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issues

**Southwestern Pennsylvania's
Water Quality Problems and
How to Address Them Regionally**

*by Conrad Daniel Volz
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Conrad Daniel Volz, DrPH, MPH, has 30 years of experience in water, air, and soil environmental contaminant characterization, human and ecological exposure and risk assessment, fate and transport analysis, environmental remediation projects, and hazard communication. Volz has performed environmental consulting services for private industry, the federal government, foreign governments, and NATO in 24 different countries on five continents. Volz is on the faculty of the University of Pittsburgh Graduate School of Public Health (GSPH) in the Department of Environmental and Occupational Health. He is the scientific director of the Center for Healthy Environments and Communities at GSPH; he is also codirector of the Division of Environmental Assessment, Monitoring, and Control at the University of Pittsburgh Cancer Institute's Center for Environmental Oncology.

Volz's research interests are primarily focused on how point- and nonpoint-source water toxins and carcinogens are taken up in fish and eaten by humans and what risk of disease this poses to the population. He is especially interested in how contaminants move through the environment to surface water and groundwater and how to block this movement. Volz is the principal investigator for projects to measure the amount of heavy metals, including mercury, as well as estrogenicity in fish in the Three Rivers area. He was director of the 2004 Amchitka Expedition in the far western Aleutian Island chain to determine radionuclide concentrations in marine plants and animals and the risk to commercial fishing operations from underground nuclear test shots fired on the island during the Cold War. At GSPH he is also a coinvestigator in the new Centers for Disease Control and Prevention Environmental Public Health Tracking Academic Center of Excellence.

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This text is not an exhaustive study of water

quality in Southwestern Pennsylvania.

Instead, it is designed as an integrative reference guide for concerned citizens, community leaders, and public officials to better understand how water quality directly and indirectly affects the region's health.

The document is divided into eight chapters that discuss Southwestern Pennsylvania's water problems and the ensuing public health effects, culminating with a series of recommendations to improve the region's water quality and planning. We hope that this brief will encourage informed discussion and enhance the ongoing efforts to remedy our region's water problems.

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The views expressed in *Issues* are those of the author and are not necessarily those of the University of Pittsburgh or the Institute of Politics.

THE MAKING OF A WATER QUALITY DEVOTEE

I grew up on a farm in Cranberry Township, Butler County. My first memories were walks with my grandmother to a little northern jungle of a watercourse, surrounded by deeply sloped hardwood forests and secret bird nests. There we would listen to the spring peepers, look for frogs, make boats in the tall grass, cool off in high summer, and watch the leaves move toward the Beaver River in the fall.

As I grew up my friends and I enjoyed exploring Brush Creek, finding the best swimming and fishing holes in summer and skating for miles in winter. We were constantly surrounded by muskrats, mink, great blue heron, and the occasional beaver, in a setting now transformed forever by rapid development.

High school came and I discovered additional watercourses, like Connoquenessing Creek, where we would meet sweethearts at riverside cottages. Not until later did I learn that the large-scale algae blooms that occurred in the creek, especially at low flow periods in the summers, were the result of severe industrial pollution.

During college my weekend recreational base changed from the Connoquenessing to the Youghiogheny River, where I came

face to face with the impact of abandoned mine drainage. My kayaker friends and I would stop near Cucumber Falls to drain our boats and stand under the falls—and notice that the water was an unsightly copper color and tasted foul besides.

After living for a time in water-starved California, I returned to Pittsburgh with my own family and we joined the Sylvan Canoe Club in Verona. Though reluctantly at first, I began swimming in the Allegheny River with my young daughter. We were thus acutely aware of the many days when wet-weather advisories kept us from swimming or even canoeing in the Allegheny for fear of waterborne illness. We would watch sewage overflows move past us downriver, wondering what they were leaving behind in river sediments and whose responsibility it was to fix the problem.

Since then, as president of an environmental consulting firm, I have personally witnessed the success of major remediation efforts in the United States and Europe. I have seen the integrated water planning of the Netherlands, whose rivers accommodate barge traffic, drinking water, and recreation simultaneously and smoothly. Now I have sold the firm and returned to academia, where I have been doing research on such topics as how the heavy metals

and chemicals in our rivers cause male fish to display female characteristics. I have talked with hundreds of recreationists who, despite a dramatic improvement in water quality during the last 25 years, still deal with problems like those I observed in my younger days: raw sewage or surges of gasoline and oil in the rivers, stream erosion, abandoned mine drainage, and ongoing release of toxic chemicals and heavy metals from contaminated sites and sediments.

Can these problems be fixed? Yes, and they must be fixed if we are to thrive as a region. But water problems know no jurisdictional boundaries. We must come together to solve them regionally, just as we build our highways regionally. If we do not, our natural advantage as a region blessed with abundant water will go down the drain.

This *Issues* essay presents a “chain of causation” designed to show the relationships among Southwestern Pennsylvania’s water problems, their causes, and their implications. The model will then be used to suggest what public policy interventions could break the chain and improve the region’s water management. This *Issues* essay supplements available research with interviews and focus groups that highlight the deeply personal impact of water problems.

OVERVIEW OF WATER QUALITY IN THE SOUTHWESTERN PENNSYLVANIA WATERSHED

A watershed is all the land area that drains into any particular stream, creek, river, or lake. The geographical reach of the watersheds that flow through the Southwestern Pennsylvania region extends from south central West Virginia and northwestern Maryland to southwestern New York and from eastern Ohio to the Appalachian ridges. Most of us, especially those living in urban and suburban areas, receive our drinking water from surface sources like rivers and creeks. Some communities and individuals get their drinking water by pumping it from underground aquifers, also called groundwater sources.

The quality of water provided by these sources varies significantly. Waters flowing from the Allegheny Plateau and Appalachian ridge regions that are unaffected by mine drainage or oil extraction processes are generally of very high quality and support a diversity of aquatic species (Anderson et al., 2000). Groundwater in these areas is also usually very good. On the other hand, groundwater sources in former mining areas, such as large portions of Greene,

Fayette, and Washington Counties, are often contaminated. Some streams in both the Allegheny and Monongahela watersheds remain so severely compromised by abandoned mine drainage (AMD) that they cannot support aquatic life. Oil refineries in both Venango and Butler Counties impact Allegheny River water quality.

The Youghiogheny River, a major tributary of the Monongahela, has improving water quality, mainly due to improvements in controlling AMD, and provides world-class white-water boating and other forms of recreation. The main stem of the Monongahela River is compromised by mine drainage from tributaries in both West Virginia and Pennsylvania (Sams and Beer, 2000). As the Monongahela River flows north toward Pittsburgh, water quality is further degraded by industrial activities, especially those related to iron and steel production or their by-products. It is well known that river sediments retain these pollutants for long periods (Hemond and Fechner-Levy, 2000). The Monongahela River was listed in 1970 as one of the top 10 polluted water bodies in the United States (EPA, 1995).

