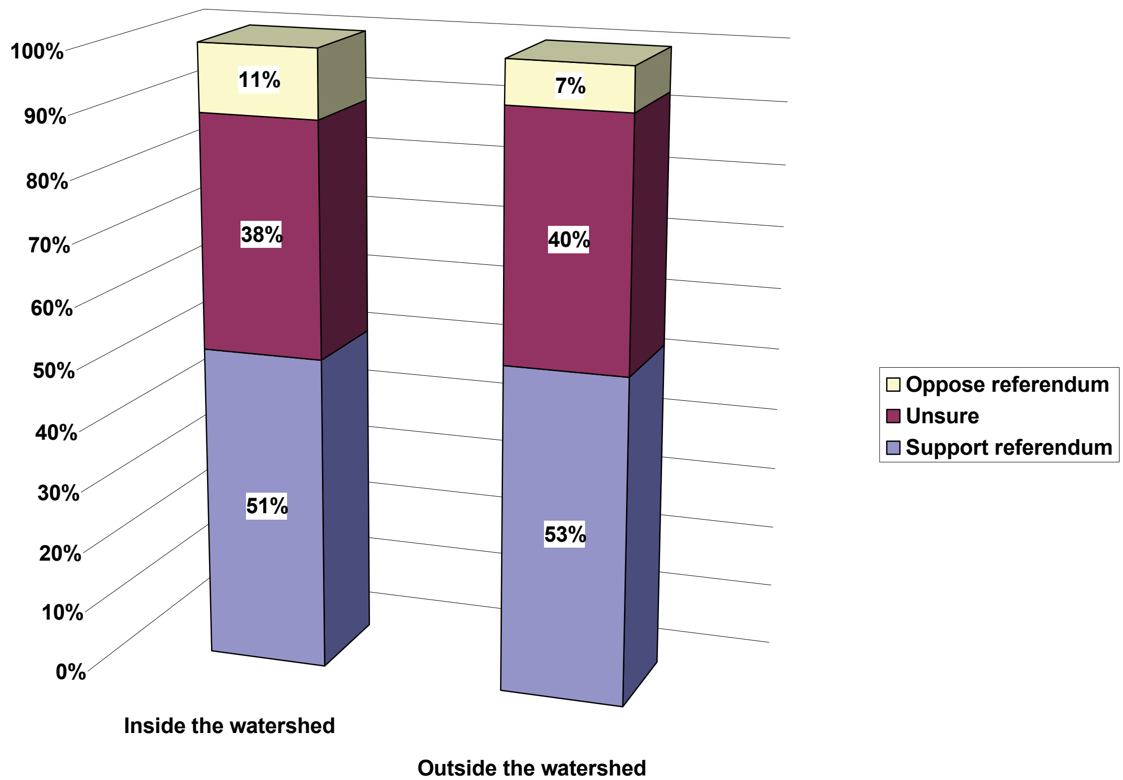
7.2.2 Use of Growing Greener funds

Pennsylvania's Growing Greener program is used for numerous efforts that improve the environment and quality of life, including, among other things, preserving farmland, protecting open space, maintaining state parks, cleaning up abandoned mines, restoring watersheds, and upgrading water and sewer systems. The survey asked specifically about respondents' priorities for spending Growing Greener funds. Cleaning up polluted rivers and streams was the most common choice: 84% in-watershed and 93% out-of-watershed.

7.2.3 Willingness-to-pay to clean up abandoned mine drainage in the watershed

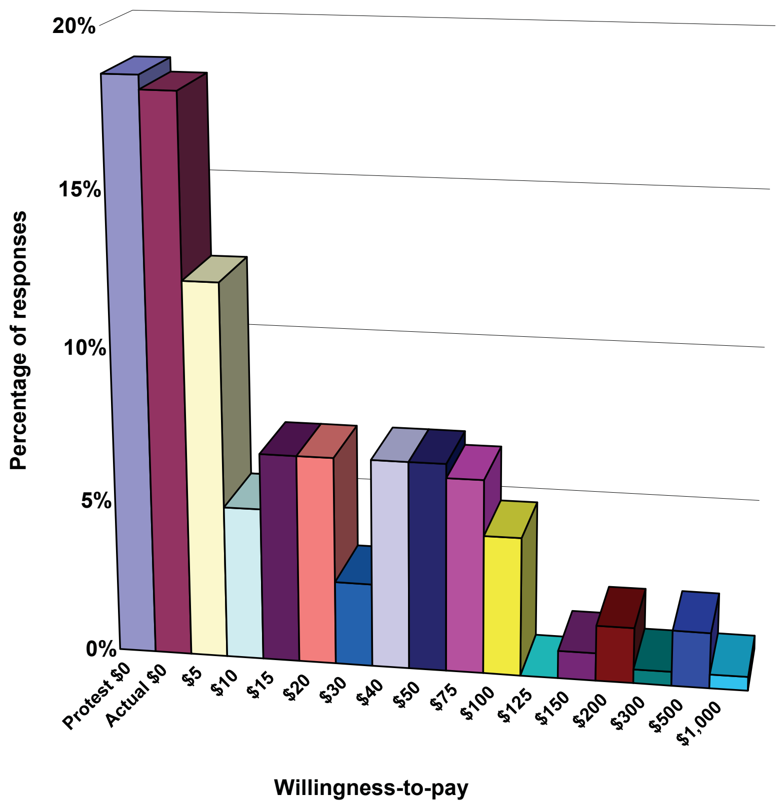
As described above, a series of three questions was used to quantify respondents' WTP to clean up AMD in the WBSR watershed. As shown in Figure 12, just over one-half of respondents were willing to support a referendum to provide funding to clean up AMD in the WBSR and its stream tributaries. Most of the remaining respondents were unsure about whether they would support or oppose such a referendum.

Figure 12: Responses to referendum question



Those who supported or were unsure about a referendum were directed to answer the CVM question. Of the 221 responses to the CVM question, the most common response was $0 (Figure 13). In fact, 37% of CVM responses were $0 responses (when including the "No" responses from Question B5 as a $0 response). Slightly over one-half of all $0 responses were classified as protest responses, as described above.

Figure 13: Distribution of responses to contingent valuation method question



Including the actual $0 responses, the average willingness-to-pay was similar between groups ($42 for in-watershed and $44 for out-of-watershed respondents). This amount reflects the maximum, one-time tax increase a respondent would be willing to pay to clean up AMD.

Most respondents were confident that they would have picked the same answer if the referendum were actually on the ballot (about 75% for both groups). In-watershed respondents agreed more (62% vs. 50%) that they had enough information to decide whether or not to clean up AMD and would more likely use a cleaned-up WBSR compared with today (40% vs. 24%).

7.3 Sample WTP estimates

From the survey sample obtained, there were two deficiencies to applying the CVM responses as WTP estimates for the affected population:

1. the low response rate makes the survey sample suspect in representing the affected population; and
2. the majority of zero responses were protest responses, and therefore did not reflect true respondent WTP values.

The lack of population representation can be noted by the differences in respondent education attainment compared with the general population.[16] Thus, a WTP model was needed to apply WTP estimates to the general population and to account for protest responses. For these purposes, a Tobit model was selected (See Appendix E). This model calculates separate WTP estimates for respondents inside and outside the watershed, as shown in Table 20.

Table 20: Willingness-to-pay estimates for respondents

Watershed area	Mean	Median
Inside	$25 +/- 3.25	$22
Outside	$34 +/- 5.43	$36

These WTP estimates were on a per-household basis and represent a maximum one-time payment for remediation of damage caused by AMD in the WBSR watershed. The mean WTP for WBSR restoration was about one-third higher among respondents outside the watershed. This result can be explained by several factors. Higher education levels among outside-the-watershed respondents would likely increase their willingness to spend money on remediation. Also, familiarity with the watershed increased WTP among respondents outside the watershed but decreased WTP for inside respondents, perhaps due to a greater acceptance of the AMD problem by people living in the watershed.