The Beaver River, which drains into the Ohio, has less noticed but equally serious problems. Pennsylvania counties in this watershed include Mercer, Butler,

Lawrence, Allegheny, and Beaver. Many communities obtain their drinking water from the Beaver or its feeder waterways, such as the Neshannock, Shenango, Mahoning, Slippery Rock, and Connoquenessing watersheds. This water system was made infamous by extreme pollutant levels placed in the Mahoning River by iron and steel mills in Youngstown and Warren, Ohio (Youngstown State University Public Service Institute, 2007). The Mahoning is a low-flow river compared to the Monongahela. Toxic and carcinogenic contaminants in the Mahoning, combined with those from the Sharon/Farrell area in the Shenango River, have caused contamination of drinking water sources in downstream communities such as Beaver Falls.

Sections of the Mahoning’s sediment and riverbank remain so severely contaminated with carcinogenic substances that the Ohio Health Department has issued an order banning contact with river sediment and all fish consumption. The U.S. Army Corps of Engineers is undertaking a cleanup of riverbed sediment and of riverbank and floodplain contamination on a 30-mile stretch of the river in Ohio just outside Lawrence County. Additionally, two Superfund toxic waste sites on the Shenango River in Sharon are undergoing active assessment and cleanup. These

efforts should produce significant long-term improvement in water quality and recreational value for downstream communities.

Water Quality Improvements on the Three Rivers

Both research data and anecdotal evidence suggest recent improvements in the water quality of the Allegheny, Monongahela, and Ohio Rivers as well as in the region's smaller streams (Anderson et al., 2000). Factors in this improvement include a decrease in pollution discharges because of area manufacturing plant closings, a changing federal regulatory climate that has encouraged tighter pollution controls, and federal and state initiatives to control mine drainage. The diversity and abundance of aquatic life are primary indicators of water quality in these rivers, and surveys show an increase in the number of fish species in all main stem rivers. In 1900 the Monongahela River was almost devoid of fish species except during high water periods; a recent study has shown as many as 20 fish species in the Monongahela River (Pennsylvania Fish and Boat Commission, 2003; Venture Outdoors, 2005).

Focus groups of Pittsburgh-area anglers provide similarly encouraging reports (Volz and Christen, 2005-06). More than half of the anglers agreed that the "water

quality is improving all the time," and older members said there has been an incredible change from the fish kills, soap suds, and industrial releases they remembered seeing in the rivers. Some anglers pointed out that the area near where the Allegheny County Sanitary Authority plant discharges its effluent into the Ohio River is actually a good place to catch walleye and other species.

Washington County Commissioner Bracken Burns, currently chair of the Southwestern Pennsylvania Commission and cochair of the Institute of Politics Environment Policy Committee, said the region's water quality, like its air quality, "is much better than in the 1940s or 1950s, when Pittsburgh was known as hell with the lid off." He added, however, that even with these improvements "we still beat ourselves up, and the EPA comes in and helps us beat ourselves up, and our good friends in other states help us beat ourselves up by bringing pollution our way."

Existing Regional Studies and Comprehensive Watershed References

There have been several substantial inquiries into Southwestern Pennsylvania's water problems. This essay is not intended to replicate these studies but makes use of selected technical information in them to aid in

the presentation of a unified public health approach to water management. It is designed to serve as a toolbox for policy makers, regulators, authority members, watershed groups, and individual citizens alike. While this text can certainly be read in its entirety, many readers will find its best use as a guiding framework and reference on the region's numerous water challenges.

Those who want more detailed technical information on the state of our watersheds, contaminants within them, and the total impact of municipal and household sewage should consult the following studies: the National Research Council's 2005 report, *Regional Cooperation for Water Quality Improvement in Southwestern Pennsylvania* (Washington, D.C.: National Academies Press); *Water Quality in the Allegheny and Monongahela River Basins of Pennsylvania, West Virginia, New York and Maryland, 1996-98*, U.S. Geological Circular 1202 by R. M. Anderson et al. (2000); and *Investing in Clean Water: A Report from the Southwestern Pennsylvania Water and Sewer Infrastructure Project Steering Committee* (2002).

Additionally, depicting the full complexity of interactions of all possible factors that impact water quality is beyond the scope

of this work. Readers who want more detailed information are referred to the National Research Council Committee on Watershed Management's *New Strategies for America's Watersheds* (NRC, 1999) and *Sources, Pathways and Relative Risks of Contaminants in Surface Water and Groundwater: A Perspective Prepared for the Walkerton Inquiry* (Ritter et al., 2002).

A Lack of Data

Despite the above-referenced studies, complete and up-to-date water quality data for decision-making purposes are not readily available. We should note with dismay what we don't know. Due to the lack of adequate historical and real-time water quality and sediment sampling data for both major rivers and feeder streams, we really don't know how much of various pollutants (such as heavy metals, pesticides, hydrocarbons, oils, or grease) are in our untreated water or riverbanks and sediments. Many of these pollutants can cause cancer, neurological problems, developmental defects, and other chronic health problems; at this time we can only guess as to whether they appear in sufficient concentrations to pose a health threat here.

As Jared Cohon, president of Carnegie Mellon University and chair of the Regional Water Management Task Force, has

stated, “It is shocking how little we know about our rivers, not only in Pittsburgh but in other parts of the country.” Cohon says that the availability of water quality data has declined during the last 20 years and that existing data are not stored in convenient repositories that are available to researchers, planners, and policy makers. Knowledge of the actual concentration of river, lake, and stream contaminants is necessary for any realistic assessment of health risk from exposure to these agents.

Water Issues Are Integrated

Water issues such as sewage, water quality, water quantity, stormwater drainage, flooding, and watershed protection are closely interrelated and should be examined holistically (National Research Council, 1999; Anderson et al., 2000; WSIP, 2002). For example:

- Unsustainable forms of land use increase flood risks, negatively affect stormwater flow patterns, and deplete ecosystems all at the same time.
- Surface water and groundwater are physically interconnected and should not be treated as two separate entities.

- Untreated sewage resulting from overflows of combined sewers (which receive both stormwater and wastewater and thus cannot handle increased flows in wet weather) impairs water quality.
- In rural areas, flooding causes an increase in the concentration of pesticides in feeder streams.

Although we think of Southwestern Pennsylvania as a region blessed with abundant water, our problems with water *quality* can even threaten water *quantity*. The reason is that existing water treatment plants have limited capacity to purify available water so that it meets present drinking water standards. If the water gets dirtier, plants’ capacity will be stretched even further and the expense of treating water will increase.

“Water is probably our greatest regional asset right behind our people,” said Commissioner Burns, and not treating it in an integrated manner will directly affect regional economic development. Burns believes that we are often “throwing good money after bad” in trying to keep substandard sewage treatment plants afloat. “We are dividing ourselves into such small compartments,” he

stated, “that no one is enjoying any of the economies of scale or efficiency they could have.” Moreover, he argued, runoff from strip malls, parking lots, and paved streets is an important factor in the increased risk of catastrophic flooding. Burns expects that our flooding problems will only get worse until we begin to plan from a watershed-based perspective.

The Chain of Causation

The illustration on the inside back cover of this publication shows how water-related issues can lead to significant human suffering of numerous types. Category 1, Primary Water-Related Problems, can either cause or exacerbate Category 2, Water Contamination Problems, and Category 3, Loss of Ecological Services. Categories 2 and 3 also can combine to make Category 1 issues worse. Additionally, there is a feedback

loop from Category 3 to Category 2, in that ecological degradation hinders natural purification of water so that Category 2 contaminants can build up; this increasing contamination in turn can further erode the ecosystem’s ability to purify and hold water. The problems in Categories 1, 2, and 3, alone or in combination, result in Category 4, Secondary Water Management Outcomes, such as stormwater surges and flooding. Finally, these secondary outcomes result in Category 5, Tertiary Environmental Public Health, Medical, Social, Emotional, and Economic Outcomes. For example, flooding has the tangible effects of property loss, economic and health problems, psychological distress, and fatalities.

Major issues that fall into each of these categories are enumerated in the box on the next two pages.

A CHAIN OF CAUSATION: FROM PRIMARY WATER-RELATED ISSUES TO TERTIARY ENVIRONMENTAL PUBLIC HEALTH, MEDICAL, SOCIAL, EMOTIONAL, AND ECONOMIC OUTCOMES

Category 1: Primary Water-Related Problems

Release of municipal and household sanitary wastes directly into area water

- Aging/inadequate municipal sewer infrastructure

- Wildcat sewers and failing on-lot septic systems

- Fragmentation of water and sewer planning and management

Abandoned and active mines

Issues related to nonsustainable development

- Lack of coordinated water and land management plans

- Development in headwaters and critical watersheds

- Sprawl

Past and ongoing industrial pollution

- Contamination from the iron and steel industry

- Superfund, waste dump, and brownfield sites

- Deposition of contaminants from power plants and other industrial sources

Nonpoint-source pollution

- Household hazardous waste

- Application of lawn pesticides and nutrients

- Road topping compounds

- Vehicle exhaust

Past and present agricultural chemical use

Personal and societal attitudes toward water usage

Fragmented local, state, and federal regulatory climate

Spills or accidental releases of toxic and hazardous substances

Gravel and sand mining in main stem rivers

Category 2: Water Contamination Problems

Pathogens

Nitrates

Heavy metals: mercury, lead, copper, chromium, and cadmium

Arsenic: naturally occurring or from poultry or industrial operations

Volatile organic compounds (VOCs)

Contaminants associated with mine drainage

Pesticides and herbicides

Polychlorinated biphenyls (PCBs) and other organohalogen substances (OHSs)

Endocrine-disrupting compounds (EDCs)

Radon

Highly acidic or alkaline water

Category 3: Loss of Ecological Services

Wetland loss

Deforestation

Loss of topsoil and plant cover

Loss of native plant species

Loss of subsoil integrity

Loss of natural drainage patterns

Changes in stream and river flow characteristics

Decrease in groundwater recharge

Land and streambed erosion

Endocrine disruption in aquatic species and feeders

Uptake of contaminants in nature's food web

Riparian habitat loss

Category 4: Secondary Water Management Outcomes

Human pathogens in surface water

Human pathogens in groundwater

Increased potential for mine blowouts

Increased sediments in surface water

Decreased production of clean surface water and groundwater

Increased stormwater/snowmelt runoff

Increased contaminant loads in surface water and groundwater

Consumption of contaminated fish

Flooding

Human exposure to carcinogens, toxic substances, and endocrine-active substances

Category 5: Tertiary Environmental Public Health, Medical, Social, Emotional, and Economic Outcomes

Loss of life and property due to flood damage

Increased environmental asthma

Increased stormwater management costs

Increased cost of water purification

Decreased recreational and aesthetic value

Decreased economic growth

Loss of aquatic and terrestrial species

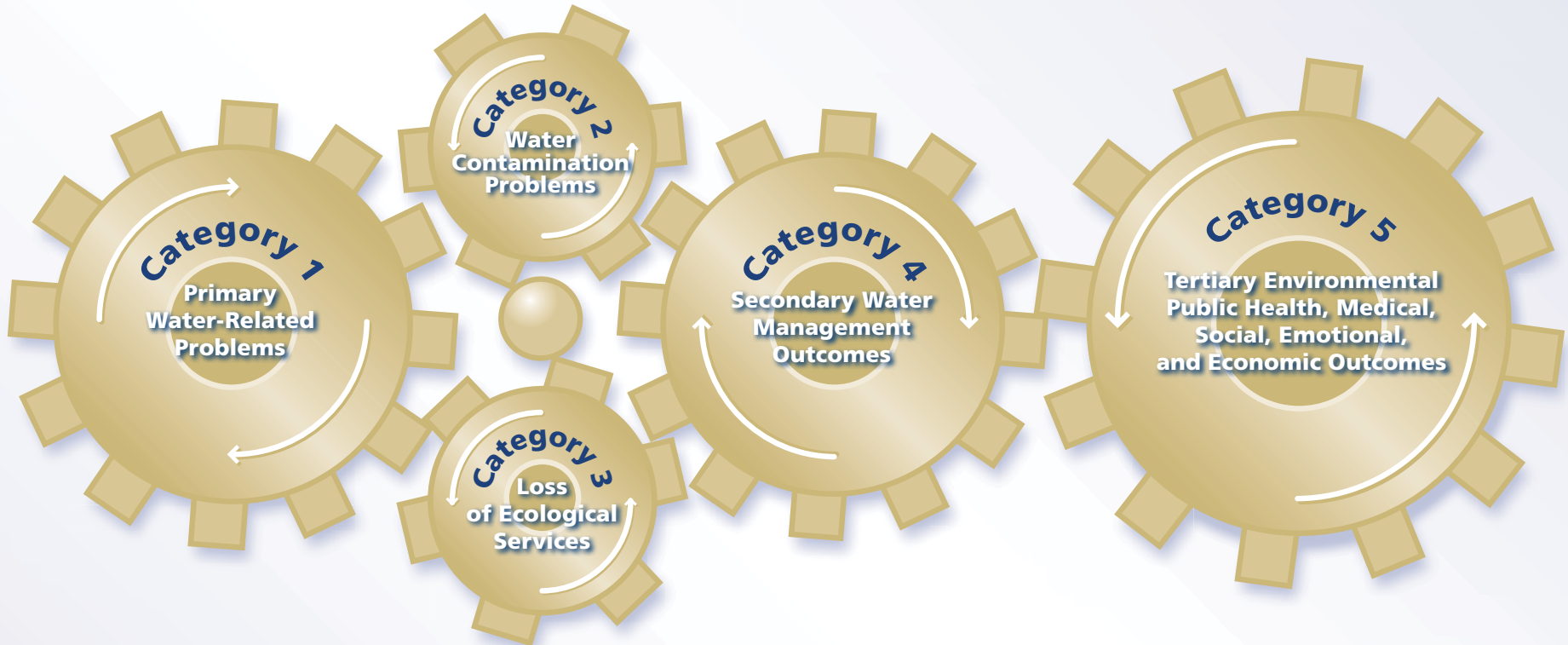
Increased cost of flood insurance

Increased risk of cancer, waterborne pathogen diseases, and other environmental diseases

Unavailability of safe drinking water

A Chain of Causation:

From Primary Water-Related Issues to Tertiary Environmental Public Health, Medical, Social, Emotional, and Economic Outcomes