The WTP estimates found in this study can be considered conservative compared with estimates found elsewhere in the literature. They are higher than the $16 per household found by Collins and Rosenberger (2007) for AMD remediation in the Cheat River in north-central West Virginia. However, the WTP estimates in the WBSR watershed are substantially lower than those found for restoration of bacteria and sediment pollution in the Opequon Creek of Virginia and West Virginia (from $32 to $62 per household annually) as reported by Borisova et al. (forthcoming). They are much lower than other WTP estimates for watershed-wide improvements found in other water quality studies throughout the United States and Canada. Seven studies are summarized by Benson (2006), where household WTP estimates ranged from $60 to $400 annually.

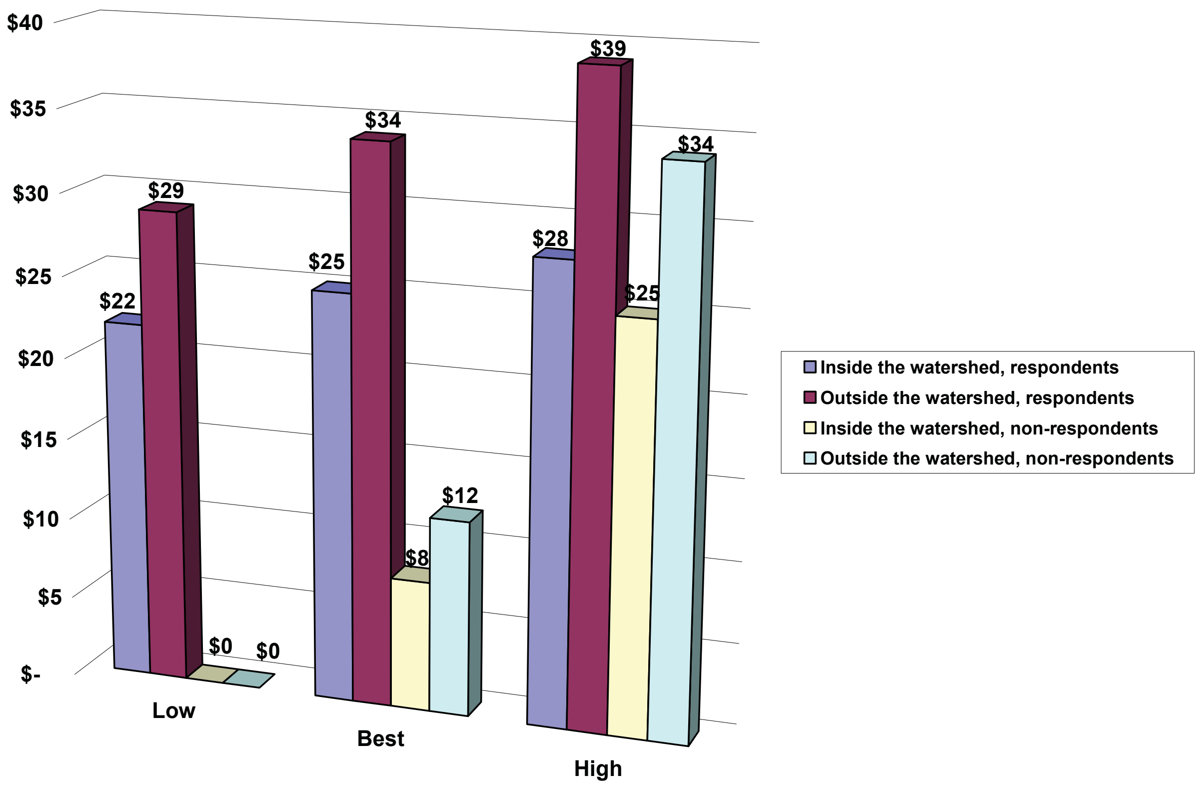
7.4 Affected population WTP estimates

In order to aggregate the sample WTP estimates into total WTP for remediation among the entire affected population, WTP for non-respondents is also required. As described in Appendix E, non-respondent WTP is calculated by assigning variable values for non-respondents in the Tobit model based on assumptions about non-respondents, survey data, and census information. The mean, non-respondent WTP is $8 inside the watershed and $12 outside the watershed.

[16] The survey sample was much more educated than the general population. Compared with census data estimates, college graduates were more prevalent in the sample both outside (49% vs. 26%) and inside (40% vs. 18%) the watershed.

Total WTP for the affected population inside and outside the watershed is computed as weighted averages of respondent and non-respondent WTP estimates. Three levels of total WTP were estimated: low, best, and high.[17] The WTP estimates are summarized in Figure 14.

Figure 14: Household low, best, and high willingness-to-pay estimates

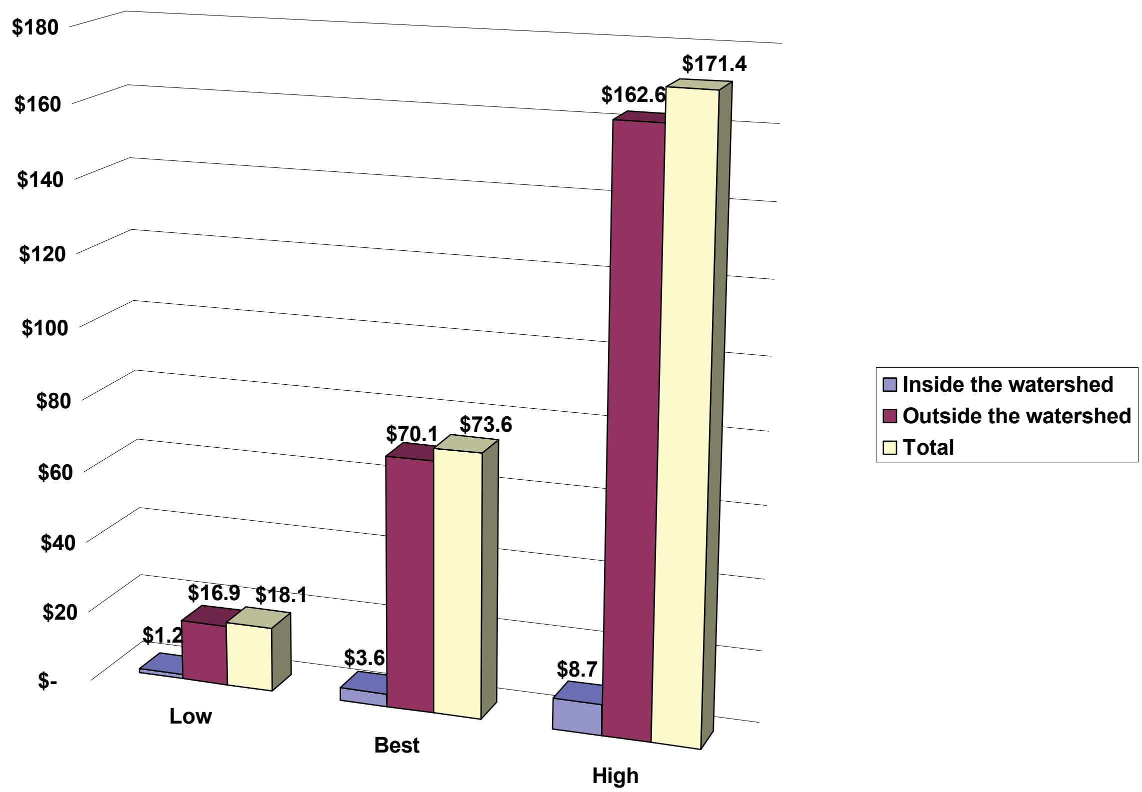


Total WTP estimates from the WTP portion of this study are presented in Figure 15. These estimates were based on 343,000 households inside and 4.7 million households outside the watershed in Pennsylvania from census population estimates in 2006.