Category 1: Primary Water-Related Problems

Release of municipal and household sanitary wastes directly into area water

- Aging/inadequate municipal sewer infrastructure
- Wildcat sewers and failing on-lot septic systems
- Fragmentation of water and sewer planning and management

Abandoned and active mines

Issues related to unsustainable development

- Lack of coordinated water and land management plans
- Development in headwaters and critical watersheds
- Sprawl

Past and ongoing industrial pollution

- Contamination from the iron and steel industry
- Superfund, waste dump, and brownfield sites
- Deposition of contaminants from power plants and other industrial sources

Category 2: Water Contamination Problems

Nonpoint-source pollution

- Household hazardous waste
- Application of lawn pesticides and nutrients
- Road topping compounds
- Vehicle exhaust

Past and present agricultural chemical use

Personal and societal attitudes toward water usage

Fragmented local, state, and federal regulatory climate

Spills or accidental releases of toxic and hazardous substances

Gravel and sand mining in main stem rivers

Category 3: Loss of Ecological Services

Pathogens

Nitrates

Heavy metals: mercury, lead, copper, chromium, and cadmium

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Highly acidic or alkaline water

Category 4: Secondary Water Management Outcomes

Wetland loss

Deforestation

Loss of topsoil and plant cover

Loss of native plant species

Loss of subsoil integrity

Loss of natural drainage patterns

Changes in stream and river flow characteristics

Decrease in groundwater recharge

Land and streambed erosion

Endocrine disruption in aquatic species and feeders

Uptake of contaminants in nature's food web

Riparian habitat loss

Category 5: Tertiary Environmental Public Health, Medical, Social, Emotional, and Economic Outcomes

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Decreased production of clean surface water and groundwater

Increased stormwater/snowmelt runoff

Increased contaminant loads in surface water and groundwater

Consumption of contaminated fish

Flooding

Human exposure to carcinogens, toxic substances, and endocrine-active substances

Loss of life and property due to flood damage

Increased environmental asthma

Increased stormwater management costs

Increased cost of water purification

Decreased recreational and aesthetic value

Decreased economic growth

Loss of aquatic and terrestrial species

Increased cost of flood insurance

Increased risk of cancer, waterborne pathogen diseases, and other environmental diseases

Unavailability of safe drinking water

I have borrowed the classifications of primary, secondary, and tertiary from the field of public health to show where interventions can most successfully be applied to break the chain of causation. In public health, primary care (e.g., immunization) is always ethically and economically better than secondary care (e.g., treating the infected), which in turn is better than relying on tertiary care (e.g., hospitalizing very sick individuals for extremely intrusive and costly treatment).

We will now address the items within each category. The issues most frequently emphasized by stakeholders and focus groups are presented first, but every issue is significant.

CATEGORY 1— PRIMARY WATER-RELATED PROBLEMS

Release of Municipal and Household Sanitary Wastes Directly into Area Water

Many national and area policy makers are under the impression that waterborne infectious diseases are now only of historical interest. This attitude must be challenged because waterborne disease still occurs in the United States (Hedberg and Osterholm, 1993). In fact, it may be growing. The frequency of such outbreaks steadily increased between 1989

and 2000 (Lee et al., 2002), and the number of recreational outbreaks in 1998 was the highest since the inception of the national waterborne disease tracking system in 1971. (An outbreak is defined as at least two related cases of persons developing a disease after water contact; single cases are not reported. Many public health officials feel that waterborne disease is significantly underreported.) A massive gastrointestinal disease outbreak in Milwaukee, produced by a parasite transmitted through the public water supply, caused approximately 400,000 illnesses and 100 deaths in 1993 (MacKenzie et al., 1994; Hoxie et al., 1997; Rose, 1997).

The relationship between sewage overflows and waterborne disease is hard to measure directly, but there is a strong correlation between wet weather (when most sewage overflows occur) and disease outbreaks (Rose et al., 2000; Curriero et al., 2001).

Aging/Inadequate Municipal Sewer Infrastructure

Research studies (Fulton and Buckwalter, 2004; National Research Council, 2005; Anderson et al., 2000; WSIP, 2002), key interviewees, and recreationists all agree that the release of untreated raw sewage is the greatest threat to Southwestern Pennsylvania's water resources. Raw sewage is

discharged during wet weather from combined sewer and sanitary sewer overflows (known as CSOs and SSOs). These discharges occur in aging and inadequate municipal sewer systems, which continue to proliferate due to the region's failure to invest systematically in system upgrades. The sheer number of sewage management entities in the region makes it harder to achieve the economies of scale necessary to correct this problem.

Wildcat Sewers and Failing On-Lot Septic Systems

Raw human waste is also released into surface water from thousands of "wildcat sewers," which are illicit sewer pipes that drain the sanitary system of a home directly into ditches, culverts, or streams without treatment. In addition, on-lot septic systems (that is, systems designed to treat sewage in one home or a small group of homes without a connection to public sewers) tend to fail over time and are often not adequately serviced, again resulting in the release of raw waste into groundwater and surface water.

We have scientific evidence that the release of raw human and pet waste into our region's water presents a significant public health threat (Young and Thackston, 1999). Fecal coliform bacteria (FC) are used as indicators to determine

the possible presence of disease-causing bacteria and viruses in water. FC contamination of the Three Rivers has greatly exceeded the national average (National Council on the Environment Report, 1996, extracted from WSIP, 2002). During the 2000-2001 recreational season, 59 percent of surface water samples in Pittsburgh violated the safe contact standard for FC, compared to just 16 percent in Cincinnati. More recent studies found 18 area streams with significant bacteriological contamination (Luneberg, 2004; see also Fulton and Buckwalter, 2004).

Although the region's waters are highly contaminated by fecal coliform and pathogens, they are not considered impaired for use as sources of drinking water because of modern filtration and chlorination techniques, which can purify them to meet drinking water standards. However, the presence of raw sewage burdens our treatment processes, limits our ability to supply water to new users, and makes us vulnerable to a massive epidemic of gastrointestinal disease as seen in Milwaukee. In rural areas, failing or illegally connected septic systems, leaching from livestock pastures, and runoff from manure storage areas add fecal matter to feeder streams; these fecal pathogen sources present infection risks to rural residents who drink well water.

Stakeholder Perspectives

Caren Glotfelty, director of environmental programs for The Heinz Endowments, gets frustrated when outlying communities discount their contributions to the sewage overflow problem, saying they are not part of the large Allegheny County Sanitary Authority (ALCOSAN) system. “They have the same problem,” she said; “they are just able to send it downstream.” Glotfelty is passionate about the significant rural problems of septic runoff and wildcat sewers: “This is what you would expect to find in Third World countries, not in the richest country in the world. These [smaller] communities have not been forced by the state or federal government to fix these problems because they lack the resources to do so. We have never had the political will and the funding to take care of them.”

John Schombert, executive director of the 3 Rivers Wet Weather Demonstration Program, said federal CSO policy will require a steep reduction in the number of overflow events—from 75 or 80 a year to four or five. Schombert added that there are more than 300 overflow points where municipal systems connect to ALCOSAN and many more upstream in the municipalities. To correct the problem, he believes,

we will have to invest in sewer line and interceptor upgrades and new technology, but these improvements will not be possible without a change in Allegheny County’s sewer governance system—and plenty of money.

Myron Arnowitt, Western Pennsylvania director of the nonprofit environmental advocacy organization Clean Water Action, lamented a funding mismatch between “a lack of money for fixing existing systems” and “an ability to get bonding power for fixing the system if you add capacity for development.” This imbalance favors sprawl and inter-community competition. “Despite having a system that can’t handle the sewerage, there is no real problem getting new tap-ins,” Arnowitt stated. “Development is by and large moving forward.” He maintained that older infrastructure should be fixed before additional sewage for new developments is added, lest we put further stress on an already overburdened system.

Greg Tutsock, former executive director of the Pittsburgh Water and Sewer Authority (PWSA), said his city has about 225 CSOs, caused largely by mixed sanitary and stormwater flows that enter Pittsburgh from other municipalities. However, he was upbeat about the future: “There is now an

understanding since the consent order [placed on ALCOSAN communities by the EPA] that fixing this system must be a regional effort.” Tutsock described remediation work with Ross Township, Bellevue, and ALCOSAN to eliminate sewage infiltration of Jacks Run as an example of the cooperation needed. He pointed out that the PWSA was able to eliminate CSOs near the Allegheny River during the construction of Heinz Field, PNC Park, and the David L. Lawrence Convention Center.

Recreationists provided the most gruesome comments. Anglers in a March 2006 focus group reported frequent sightings of toilet paper, feminine hygiene products, chemicals, and other untreated sewage in the rivers during wet weather. They explained how, in some locations, even a small amount of rain causes sewage to belch forth and fish to disappear. Some anglers have contracted gastrointestinal diseases that they associate with contact with contaminated water (Volz and Christen, 2007). One fisherman became an active advocate for cleaner water after his doctor told him not to fish competitively because the contaminated water could exacerbate a prior infection. Problems happen even in dry weather because the sewer gates get jammed open by debris,

which often is not cleaned out for extended periods of time (Volz and Christen, 2005–2006).

Fragmentation of Water and Sewer Planning and Management

Southwestern Pennsylvania has one of the most disjointed systems of sewer and water provision in the country. This fragmentation is an outgrowth of political developments in the 19th and 20th centuries (Tarr, 2003) but cannot meet 21st-century demands for cost-efficient, environmentally acceptable service delivery.

More than 260 authorities and hundreds of municipalities are involved in providing sewer and water services in Southwestern Pennsylvania. It does not make public health, economic, or regulatory sense for one political subdivision to have wet-weather releases upstream of another’s intakes and not cooperate with its neighbor regarding wastewater treatment; nevertheless, this situation prevails in many locations throughout the region.

“There needs to be a major change in the way we govern ourselves,” said Washington County Commissioner Bracken Burns. “Until we do that, there is no way that we can tackle a problem as intractable and as complex as this one.” Burns sees a lack of vision on the part of both

authorities and municipalities when it comes to water management. Meanwhile, he warned, the price tag for fixing the problems is growing exponentially.

Cohon feels the lack of regional priority setting is a serious weakness and a threat to water quality: "We can't set [regional] goals if we have fragmented systems."

Schombert related the unfortunate story of how Allegheny County's sewage system remained fragmented after World War II. Originally, it was proposed that communities in Allegheny County were to give up their systems to ALCOSAN, which would locate its plant at Leetsdale, at the lowest elevation in Allegheny County on the Ohio River. "This was called Plan A," Schombert recalled. "The best models in the United States [were done in this way]. But many engineers had clients who didn't want to lose their municipal systems." These parochial attitudes toward municipal assets led to an agreement under which 65 different Allegheny County towns owned and operated their own collection system, with combined sewers at virtually every point of connection to ALCOSAN. ALCOSAN designed mechanical controls that permit diversion of sewage directly to the river when the amount of combined stormwater and wastewater would

otherwise overwhelm the system (see also Tarr, 2003).

Abandoned and Active Mines

Sulfuric acid discharge from active and abandoned coal mines is "the most pervasive and widespread water pollution problem in Southwestern Pennsylvania's industrial history" (National Research Council, 2005). Abandoned mine drainage (AMD) significantly impairs the quality of drinking water sources, and its corrosive properties have forced area water authorities to build neutralizing systems to protect water treatment plant and distribution system infrastructure. These protective actions increase costs and reduce the quantity of water that can be delivered.

AMD is produced, through geochemical and bacterial reactions, when the iron disulfides pyrite and marcasite, contained in high quantities in northern West Virginia and Appalachian and Southwestern Pennsylvania coal and overburden rock, are exposed to water and dissolved oxygen. The resultant reaction produces ferrous iron and sulfuric acid. This acidic solution dissolves other metals found in rock and soil such as aluminum, arsenic, barium, cadmium, cobalt, copper, manganese, and silver. These metals can attain concentrations well over drinking water quality

standards, threatening aquatic and human health. Sulfate is the most predictable indicator of mine drainage and can cause diarrhea in sensitive populations.

AMD has historically decimated fish and other aquatic organism populations in both small streams and main stem rivers (Casner, 1994). Federal and state regulations requiring active mining operations to treat drainage water and efforts to control AMD at abandoned mine sites have resulted in the revival of aquatic life in many streams. Although water quality is improving, the mixture of large quantities of toxic heavy metals into stream and river sediments in Southwestern Pennsylvania poses an ongoing threat.

In one study of river and streambed sediments, zinc and chromium were found in all 50 sampling sites in the Allegheny-Monongahela drainage area. Chromium is a known human carcinogen. Of the 50 sites sampled, 11 contained zinc concentrations that were in the top 10 percent nationally since 1991 (Anderson et al., 2000). In such situations, fish highest on the food chain can accumulate metal concentrations up to 100 times as high as those in the sediments; if consumed, these fish may pose a threat to human health. As a result, the Pennsylvania Fish and Boat Commission has issued fish

consumption advisories, asking consumers of fish caught in Southwestern Pennsylvania waters to limit the number of fish meals they eat.

The amount of heavy metal found in river and stream sediments is dependent on land use, with the most metals found in areas influenced by mining or other industrial activity.

Rural residents of Southwestern Pennsylvania are at risk of ingesting sulfate and dangerous metals through well water if they live near reclaimed surface coal mines. The levels of aluminum, iron, magnesium, and manganese as well as turbidity are usually higher than normal in wells within 2,000 feet of reclaimed surface mines. Private wells in areas of underground mining can be heavily contaminated with sulfate and ferric iron. This hard water smells like rotten eggs and tastes foul. We do not have good data on the extent to which private well water quality has been affected by surface or subsurface mining in Southwestern Pennsylvania.

Stakeholder Perspectives

Davitt Woodwell, western region vice president for the Pennsylvania Environmental Council (PEC), sees AMD as a high-priority issue for both environmental and political reasons. Woodwell believes AMD is at the heart of the region's

urban-rural friction concerning water resources because Allegheny County is focused primarily on combined and sanitary sewage overflows while “those in the outlying counties think that Allegheny County will steal their AMD monies for CSO and SSO fixes.” This friction illustrates the potential value of a collaborative, regional approach to water management.