In each of the three levels estimated, about 95% of the monetary value in total WTP comes from Pennsylvanians residing outside the watershed. The low estimate was just over $18 million and the high estimate was over $171 million. The best estimate of total WTP was $73.6 million.

[17] The best estimate utilized average WTP for respondents and non-respondents. Low total WTP utilized the lower bound of the 90% confidence interval for the respondent group WTP estimate and assumed a zero WTP for non-respondents. High total WTP utilized the upper bound of the 90% confidence interval for the respondent group WTP estimate and assumed that non-respondents had the average WTP estimate for respondents.

Figure 15: Total willingness-to-pay estimates for remediation (million $)



7.5 Comparisons with other components of this study

The WTP study asks how much money people would be willing to pay to clean up the WBSR and its stream tributaries. Different respondents are likely to base their answers on different perceived benefits. For example, one respondent might be willing to pay in order to improve fishing opportunities. Another respondent might focus in on cleaner drinking water. A third might be thinking about the economic activity that would be generated by funding large-scale remediation projects. And a fourth might be concerned solely about non-use values such as aesthetics. In short, the WTP study provides a broad estimate that mixes different people's values and concerns.

In contrast, Sections 3 through 6 present more specific analyses of particular components of people's WTP, and care must be taken when reporting the results from the different sections.

For example, the local benefits generated by spending remediation dollars are in addition to increased recreational spending, new and cleaner drinking water options, and increased property values. Without asking WTP respondents, it is not known whether WTP estimates include some accounting of people's WTP for remediation in expectation of those remediation projects then benefiting the local community through the purchase of local goods and services.

The local economic benefits of increased recreational spending, discussed in Section 4, likely overlap more completely with the WTP estimates in this section. When people provide WTP figures, these figures include a range of benefits that respondents may attribute to cleaner streams, including recreational benefits. The $22.3 million in expected benefits from increased fishing revenues due to AMD remediation could be expected to be included in the total WTP estimate calculated in this section.

7.6 Summary

Based on a mail survey of Pennsylvanians living both within and outside of the WBSR watershed, the best estimate of total WTP for remediation of the AMD in the watershed was calculated as $73.6 million. Low and high estimates of $18 and $171 million provide a broader range.

8. CONCLUSIONS

AMD remediation in the WBSR watershed will require large capital investments and annual O&M expenditures. A project of this scale will require a long-term commitment from governments at the federal, state, and local levels, and the involvement and support of local stakeholders. However, by incurring these large costs, remediation of AMD-impaired streams will have numerous local economic benefits. This report investigates and, where possible, quantifies these benefits.

8.1 Remediation generates jobs and stimulates the local economy

To build remediation projects, money is spent on engineers and contractors, alkaline materials and construction equipment. These expenditures on labor, materials, and machinery pump money into the local economy and generate jobs. Salaries and expenditures are circulated through the local economy.

Depending on which technologies are ultimately chosen at each AMD source, remediation expenditures will generate local benefits of up to $616 million for capital expenditures, and up to $23 million per year for O&M. Even greater economic gains would accrue to the state as a whole.

More than one-half of the jobs created as a result of these expenditures will be green-collar jobs: Workers will be directly employed to design, build, operate, and maintain these systems.

8.2 Recreational spending will increase with cleaner waters

Outdoor recreation is big business, and the cleaner the streams, the more people will spend on equipment, transportation, and lodging. In Pennsylvania, almost $4 billion was spent on fishing, hunting, and wildlife viewing in 2006. People who participate in a wider range of outdoor recreational activities spend even more money.

AMD directly impacts fishing opportunities. After remediation of the WBSR watershed, an additional $22.3 million in sport fishing revenues could be expected to be generated each year. Additional recreation spending—over and above that for fishing—would be expected after remediation is completed.

8.3 Property values will increase with AMD remediation

Based on an analysis of parcels in Clearfield County, property values near AMD-impacted streams are reduced and are projected to increase with AMD remediation. In Clearfield County alone, the total value lost by owners of the 2,734 parcels within 200 feet of AMD-impacted streams is $4,077,682, for an average of $2,587 per acre or $1,491 per parcel.

8.4 Drinking water options will be cheaper and more plentiful

Both public and private drinking water systems have been affected by AMD in the WBSR watershed. Public systems face increased treatment requirements and costs when source water is impacted by AMD. Several systems in the watershed are considering using reserve and emergency sources that are impacted by AMD; these systems would benefit from nearby AMD remediation projects.

Private systems have also been impacted by AMD. More than $11 million has been spent on waterline extensions to bring clean water to 696 residences and five businesses within the WBSR watershed.

Remediating AMD across the watershed would open up more plentiful and cheaper source water options for public water systems, and would minimize the need for additional spending on waterline extensions for private residences and businesses.

8.5 Residents are willing to pay for remediation

Based on a mail survey of Pennsylvanians living both within and outside of the WBSR watershed, the best estimate of total WTP for AMD remediation in the watershed was calculated as $73.6 million. Low and high estimates of $18 and $171 million provide a broader range.

8.6 Summary

To make the most informed decisions possible about AMD remediation across the WBSR watershed, policymakers and the general public should consider not just the costs, but also the benefits. As described in this report, a number of economic benefits can be expected upon completion of AMD remediation. These benefits are significant and extend outside the watershed to the entire state of Pennsylvania.

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APPENDIX A: LOST VALUE OF RECREATION

As shown in Table 21, an estimated $22.3 million in sport fishing revenues was lost in the WBSR watershed due to AMD in 2006. This estimate includes lost angling opportunities in both warm and cold water streams. To perform these calculations, all AMD-impaired streams were taken from Pennsylvania's 305(b) report and were categorized as wild trout (WT), trout stocked fishery (TSF), or warm water fishery (WWF) streams. The use rates were calculated by PAFBC based upon use and harvest information from surveys. Valuation rates were calculated based on figures from the American Fisheries Society (1992).[18] These numbers quantify the amount of money that anglers would have spent for the different types of fishing.

Table 21: Lost value of angling due to abandoned mine drainage in the West Branch Susquehanna River watershed