Jackie Bonomo of the Western Pennsylvania Conservancy pointed out that we may need to expand our regional thinking to encompass a watershed approach, as significant portions of the AMD problem originate in northern West Virginia or as far north in Pennsylvania as the Clarion River.

Deb Simko, the Fayette County board member for the Regional Water Management Task Force, is a watershed consultant and manager of an AMD mitigation project. Simko stated firmly that AMD is the biggest threat to water quality in Fayette County and the biggest water problem in the commonwealth of Pennsylvania. “Most people here depend on well water,” she said. “People aren’t going to care about the sewage problem until they get water” free from AMD.

Glotfelty lists AMD high on her list of regional water management threats, arguing that areas affected by AMD “will never have the

opportunity to attract economic development until we solve this problem.”

Issues Related to Nonsustainable Development

Most of the experts interviewed for this study included some aspect of nonsustainable development on their list of water management problems. Among the specific practices that fall into this category are lack of coordinated water and land management plans, development in headwaters and critical watersheds, municipal infighting about development, and sprawl. Proper land-use planning, water management, and public health are vitally linked.

Large-scale paving, increase of impervious surfaces, and water diversion projects—all commonly involved in new residential and commercial development—have contributed mightily to our problem of stormwater surges and eventual flooding. These surge events also move massive amounts of contaminants into area waterways.

Proper land-use planning is itself a matter of public and environmental health because the protection of the public water supply depends on it (Greenberg et al., 2003). Across America nonsustainable development is threatening our most valuable water assets by impacting the land areas from

which our water derives. For example, the Croton and Catskill watersheds, which once produced some of the best drinking water in the United States for New York City, are now threatened by contamination from development-related nutrients, deicing material, and hazardous waste (Heisig, 1999). Similarly, a modeling exercise based on actual data from New Jersey found a substantial increase in 14 water pollutants in receiving waters under both an eight-unit-per-acre and a two-unit-per-acre development scheme (Greenberg et al., 2003). It is also well documented that increasing urbanization contributes to water turbidity associated with land and stream erosion and water sedimentation. These turbidity increases also have been linked to increases in gastrointestinal diseases (Gaffield et al., 2003). Thus, without sensitive land-use planning, our population is at higher risk for both acute and chronic health problems.

Southwestern Pennsylvania’s deep-seated culture of individual property rights influences how we deal with nonsustainable development. Private landowners’ main incentive is to maximize profit, not to safeguard the public health benefit that might accrue from leaving their land undeveloped (Volz, 2002). Developers prefer to use open space rather than

more urban landscapes because the costs of land clearance and development are lower. And many farmers feel unable to achieve an adequate financial return on their holdings. The result: despite our stagnant population numbers, area farms and associated woodlands and slopes are coming under great development pressure.

“When I first arrived in Pittsburgh 10 years ago,” said Arnowitt, “there was very little sprawl here compared with where I had come from in Eastern Pennsylvania and New England. Now the old river communities are pretty much the same, but areas away from the valleys are being developed very quickly; this pattern is especially evident in the I-279 corridor, which could serve as a case study regarding the connections between transportation, development, environmental damage, and water decrements.”

Nonsustainable development also results because decision makers do not understand the interconnectedness among transportation, development, and water issues and thus do not realize how inappropriate projects can create or exacerbate water management problems. Few developers or municipal staffs are trained in environmental management. Conclusive evidence of the disconnect among water,

transportation, and development issues lies in the existence of separate, uncoordinated plans for each of these components. At the local level, zoning ordinances and planning modules are instituted without regard not only to watershed recharge but even to water and sewage infrastructure planning needs (WSIP, 2002).

Schombert expressed frustration about the past practice of installing public sewage systems that encouraged sprawling development, as well as about continuing poor stormwater management. “We have flooding in Etna, not because of anything that’s going on in Etna, but because of what’s occurring upstream,” he said. He also noted that the area where he grew up—near the Montour Run watershed—never flooded before the sprawling development upstream in and around Robinson Town Centre.

Glotfelty observed that, since we have depended on the large rivers for transportation and commerce, we have spent many years solving flood problems in these valleys. At that time, she said, “We didn’t worry as much about the local uplands because they were forested or in farm production. Now that the farms are gone and the forests are being cut, the small tributaries like Pine Creek [which flows into Etna] are a problem.”

Bonomo said the Western Pennsylvania Conservancy is attempting to preserve large tracts of land, especially in the upper Allegheny River watershed. She called for establishment of “water sanctuaries” along our rivers and for taking an extremely long-term view regarding preservation and the viability of economic development projects. Bonomo recommended a comprehensive development plan that takes into account the needs of struggling river towns and conservation reserve programs. She also said greater focus on water issues by our region’s congressional delegation could be helpful, pointing out that “we are not as well served [with federal funding] in Western Pennsylvania as the Chesapeake watershed is in the east.”

Past and Ongoing Industrial Pollution

The history of Pittsburgh and its surrounding area is associated with unbridled industrial development (Tarr, 2003). This industrial development brought immigrants to the region in large numbers, which in turn resulted in overbuilding on sensitive slope lands and in vital watersheds. Although we have made great strides in environmental cleanup, and although heavy industrial activity has declined precipitously in this region, our legacy of industrial pollution still affects

our water. Brownfield, Superfund, and abandoned waste sites abound from the upper regions of the Allegheny River to the long-industrialized Monongahela River valley. Rainfall and snowmelt continue to leach toxins from contaminated soils into both surface and groundwater supplies. Additionally, we still have numerous industrial operations that release contaminants in their wastewater. Lastly, emissions from local and upwind coal-fired power plants contain heavy metals, such as mercury, that can be deposited in water.

The Iron and Steel Industry and Environmental Contamination

Due partly to the availability of raw materials (including coal) and the abundance of river water for material transport, processing, and waste elimination, Southwestern Pennsylvania became the world’s largest producer of coke, iron, and steel for the better part of a century. Factories producing iron, steel, and needed process ingredients like metallurgical coke and iron sinter sprang up along the Monongahela, Allegheny, Ohio, Shenango, and Mahoning Rivers. Eventually plants became integrated processes, one of them stretching for as many as 15 miles along the Ohio River. Steel was the lifeblood of these communities, and belching

smokestacks were considered signs of increased wealth and prosperity.

When people think of the health threats posed by the steel industry, they usually think of air pollution—especially the environmental crisis that occurred at Donora, Pa. (28 miles south of Pittsburgh) in October 1948, when a temperature inversion trapped contaminants in the town. Half the residents became ill, and 20 people died (Helfand et al., 2001). However, significant water pollution is also part of this industry’s legacy. Facilities disposed of waste by-products in the hollows of the foothills of the Appalachian Mountains and their associated streambeds, on riverbanks, and in the rivers themselves. Overall, the iron and steel industry was the largest industrial source of toxic environmental contamination in the United States (EPA, 1995). The industry disposed of toxic metals including manganese, nickel, cobalt, copper, cadmium, chromium, lead, and zinc in its wastewater (Vijay and Sihorwala, 2003).

The decline of this industry after 1980 left once-buzzing plants to become vacant and deteriorate. As they did, water and wind further distributed residual contaminants on and beyond the industrial sites, while waste ponds, impoundments, sludge pits, and slag piles

A Case Study: The Shenango and Mahoning Rivers

The Shenango and Mahoning Rivers both originate outside Southwestern Pennsylvania but send significant environmental problems downstream to communities in Lawrence and Beaver Counties. Both rivers illustrate the need for a watershed approach to legacy contamination problems.

Soil, surface water, groundwater, and sediments along the Shenango have been impacted primarily by the Sharon Steel Corp.'s Farrell Works Disposal Area in Hickory Township, Mercer County. The Westinghouse Electric Corp.'s Sharon Plant, located across the river from the Sharon Steel site, added polychlorinated biphenyls (PCBs) and lead to the mix. The Farrell Works Disposal Area has been on the National Priorities List since 1998 and is the site of ongoing Superfund investigations; metals including arsenic, lead, and chromium have been detected in the site's groundwater, and the high pH level of the slag materials and runoff water poses a hazard to wetland ecological systems.

Meanwhile, two Ohio plants, Youngstown Sheet and Tube in Youngstown and WCI Steel in Warren, have contaminated large sections of the Mahoning River's banks and streambed, as well as soils and groundwater surrounding the sites. The major pollutants in the Mahoning River watershed include polycyclic aromatic hydrocarbons (PAHs), PCBs, and heavy metals such as mercury, lead, zinc, copper, cadmium, and silver. In 1977, when the major steel mills on the river were still in operation, the EPA estimated that each day 400,000 pounds of suspended solids (many containing metals), 70,000 pounds of oil and grease, 9,000 pounds of ammonia-nitrogen, 800 pounds of zinc, 600 pounds of phenolics, and 500 pounds of cyanide were disposed of directly into the river (U.S. Army Corps of Engineers, 2006). Today the Ohio Department of Health continues to advise against human contact with Mahoning River sediment or consumption of any fish caught in the river.

The Mahoning and Shenango Rivers meet just below New Castle. Pollution in this watershed so severely affected Beaver County residents' water supplies that the situation helped push federal legislators to create the Environmental Protection Agency in 1970 (Youngstown State University Public Service Institute, 2007).

How much of this legacy contamination remains present in downstream surface water and groundwater? Amazingly, we don't know. Many residents within the affected area get their drinking water from wells, and even municipal water authorities do not sample for all possible legacy contaminants. Moreover, a passing sample one day is no guarantee that contaminants will not be higher on another day, especially during a wet-weather event. Dave Dzombak, professor of civil and environmental engineering at Carnegie Mellon University and codirector of the new Center for Water Quality in Urban Environmental Systems (WaterQUEST), deplores the lack of information: "Without better water quality and sediment contamination data we cannot adequately define the remediation technologies to employ here in Southwestern Pennsylvania."

were often left unattended without appropriate engineering and institutional controls. These problems further threaten our water quality. Many former industrial sites in the tri-state area have been placed on the National Priorities List for cleanup or have been the subject of consent decrees or other remediation activities.

Stakeholder Perspectives

Local anglers are extremely concerned about the impact of heavy metals in river sediments. Focus group participants said they can often see the water pollution, including petroleum sheens on the river surface. Anglers have noted the lack of insect life and crayfish in the Monongahela River. They blamed the unhealthy river conditions for restricting spawning opportunities for many types of fish, including the ones they most would like to catch and eat—walleyes and saugers. Anglers also expressed concern about releases of oil by-products from old oil wells and refineries along the upper Allegheny River, and about the release of chemicals from Neville Island industrial facilities into the Ohio River. In contrast, the Allegheny County Sanitary Authority's cleanup efforts received high marks, as only one angler believed ALCOBAN's plant was releasing contaminated water into the Ohio basin (Volz and Christen, 2005-2006, 2007; Volz, 2006).

Arnowitz of Clean Water Action bemoaned that "decision makers still consider jobs over environmental concerns and don't want to see existing industrial facilities threatened." He believes this is a false dichotomy and that both economic and environmental goals are compatible with proper engineering controls and community involvement. Arnowitz views air and water pollution from Neville Island facilities as a particular problem for surrounding communities and the whole Ohio River valley.

Superfund, Resource Conservation and Recovery Act, and Brownfield Sites

Due to Western Pennsylvania's industrial past, Superfund, Resource Conservation and Recovery Act, and brownfield sites abound in both urban and rural areas. These sites present unique hazards to local residents and area watersheds because they are associated most commonly with a variety of contaminants, which have different transport routes through water and cause various health effects. For example, the Osborne Superfund site, near Grove City in Mercer County, has threatened municipal groundwater wells with high levels of lead, trichloroethene, PCBs, and other carcinogens including vinyl chloride (EPA, 2007). This site is of regional hydrological importance because

its surface waters flow into Wolf Creek and associated wetlands, which are used for fishing and also for downstream water usage. Wolf Creek in turn flows into Slippery Rock Creek, which then runs through Slippery Rock State Park in Lawrence County, an area extensively used for recreation by fishers, kayakers, and canoeists and marked by unique ecological habitats. Further downstream, Slippery Rock Creek empties into the Beaver River and finally the Ohio River; numerous communities draw water from these sources.

Deposition of Contaminants from Power Plants and Other Industrial Sources

Contaminants released into the air by coal-burning power plants or other industrial sources eventually find their way into streams and rivers and pose a potential health hazard. For example, mercury deposits originating from power-plant emissions are transformed by water-based bacteria into methylmercury, which then accumulates as it moves up the food chain (Kammen et al., 2005). Methylmercury is highly toxic, especially to the developing fetus and to children; it can even cause neurological problems in adults. One study of the Allegheny River near Kittanning, Armstrong County, found that 25 percent of channel catfish had concentrations

of methylmercury greater than the EPA's acceptable standard (Volz et al., 2007a).

Other contaminants, such as selenium and arsenic, can also be deposited from industrial emissions. Stream and river sediments retain these contaminants for long periods of time. Long-term water and sediment monitoring programs are needed to quantify the risks these contaminant deposits may pose.

Nonpoint-Source Pollution

Nonpoint-source pollution means the introduction into watersheds of any toxin, carcinogen, hazardous material, or change in water chemistry by a generalized process rather than from a specific pipe or facility. Nonpoint sources are thus small in scale and widely dispersed.

Faulty on-site sewage treatment and disposal systems (i.e., septic tanks) are an important type of nonpoint-source pollution (National Research Council, 2005). Although the amount of raw sewage and hazardous material generated by each individual septic tank is small, cumulatively these failing systems release massive amounts of contaminants into our surface and ground water.