Stream name	Sub-watershed	Pollutant	Miles	Projected use	Lost value ($)
Bennett Branch Sinnemahoning Creek	8-A	pH-Metals	4.8	TSF	355,133
Bennett Branch Sinnemahoning Creek	8-A	pH-Metals	24	TSF	1,775,664
Bennett Branch Sinnemahoning Creek	8-A	pH-Metals	8.8	TSF	651,077
West Creek	8-A	pH-Metals	3	TSF	221,958
West Creek	8-A	pH-Metals	9	TSF	665,874
Dents Run	8-A	pH	6.5	WT	185,088
Trout Run (Unt)	8-A	pH-Metals	1.2	WT	34,170
Spring Run	8-A	pH-Metals-Sulfates	7.7	WT	219,258
Sinnemahoning Creek	8-A	pH-Metals	6.7	WWF	103,597
Sinnemahoning Creek	8-A	pH-Metals	9.1	WWF	140,706
Montgomery Run	8-B	pH-Metals	1.9	TSF	140,573
Montgomery Run	8-B	pH-Metals	0.7	TSF	51,790
Anderson Creek	8-B	pH-Metals	10.3	TSF	762,056
Montgomert Creek (Unt)	8-B	pH-Metals	1.3	WT	37,018
Woods Run	8-B	pH-Metals	3	WT	85,425
Montgomery Creek (Unt)	8-B	pH-Metals	1.7	WT	48,408
Montgomery Creek (Unt)	8-B	pH	0.5	WT	14,238
North Branch Montgomery Creek (Unt)	8-B	pH	0.9	WT	25,628
Tinker Run	8-B	pH	0.7	WT	19,933
Montgomery Creek (Unt)	8-B	pH	1.5	WT	42,713
Hartshorn Run	8-B	pH-Metals-Sulfates	3	WT	85,425
Kratzer Run	8-B	pH-Metals	5.1	WT	145,223
Irvin Branch	8-B	Metals	1.5	WT	42,713
Little Anderson Creek	8-B	pH-Metals	5.7	WT	162,308
Wilson Run (Unt)	8-B	pH	1.8	WT	51,255
Wilson Run (Unt)	8-B	Metals Hwc	0.8	WT	22,780
North Camp Run	8-B	Metals Hwc-Sulfates	2.8	WT	79,730
Rock Run	8-B	pH-Metals	3	WT	85,425
Bear Run	8-B	pH-Metals	2.9	WT	82,578
South Branch Bear Run	8-B	pH-Metals	5.3	WT	150,918
West Branch Susquehanna River	8-B	pH-Metals	6.8	WWF	105,143
West Branch Susquehanna River	8-B	pH-Metals	72.9	WWF	1,127,193
Lick Run	8-C	pH-Metals	3.7	TSF	273,748
Clearfield Creek	8-C	pH-Metals	27.7	TSF	2,049,412
Little Muddy Run	8-C	Metals	1	TSF	73,986
Brubaker Run	8-C	pH-Metals-Sulfates	2	TSF	147,972
Alder Run	8-C	pH-Metals	10.7	WT	304,683
Sandy Creek	8-C	pH-Metals-Sulfates	4.2	WT	119,595
Big Run	8-C	pH	1	WT	28,475
Deer Creek	8-C	pH-Metals	5	WT	142,375
Surveyor Run	8-C	pH-Metals	4	WT	113,900
Little Surveyor Run	8-C	pH-Metals	2	WT	56,950
Trout Run	8-C	pH	5	WT	142,375
Taylor Springs Run	8-C	Metals Hwc	0.4	WT	11,390
Pine Run	8-C	pH	2.2	WT	62,645

[18] 1992 dollars were inflated to 2006 dollars based upon the Consumer Price Index.

Table 21: Lost value of angling due to abandoned mine drainage in the West Branch Susquehanna River watershed (continued)

Stream name	Sub-watershed	Pollutant	Miles	Projected use	Lost value ($)
Fork Run	8-C	pH-Metals	3.8	WT	108,205
Sanbourn Run	8-C	pH-Metals-Sulfates	3.3	WT	93,968
North Branch Upper Morgan Run	8-C	pH-Metals	2.7	WT	76,883
Little Muddy Run	8-C	pH	4.5	WT	128,138
Blue Run	8-C	Metals Hwc	1.2	WT	34,170
Clearfield Creek	8-C	pH-Metals	44.2	WWF	683,429
Mosquito Creek	8-D	pH-Metals	6	TSF	443,916
Moshannon Creek	8-D	pH-Metals	26.2	TSF	1,938,433
Black Moshannon Creek	8-D	pH-Metals	1	TSF	73,986
Cold Stream	8-D	pH-Metals	1	TSF	73,986
Laurel Run	8-D	pH-Metals	5.4	TSF	399,524
Birch Island Run	8-D	pH-Metals	6.2	WT	176,545
Little Birch Island Run	8-D	pH-Metals	4.3	WT	122,443
Amos Branch	8-D	pH-Metals	1.6	WT	45,560
Sterling Run	8-D	pH-Metals	7.2	WT	205,020
Saltlick Run	8-D	pH-Metals	1.5	WT	42,713
Curleys Run	8-D	pH-Metals	1.2	WT	34,170
Grimes Run	8-D	pH-Metals-Sulfates	2.3	WT	65,493
Pine Creek	9-A	pH-Metals	4	TSF/WWF	120,261
Otter Run	9-A	pH-Metals	3.8	WT	108,205
Left Fork Otter Run	9-A	pH-Metals	1.5	WT	42,713
Right Fork Otter Run	9-A	pH-Metals	0.4	WT	11,390
Babbs Creek	9-A	pH-Metals	1	WT	28,475
Babbs Creek	9-A	pH-Metals	22	WT	626,450
Wilson Creek	9-A	pH-Metals	2.3	WT	65,493
Cooks Run (Basin)	9-B	pH-Metals	6.8	TSF/WT	365,894
Cooks Run	9-B	pH-Metals	3.3	TSF/WT	177,566
Lick Run	9-B	pH	3.7	WT	105,358
Tangascootack Creek	9-B	pH-Metals	8.4	WT	239,190
Drury Run (Basin)	9-B	pH	14.6	WT	415,735
Stony Run	9-B	pH-Metals	1.3	WT	37,018
Woodley Draft Run	9-B	pH-Metals	1.7	WT	48,408
Sandy Run	9-B	pH-Metals	1	WT	28,475
Two Mile Run	9-B	pH-Metals	1.9	WT	54,103
Middle Branch Two Mile Run	9-B	pH-Metals	2.1	WT	59,798
Crowley Hollow'	9-B	pH-Metals	3.1	WT	88,273
Camp Run	9-B	pH-Metals	2	WT	56,950
Rock Run	9-B	pH-Metals	1.2	WT	34,170
West Branch Susquehanna River	9-B	pH-Metals	50.6	WWF	782,386
Kettle Creek	9-B	pH-Metals	3	WWF	46,387
Beech Creek (Basin)	9-C	pH-Metals	26	TSF/WT	1,399,008
Middle Branch Big Run	9-C	pH-Metals	1.1	WT	31,323
Middle Branch Big Run	9-C	pH-Metals	4.9	WT	139,528
East Branch Big Run	9-C	pH-Metals	4.7	WT	133,833
Logway Run	9-C	pH-Metals	0.8	WT	22,780
North Fork Beech Creek	9-C	pH-Metals	5.9	WT	168,003
Little Sandy Run	9-C	pH-Metals	2.7	WT	76,883
Cherry Run	9-C	pH-Metals	0.9	WT	25,628
Red Run	10-A	pH-Metals	3.9	WT	111,053
Loyalsock Creek	10-B	pH-Metals	6	TSF	443,916
Loyalsock Creek	10-B	pH-Metals	7.4	WT	210,715
West Branch Susquehanna River	10-D	pH-Metals	3	WWF	46,387
Total			614.4		22,346,823

Source: PAFBC (2007). Use rates (the number of trips made to these types of stream per year) for TSF (1,100), WT (500), and WWF (306) were estimated by PAFBC based upon use and harvest information collected through surveys along these types of waterways. Valuations are as follows: TSF $67.26, WT $56.95, WWF $50.53. The lost value for the Pine Creek watershed includes figures for Babb Creek and other nearby waters that are no longer significantly impaired due to successful AMD remediation.

APPENDIX B: DETAILS ON THE HEDONIC PROPERTY PRICE METHOD

The hedonic framework relies on Lancaster's (1966) consumer theory, which states that utility is derived not from the good itself, but from the intrinsic properties or characteristics of the good. Rosen (1974) developed Lancaster's idea into a model in which observed prices of goods and the amounts of characteristics associated with each good identify a set of implicit prices, and the total value of a good depends upon the quantities of each of the various attributes that comprise it. Hedonic models provide us with a method for estimating the marginal implicit prices of characteristics associated with a package of location-specific goods, such as land and housing. The hedonic price function is a reflection of the quantities of the good's characteristics, and comes about through the transactions of buyers and sellers in the market. Since land and housing are fixed in space, the values of environmental and other location-specific characteristics are included in the transaction price, and can be isolated with the hedonic model. When applied to the residential market, the model consists of a vector of a house's attributes, $z = (z_1, ..., z_n)$, and a hedonic price function, *p(z)*. The hedonic price function is the relationship between the market price of a given house and the levels of its attributes. This function describes the equilibrium set of house prices, given the population of buyers and the available housing stock.

The hedonic price function is important to policy analysts because it reveals information on consumers' preferences over *z*. Buyers search the set of available houses, and choose the one that maximizes their indirect utility function, given by $V(W - P(z), z)$, where *W* is the wealth of the household. By differentiating the hedonic price function with respect to the characteristic in question, we can find the marginal implicit price for the particular characteristic. For each house attribute, z_i, the first-order condition for this maximization is:

$$\frac{\partial P}{\partial z_i} = \frac{\partial V / \partial z_i}{\partial V / dW}$$

In this study, the determinants of residential prices (the z_i's) are grouped into vectors of like variables (Irwin, 2002):

$$P_i = f(H_i, N_i, E_i, \beta, \alpha, \delta),$$

where P_i is the residential sale price of the i^{th} parcel, H_i is a vector of structural characteristics associated with the house, N_i is a vector of location-specific (or neighborhood-level) variables, E_i is a vector of environmental variables including distance to the nearest AMD-impacted stream, and β, α, and δ are the respective parameter vectors to be calculated.

The subject of hedonics in the literature is replete with research examining housing and land prices in urban and rural areas. This research includes studies of the non-market value of agricultural land (Shi et al., 1997; Ready et al., 1997), open space (Geoghegan et al., 2003; Irwin, 2002), transportation infrastructure (Haider and Miller, 2000), and other environmental amenities (Kim et al., 2003; Bockstael, 1996; Geoghegan et al., 1997; Sengupta and Osgood, 2003).

One recent study (Williamson et al., 2007) used the hedonic method to estimate WTP for AMD remediation in West Virginia. Using 21 years of housing sales data, sale prices of single family homes statistically related to a set of variables that include proximity to AMD-impaired streams. The study found that properties located within one-quarter mile of AMD streams face an implicit cost of $4,783 due to proximity.

Two models were estimated in the current analysis: an unrestricted model containing stream quality–related variables, and a restricted model containing basic hedonic variables. These two models were estimated in order to determine whether or not the stream quality variables resulted in a better statistical model than the basic model.

The unrestricted model is:

LN(SALE PRICE) is a function of: LN(LOT SIZE), LN(PERIMETER), LN(STRUCTURE VALUE), URBAN, BAD SOIL, STREAM 200FT, LN(AMD DISTANCE), (STREAM 200FT * LN(AMD DISTANCE)).

The restricted model is:

LN(SALE PRICE) is a function of: LN(LOT SIZE), LN(PERIMETER), LN(STRUCTURE VALUE), URBAN, BAD SOIL.

Table 22 provides summary statistics for the variables. The log-log specification was chosen to reduce heteroskedasticity in the dataset due to nonlinear relationships between variables. Table 23 summarizes the statistical results.

Table 22: Results of unrestricted hedonic price model

Variable	Coefficient	Standard error	t-statistic	Probability
CONSTANT	18.893	0.390	48.468	0.000
LOT_SIZE	0.160	0.016	9.736	0.000
PERIMETER	-1.896	0.036	-53.014	0.000
STRUCT_VALUE	0.335	0.026	12.941	0.000
INURBAN (0,1)	0.074	0.046	1.604	0.109
BAD_SOIL (0,1)	0.062	0.038	1.635	0.102
STREAM_200FT	0.176	0.179	0.983	0.325
AMD_DISTANCE	0.040	0.020	2.067	0.039
STR200XAMD	-0.029	0.024	-1.195	0.232
# Observations:	1577			
R-squared:	0.71			
Log-Likelihood:	-1689.62			
AIC:	3397.23			

Note: Model estimated in double-logarithmic form using Ordinary Least Squares.

Table 23: Results of restricted hedonic price model

Variable	Coefficient	Standard error	t-statistic	Probability
CONSTANT	19.245	0.361	53.291	0.000
LOT_SIZE	0.155	0.016	9.504	0.000
PERIMETER	-1.907	0.035	-54.022	0.000
STRUCT_VALUE	0.337	0.026	13.053	0.000
INURBAN (0,1)	0.057	0.045	1.264	0.206
BAD_SOIL (0,1)	0.065	0.038	1.698	0.090
# Observations:	1577			
R-squared:	0.70			
Log-Likelihood:	-1692.89			
AIC:	3397.78			

Note: Model estimated in double-logarithmic form using Ordinary Least Squares. F-stat (restricted vs. unrestricted) = 1.16. F-crit (numerator df = 6; denominator df = 1567): 2.10 Do not reject (restricted model performs equally well).

Both models have R-squared values of at least 0.70, which indicate that they are both very good predictors of residential land prices. The t-statistics on the coefficients for the independent variables indicate that many of them are statistically significant at the 1% and 5% levels. Interpreting the coefficients on continuous independent variables in a log-log model is simple: a 1% increase in the amount of the variable results in a (coefficient value) % increase/decrease in the dependent variable. Interpretation of coefficients on the (0,1) variables is a little more difficult: rather than it being a percent change in the variable from 0 to 1, it is: $e^{coefficient}-1$.

An F-test performed on the two models indicates that the restricted model explains the variation in the data equally as well as the unrestricted model. Statistical procedure usually dictates that the simpler model should be chosen when this is the case; however, since our variables of interest are found only in the unrestricted model, the more complex analysis is preferred.

APPENDIX C: IN-WATERSHED WILLINGNESS-TO-PAY QUESTIONNAIRE

Pennsylvania Clean Water Survey 2007

The red-orange color shows the impact of acid mine drainage on the West Branch Susquehanna River just below the confluence with Alder Run.

Introduction

The objective of this survey is to determine the benefits that you would receive from improving water quality in Pennsylvania rivers and streams. This survey will focus on the West Branch Susquehanna River.

Please answer the following questions to the best of your ability. All information gathered in this survey will be kept confidential. The only data released to the public will be in a form where no individual responses are identified.

There are 20 questions in this survey and it should take about 10 minutes to complete. If you have any questions about or problems with this survey, please contact either Amy Wolfe from Trout Unlimited (at 570-726-3118 or awolfe@tu.org) or Alan Collins (at 304-293-4832 ext. 4473 or alan.collins@mail.wvu.edu).

Section A. First, we would like to find out some general information about your concerns and knowledge of clean water in Pennsylvania along with your outdoor recreation activities.
==

A1. Why is clean water in Pennsylvania rivers and streams important to you? (Please check all reasons that apply)

____ To provide water for drinking and household use.
____ To provide water for industrial or agricultural use.
____ For water-based recreation (swim, boat, fish, etc.).
____ To provide good habitat for fish and wildlife.
____ To protect the environment.
____ It is not really important to me.
____ Other. Please explain ____________________

A2. What outdoor activities do you regularly participate in, i.e. more than once per year? (Please check all that apply)

____ Fishing in a lake, river, or stream
____ Kayaking, canoeing or rafting rivers or streams
____ Swimming or wading in a lake, river, or stream
____ Hiking or biking along a river or stream
____ Picnicking near a river or stream
____ Hunting
____ Bird watching activities
____ None of the above

A3. How would you describe your level of knowledge about Pennsylvania rivers and streams? (Please check one)

____ High
____ Medium
____ Low

A4. In your opinion, how clean are Pennsylvania rivers and streams? (Please check one)

____ Very clean
____ Clean
____ Some are clean, some are polluted
____ Polluted
____ Very polluted
____ Don't know

A5. The state of Pennsylvania has a Growing Greener program that provides funds for environmental protection. In your opinion, how should state government spend Growing Greener funds? (Please check all that apply)

____ To clean up polluted rivers and streams
____ To develop alternative energy sources (wind, solar, etc.)
____ To improve and maintain parks
____ To clean up trash dumps
____ To clean up toxic waste sites
____ To protect farmland and open space from development
____ To promote community revitalization and beautification
____ Other. Please explain ______________________________
____ Don't know

Section B. This section refers to the West Branch Susquehanna River.

==

B1. With what portions of the West Branch Susquehanna River and its stream tributaries are you familiar? Please answer this question in terms of having used or seen these portions of the river before. There is a map on the back of this survey to assist you. (Please check all that apply)

____ The eastern portion of the West Branch Susquehanna River and its stream tributaries upstream (the red shaded area of the map including Blacks, Buffalo, Little Pine, Muncy, Loyalsock, Lycoming, Pigeon, and Pine Creeks)

____ The western portion of the West Branch The West Branch Susquehanna River and its stream tributaries (the blue shaded area of the map including Bald Eagle, Beech, Fishing, Cheat, Clearfield, Kettle, Moshannon, and Sinnemahoning Creeks)

____ I am not familiar with any portion of the West Branch Susquehanna River or its stream tributaries.

B2. In the past five years, about how many visits have you had to any portion of the West Branch Susquehanna River or its stream tributaries for any of the outdoor recreation activities listed in question A2? (Please check one)

____ None
____ Between 1 and 5 visits
____ Between 6 and 20 visits
____ Over 20 visits

5

B3. Based upon what you know about the West Branch Susquehanna River and its stream tributaries, do you think there are environmental problem(s) associated with this river and its stream tributaries? (Please check one)

____ Yes
____ No (please skip to question B4 on the next page)
____ Don't know (please skip to question B4 on the next page)

If you answered yes to Question B3, based upon what you know about the West Branch Susquehanna River and its stream tributaries, what do you think are the main environmental problem(s) associated with this river and its stream tributaries? (Please check all that apply)

_____ Orange colors of the water and rocks along the river
_____ Lack of fish or aquatic life
_____ Trash in the river and along the banks
_____ Abandoned coal mine pollution
_____ Unsafe to swim or wade
_____ Too much dirt and sediment in the water
_____ Pollution from farms or logging operations
_____ Flooding
_____ Other__________________________

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

Introduction to Question B4

Acid mine drainage (AMD) from abandoned coal mines has been identified as the primary pollution problem on the West Branch Susquehanna River and its stream tributaries. AMD is caused by the flow of water through abandoned coal mine lands such as surface mines, deep mines, or coal refuse piles. Water polluted by AMD is typically acidic and has high levels of toxic heavy metals such as iron, aluminum, and manganese. AMD-

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polluted water kills fish and other living things in rivers and creeks. Currently, AMD is responsible for more than 1,000 miles of polluted rivers and streams in the West Branch Susquehanna region.

It has been estimated that up to $250 million may be needed to clean up AMD in the West Branch Susquehanna River and its stream tributaries. If AMD were cleaned up in the West Branch Susquehanna River and its stream tributaries, hundreds of miles of streams would once again support trout populations, or in some areas, warm water fish (like bass). In addition, the rivers and creeks would provide cleaner water for community and industrial water supplies and improve recreational experiences for swimming, canoeing, rafting, etc.

B4. Prior to receiving this survey, were you aware of how much AMD pollution exists in the West Branch Susquehanna River and its stream tributaries? (Please check one)

____ Yes
____ No

B5. One way to provide money for AMD clean up is for the state of Pennsylvania to create a fund through a statewide referendum. Suppose that the following referendum was placed on the next ballot in the state of Pennsylvania:

"Do you favor creation of a fund by the Commonwealth that contains sufficient funds to clean up acid mine drainage in the West Branch Susquehanna River and its stream tributaries?"

How would you vote on this referendum? (Please check one)

____ Yes, I would support a referendum on an AMD clean up fund (Please answer question B6)
____ I am unsure how I would vote (Please answer question B6)
____ No, I would oppose an AMD clean up fund (Please skip to question B7)

7

B6. In order to pay for the clean-up fund described in question B5, funding would be needed. What is the **maximum, one time** tax increase that you would be willing to pay to clean up acid mine drainage in the West Branch Susquehanna River and its stream tributaries? (Please circle the highest amount that you would be willing to pay remembering your household budget)

$0	$5	$10	$15	$20
$30	$40	$50	$75	$100
$125	$150	$200	$300	$500
$1,000	Other (please specify) $_______			

If you answered question B6, please skip to B8.

B7. If your answer is **NO** to question B5, which statement best reflects why you would oppose the referendum to create a fund to clean up acid mine drainage in the West Branch Susquehanna River and its stream tributaries? (Please check one)

____ I support AMD clean-up, but I can't afford to pay any more taxes.
____ I support clean-up, but I think someone else other than the state should pay for the clean up.
____ I support clean-up, but don't support any new taxes.
____ I don't support a clean-up fund because there are higher priorities for spending state money.
____ I don't think acid mine drainage is a problem in the West Branch region.
____ Other, please explain ____________________________
____

8

B8. Thinking about your responses to the previous three questions, please indicate how strongly you agree or disagree with each of the following (Please check one level for each)

A. I am confident that I would have picked the same answer if the referendum were actually on the ballot.

Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
___	___	___	___	___

B. I had enough information to decide whether or not to clean-up the West Branch Susquehanna River and its stream tributaries.

Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
___	___	___	___	___

C. I would use a cleaned up West Branch Susquehanna River and its stream tributaries more than I currently use them now.

Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
___	___	___	___	___

Please express any comments or thoughts that you have about water quality in the West Branch Susquehanna River and its stream tributaries.

____
____
____
____

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Section C: We would like to finish up this survey with some questions about you. These questions are for research purposes only. The information that you provide will remain confidential and will not be shared with any business or other institution. (Please check one response for each question)

C1. What is your gender?
____ Male
____ Female

C2. What is your year of birth? 19______

C3. Including yourself, how many people live in your household? __________

C4. Where do you receive your household water supply? (Please check all that apply)

____ Private water well
____ Municipal or public water system
____ Other, please explain______________________________

C5. What is your zip code? __________

C6. What is the highest level of education that you completed? (Please check one)

____ Eighth grade or less
____ High school diploma or GED
____ Technical school
____ College degree
____ Graduate school

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C7. What was your total household income for 2006? (Please check one)

____ Under $10,000
____ $10,000 - $14,999
____ $15,000 - $24,999
____ $25,000 - $34,999
____ $35,000 - $49,999
____$50,000 - $74,999
____ $75,000 - $99,999
____ $100,000 - $149,999
____ $150,000 - $199,999
____ $200,000 or more
____ I choose not to answer this question.

Thank you for participating in this survey. Your time is appreciated. Please return this survey by folding lengthwise and inserting into the addressed envelope provided. **No postage is required.**

If you would like to be sent a copy of the results, please fill in your name and mailing or email address below:

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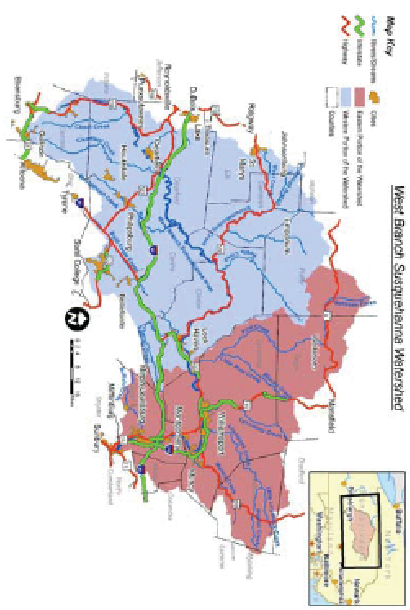

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APPENDIX D: OUT-OF-WATERSHED WILLINGNESS-TO-PAY QUESTIONNAIRE

Pennsylvania Clean Water Survey 2007

The red-orange color shows the impact of acid mine drainage on the West Branch Susquehanna River just below the confluence with Alder Run.

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Section A. First, we would like to find out some general information about your concerns and knowledge of clean water in Pennsylvania along with your outdoor recreation activities.
===

A1. Why is clean water in Pennsylvania rivers and streams important to you? (Please check all reasons that apply)

____ To provide water for drinking and household use.
____ To provide water for industrial or agricultural use.
____ For water-based recreation (swim, boat, fish, etc.).
____ To provide good habitat for fish and wildlife.
____ To protect the environment.
____ It is not really important to me.
____ Other. Please explain ____________________

A2. What outdoor activities do you regularly participate in, i.e. more than once per year? (Please check all that apply)

____ Fishing in a lake, river, or stream
____ Kayaking, canoeing or rafting rivers or streams
____ Swimming or wading in a lake, river, or stream
____ Hiking or biking along a river or stream
____ Picnicking near a river or stream
____ Hunting
____ Bird watching activities
____ None of the above

A3. How would you describe your level of knowledge about Pennsylvania rivers and streams? (Please check one)

____ High
____ Medium
____ Low

A4. In your opinion, how clean are Pennsylvania rivers and streams? (Please check one)

____ Very clean
____ Clean
____ Some are clean, some are polluted
____ Polluted
____ Very polluted
____ Don't know

A5. The state of Pennsylvania has a Growing Greener program that provides funds for environmental protection. In your opinion, how should state government spend Growing Greener funds? (Please check all that apply)

____ To clean up polluted rivers and streams
____ To develop alternative energy sources (wind, solar, etc.)
____ To improve and maintain parks
____ To clean up trash dumps
____ To clean up toxic waste sites
____ To protect farmland and open space from development
____ To promote community revitalization and beautification
____ Other. Please explain ______________________________
____ Don't know

Section B. This section refers to the West Branch Susquehanna River.

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Introduction to Question B4

Acid mine drainage (AMD) from abandoned coal mines has been identified as the primary pollution problem on the West Branch Susquehanna River and its stream tributaries. AMD is caused by the flow of water through abandoned coal mine lands such as surface mines, deep mines, or coal refuse piles. Water polluted by AMD is typically acidic and has high levels of toxic heavy metals such as iron, aluminum, and manganese. AMD-

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B5. One way to provide money for AMD clean up is for the state of Pennsylvania to create a fund through a statewide referendum. Suppose that the following referendum was placed on the next ballot in the state of Pennsylvania:

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How would you vote on this referendum? (Please check one)

____ Yes, I would support a referendum on an AMD clean up fund (Please answer question B6)
____ I am unsure how I would vote (Please answer question B6)
____ No, I would oppose an AMD clean up fund (Please skip to question B7)

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B6. In order to pay for the clean-up fund described in question B5, funding would be needed. What is the **maximum, one time** tax increase that you would be willing to pay to clean up acid mine drainage in the West Branch Susquehanna River and its stream tributaries? (Please circle the highest amount that you would be willing to pay remembering your household budget)

$0	$5	$10	$15	$20
$30	$40	$50	$75	$100
$125	$150	$200	$300	$500
$1,000	Other (please specify) $_______			

If you answered question B6, please skip to B8.

B7. If your answer is **NO** to question B5, which statement best reflects why you would oppose the referendum to create a fund to clean up acid mine drainage in the West Branch Susquehanna River and its stream tributaries? (Please check one)

____ I support AMD clean-up, but I can't afford to pay any more taxes.
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____ I don't support a clean-up fund because there are higher priorities for spending state money.
____ I don't think acid mine drainage is a problem in the West Branch region.
____ Other, please explain ___________________________
____

8

B8. Thinking about your responses to the previous three questions, please indicate how strongly you agree or disagree with each of the following (Please check one level for each)

A. I am confident that I would have picked the same answer if the referendum were actually on the ballot.

Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
___	___	___	___	___

B. I had enough information to decide whether or not to clean-up the West Branch Susquehanna River and its stream tributaries.

Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
___	___	___	___	___

C. I would use a cleaned up West Branch Susquehanna River and its stream tributaries more than I currently use them now.

Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
___	___	___	___	___

Please express any comments or thoughts that you have about water quality in the West Branch Susquehanna River and its stream tributaries.
____
____
____
____

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C1. What is your gender?
- ____ Male
- ____ Female

C2. What is your year of birth? 19______

C3. Including yourself, how many people live in your household? __________

C4. What is your race? (Please check one)

- ____ African-American
- ____ Asian
- ____ Caucasian (White)
- ____ Hispanic
- ____ Other

C5. What is your zip code? __________

C6. What is the highest level of education that you completed? (Please check one)

- ____ Eighth grade or less
- ____ High school diploma or GED
- ____ Technical school
- ____ College degree
- ____ Graduate school

C7. What was your total household income for 2006? (Please check one)

____ Under $10,000	____ $50,000 - $74,999
____ $10,000 - $14,999	____ $75,000 - $99,999
____ $15,000 - $24,999	____ $100,000 - $149,999
____ $25,000 - $34,999	____ $150,000 - $199,999
____ $35,000 - $49,999	____ $200,000 or more

____ I choose not to answer this question.

Thank you for participating in this survey. Your time is appreciated. Please return this survey by folding lengthwise and inserting into the addressed envelope provided. **No postage is required.**

If you would like to be sent a copy of the results, please fill in your name and mailing or email address below:
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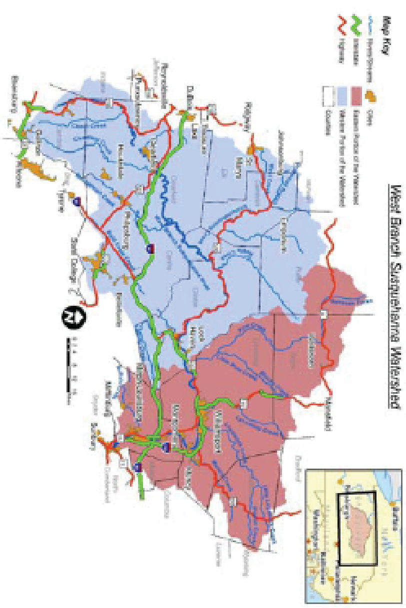

APPENDIX E: DETAILS ON THE WILLINGNESS-TO-PAY MODEL

A Tobit model was used to apply WTP estimates to the general population and to account for protest responses.

Tobit models are based on economic behavior that yields numerous zero (or other limit) outcomes (Wooldridge, 2006). When employing a Tobit model, a latent variable (y*) format was assumed:

$y^* = \beta X + u$ where u is an error term with a normal distribution $(0, \sigma^2)$
$y = y^*$ if $y^* > 0$
$y = 0$ if $y^* \leq 0$

In this study, the latent variable (y*) represents a respondent's true value of AMD restoration in the WBSR watershed and y represents a respondent's stated value from the CVM question. When $y^* > 0$, a respondent is able to express her/his monetary value from restoration as a WTP (i.e., s/he does not claim a property right to clean water). When $y^* \leq 0$, a respondent claims a property right to clean water in the WBSR watershed and expresses a zero response within a WTP format in the CVM question. In this case, a respondent wishes to express her/his true value as a willingness-to-accept or a negative y*. In order to estimate positive WTP values from these protest values, only predicted y values from the Tobit model were utilized.

Tobit analyses of survey data for the CVM question were conducted with the software package LIMDEP (Greene, 2002). A log likelihood function was formed that included respondents with a stated positive value in the CVM question plus respondents with zero values but who were designed as protest responses. Maximum likelihood estimation (MLE) was used to derive β and σ (standard deviation of u) estimates.

The matrix of independent variables included knowledge, use, and demographic variables (Table 24). Other independent variables considered in modeling of WTP included: knowledge variables (river pollution levels, environmental problem in WBSR, and enough information given in the CVM question); recreational use variables (various outdoor activities); and demographic characteristics (gender, age, income). None of these other variables were important in explaining variation in WTP.

Three separate Tobit models were estimated: (1) using survey data from inside the WBSR watershed; (2) using survey data from outside the watershed; and (3) using pooled data from both samples. A likelihood ratio test was used to determine if the sample can be pooled inside and outside the watershed. This test utilized a null hypothesis that coefficients (β) were equal inside and outside. A chi-square statistic (χ^2) for the likelihood ratio test gave a statistically significant result to not accept the null hypothesis:

$$\chi^2_{df=10} = 33.3 \ (\chi^2_{.01,df=10} = 23.2)$$

Thus, separate models were estimated for survey data using data inside and outside the watershed because the coefficients were not statistically equal.

Since Tobit models rely on an assumption of homoskedasticity[19] (Wooldridge 2006), this assumption was tested and rejected in favor of models adjusted for heteroskedasticity both inside and outside the watershed. Multiplicative heteroskedasticity on variance term was assumed using the following variables: Inside (UNSURE and COLLEGE); and Outside (UNSURE, FAMILIAR, and CURRENT).

Table 24: Variable definitions and expected impacts

Name	Definition	Expected Impact
Dependent		
WTP	Positive values to a maximum one-time tax increase for watershed clean-up and protest zero responses	N/A
Independent		
Knowledge		
AWARE	Respondent awareness of AMD in WBSR prior to survey, yes=1, no=0 (means: 0.5 inside; 0.13 outside)	-
FAMILIAR	Respondent familiar with WBSR prior to survey, 1=no, 0=yes (means: 0.22 inside; 0.72 outside)	-
KNOW	Respondent level of knowledge about Pennsylvania rivers and streams, 1= high, 0=medium or low (means: 0.12 inside; 0.09 outside)	+
Use		
CURRENT	Visits to WBSR in the past five years, 0=none, 1= 1 to 5, 2= 6 to 20 , 3= over 20 (means: 1.4 inside; 0.49 outside)	+
FUTURE	Respondent would use a cleaned up WBSR more than current use. 1=strongly agree or agree, 0=otherwise (means: 0.24 inside; 0.4 outside)	+
RIVER	Respondent participates in river-based recreation, 1=yes, 0=no (means: 0.15 inside; 0.13 outside)	+
Demographics		
COLLEGE	Respondent education level, 1=college degree, 0=less than college (means: 0.41 inside; 0.48 outside)	+
WELL	Respondent uses private well for household water supply, 1=yes, 0=no (means: 0.41 inside)	+
Other		
UNSURE	Respondent was unsure about referendum response, 1=yes, 0=no (means: 0.38 inside; 0.39 outside)	-

Table 25 presents four sets of Tobit model results: initial and heteroskedastic-adjusted models for inside and outside the watershed survey data. All models were statistically significant based on Lagrangian Multiplier (LM) tests. Adjustments for heteroskedasticity improved the LM test statistics but decreased the statistical significance of variable coefficients. Variables with coefficients that are statistically different from zero in the adjusted models included COLLEGE, WELL, and UNSURE (inside) and COLLEGE and FUTURE (outside).

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[19] This assumption is that variance of the error term (σ^2) does not change over the range of observed data. Violation of this assumption means that variance does change, i.e., variance is heteroskedastic.

Table 25: Tobit model results, unadjusted and adjusted for heteroskedasticity

	Inside the watershed (N = 95)		Outside the watershed (N= 80)	
Variable	Coefficients	Adjusted coefficients	Coefficients	Adjusted coefficients
CONSTANT	-0.796	-1.675	-28.541	-14.147
AWARE	-19.477	-1.414	-46.518	35.047
FAMILIAR	-20.292	-9.814	13.131	12.267
KNOW	15.651	6.709	56.798*	-0.291
CURRENT	-0.045	4.133	26.106*	-0.668
FUTURE	19.743	7.712	61.581**	49.799**
RIVER	21.218	10.292	32.440	34.714
COLLEGE	48.484***	34.624***	51.256***	34.725**
WELL	24.807**	18.527*		
UNSURE	-29.274**	-17.901*	-16.368	1.32
Sigma	50.753***	33.468***	85.338***	33.05***
Heteroskedasticity variables				
FAMILIAR				0.661***
CURRENT				0.653***
COLLEGE		0.790***		
UNSURE		-0.905***		-0.750***
LM TEST	48.09***	70.89***	59.88***	472.9***

Note: Statistical significance levels: *** = p < .01 , ** = p < .05 , * = p < .10. The variable WELL was not included in the outside-the-watershed questionnaire.

Predicted y values were computed using the heteroskedastic-adjusted coefficients for each respondent with a positive CVM response or a protest response. After including respondents with a true zero response, WTP estimates for sample respondents inside and outside the watershed were derived:

Inside: Mean WTP = $25 +/- 3.25[20] Number of observations = 127
Median WTP = $22

Outside: Mean WTP = $34 +/- 5.43[21] Number of observations = 99
Median WTP = $36

These WTP estimates were on a per-household basis and represent a maximum one-time payment for restoration of damages caused by AMD in the WBSR watershed. Both inside and outside WTP estimates have very similar mean and median values so that the predicted y's from the Tobit model were not skewed. Also, mean WTP for WBSR restoration was about one-third higher among respondents outside the watershed than inside. This result was explained by several factors: higher education levels among outside respondents, and familiarity with the WBSR watershed increased WTP among respondents outside the watershed but decreased WTP for inside respondents, perhaps due to a greater acceptance of the problem by people living in the watershed.

[20] 90% confidence interval.
[21] 90% confidence interval.

Respondents were assumed to be the percentage of the affected population that is represented by the survey sample. These percentages were set at the survey response rates: 15.88% inside and 12.60% outside the watershed.

Non-respondents were assumed to be the remaining percentage of the affected population, and were assumed to be represented by characteristics of those who did not respond to the survey. These characteristics were derived primarily from assumptions about non-respondents, survey data, or census information (Table 26). Non-respondents from both inside and outside the watershed were assumed to unaware of AMD in WBSR prior to survey (AWARE=0), have a low or medium level of knowledge about Pennsylvania rivers and streams (KNOW=0), not be a current or future recreational user of the WBSR watershed (CURRENT=0 and FUTURE=0), not to participate in river-based recreation (RIVER=0), and to be unsure about their response to the referendum (UNSURE=1). Familiarity with the WBSR watershed was derived from survey averages, and the percentage of college graduate came from 2000 census data. Information about private well usage in the WBSR watershed was obtained from Clemens (2007).

The Tobit model constructed to calculate WTP for respondents was used to predict WTP for non-respondents. With variable levels set at values in Table 26, predicted y values from inside and outside Tobit models were computed at $10.4 and $15.2, respectively. Adjusting for the same percentage of true “$0” as in the survey, non-respondent WTP estimates were computed at $8 inside and $12 outside the watershed. These WTP estimates were regarded as reasonable, being approximately one-third the size of respondent WTP estimates.

Table 26: Variable values used for computation of non-respondent willingness-to-pay

Variable	Inside value	Outside value
AWARE	0.00	0.00
FAMILIAR	0.22	0.7
KNOW	0.00	0.00
CURRENT	0.00	0.00
FUTURE	0.00	0.00
RIVER	0.00	0.00
COLLEGE	0.183	0.259
WELL	0.329	-
UNSURE	1.00	1.00