Other nonpoint sources include fertilizers, insecticides, and herbicides applied widely by homeowners, municipalities, and utilities; runoff of car and

truck exhaust products, oils, grease, gasoline, and road salts (deicers); and topping compounds containing carcinogens that are used on parking lots and roadways. All these substances are flushed down our stormwater conveyance systems and through our waterways in vast amounts. Road salts change the salinity and conductivity of the water, while other substances may make water more alkaline or acidic; sometimes these changes can actually pull metals and other toxins into solution, thus facilitating their transfer downstream. Runoff from roads, households, and city streets impairs more than 3,000 miles of rivers and streams and 6,797 lake-acres in Pennsylvania (National Research Council, 2005). Some contaminants from road toppings are themselves carcinogenic, such as benz-a-pyrene (which is also an endocrine-disrupting chemical). One study that examined Deer Creek (a watershed in northeast Allegheny County) found that, following storms, the pesticides diazinon and carbaryl were present at levels exceeding the standard considered safe for aquatic life (Anderson et al., 2000).

Past and Present Agricultural Chemical Use

Agriculture remains Pennsylvania's leading industry. With the advent of modern farming techniques, farmers began increasing their

usage of pesticides, herbicides, and fertilizers. One such chemical, DDT, is a Persistent Organic Contaminant (POC), almost totally immune to natural breakdown; it has accumulated in fish, bird, animal, and human fats, and traces of it can still be found in our aquifers, farming soils, and riverbed sediments. Additionally, as we will see further, farming adds considerable manmade and manure-based nitrates to our surface water and groundwater. Farmers must be encouraged to use alternative forms of soil replenishment and environmentally safe pest management techniques.

Personal and Societal Attitudes toward Water Resources

Personal attitudes and actions regarding disposal of household wastes and trash may add just as much to our water quality problems as industrial pollution does, since more than a million Southwestern Pennsylvania households are generating waste. Citizens seem slow to realize that the pollutants we pour into soils, onto a parking lot surface, down the drain or toilet, or into street drains eventually end up in our drinking water sources or those of downstream communities.

Similarly, the federal Centers for Disease Control and Prevention frequently receive reports of

people becoming ill (especially at summer camps) from pathogens that seep from outhouses or faulty septic systems into drinking water sources. However, the general public does not understand the interconnection between surface water and groundwater. Nor do people realize that unnecessary water use affects the recharge of underground aquifers and makes it easier for contaminated water to get into wells. Both education and enforcement may be necessary to help citizens understand the real impact of their water usage decisions.

Fragmented Local, State, and Federal Regulatory Climate

Fragmented regulatory climates discourage meaningful approaches to water-related problems because the many national, state, and local regulations and regulatory bodies often have conflicting goals or enforcement strategies. Seldom do multiple bureaucracies cooperate effectively and speak with one voice.

Caren Glotfelty was in a particularly good place to observe this problem when she became the first deputy secretary for water management at Pennsylvania's Department of Environmental Resources (DER). Her assignment, she recalled, was "to forge a new

unit out of the water quality and quantity folks under one roof. Prior to that time the agency had two big wings: one for environmental protection (regulatory issues) and a resource management section that had all the other water issues such as dam safety, wetlands, erosion, and sediment control. We were dealing with two different cultures and also with a long history of laws, regulations, and institutions that separated water quality from quantity, almost not acknowledging the relationship." Now, ironically, these two units are separated once again, with the breakup of the former DER into the Department of Environmental Protection (DEP) and the Department of Conservation and Natural Resources (DCNR).

The many-faceted cornucopia of county, township, borough, and city planning and zoning regulations complicates the situation further. Planning and zoning laws often change at municipal and county borders, but water flow does not. If a zoning decision in one township causes storm surges, the next jurisdiction bears the impact. Proper regional water management is extremely difficult without a master plan that can inform local zoning and planning modules.

Spills or Accidental Releases of Toxic and Hazardous Substances

Great amounts of chemicals travel through Southwestern Pennsylvania's river valleys on barges, railways, and highways (Ali and Wheatner, 2005). Historically, good records have not been kept regarding spills that can affect water quality directly or, through deposition and leaching, indirectly. Recently a derailed train industrial tanker car released between 15,000 to 20,000 gallons of anhydrous hydrogen fluoride into the Allegheny River. Water intakes downstream were closed because anhydrous hydrogen fluoride produces hydrofluoric acid (HFA) when mixed with water. HFA is corrosive to the eyes, nose, and larynx; can erode teeth; and can cause fluorosis (a condition caused by the substitution of fluoride for calcium in bone) if ingested.

Gravel and Sand Mining in Main Stem Rivers

Because of the breakdown of igneous rock formations during the Ice Age, the Allegheny and Ohio Rivers have sand deposits, and the Allegheny also has gravel deposits. The construction industry covets these clean sources of sand and gravel, which fueled the development of the area's glass industry. In the 19th century people would come to the rivers

during low-water periods in search of cobblestones to pave area streets.

Today, dredgers on the Allegheny River customarily use a clamshell dredge to mine river sand and gravel. This hinged, heavy bucket is lowered from a vessel to the river bottom, and its two halves are closed to capture the material. In the process macroinvertebrates are removed from the river bottom, the bottom becomes pockmarked, and river turbulence occurs (U.S. Army Corps of Engineers, 1980). River dredging reduces aquatic habitat for many aquatic species as well as fish species.

Both Bonomo and Arnowitz cited gravel and sand mining in the Allegheny and Ohio Rivers as important threats to aquatic life and overall river health. Arnowitz fears that we could remove all the available sand and gravel from the Ohio and Allegheny Rivers in the next 10 to 20 years; according to an environmental impact statement by the Corps of Engineers, this could represent 40 percent of river bottom material. Arnowitz also contends that tests performed downstream from riverbed mining have shown elevated levels of lead and other heavy metals (Clean Water Action, 2005). He explained, "The process of riverbed mining can create bottom holes up to 60 feet deep and resuspend sediments

carrying toxic substances and pathogens. These holes can change the river flow characteristics.”

Bonomo said that many unique aquatic creatures, including endangered freshwater mussels, require gravel bottoms to live and breed. Both the Western Pennsylvania Conservancy and Clean Water Action are advocating for a ban on further river mining in Pool 8 of the Allegheny River (between the towns of Templeton and Cosmus in Armstrong County) and for limits on new mining activities. They believe riverbed mining could also add to the technical and economic burden of purifying drinking water.

CATEGORY 2— WATER CONTAMINATION PROBLEMS

Contaminants can enter surface water or groundwater directly, or they can move through the air or soils to water. The speed of movement depends on the contaminants’ physical and chemical characteristics; in some cases it can be very slow. Sediments, for example, are like a sink that holds contaminants for long periods of time, giving them up into water during turbulent periods or changes in water chemistry.

As an illustration of how the process works, consider a group

of cancer-causing organic compounds known as polynuclear aromatic hydrocarbons (PAHs) that are produced as a result of the metallurgical coke-making process. Parking lots are often sealed with coal tar or asphalt-based emulsions containing PAHs. Runoff from these lots carries PAHs into storm-water drains and retaining ponds, causing the presence of these compounds to increase in receiving waters nationwide (U.S. Geological Survey, 2005). PAHs also can be introduced directly into air during the coke-making process, into soils as part of waste liquids or runoff, or directly into surface water as an industrial waste product released into rivers. Once PAHs have entered the environment they can move among the air, soils, surface water, sediments, and groundwater very easily by well-known pathways—such as air emission deposits, runoff, leaching, and flooding. If PAHs get into sediments, they are not broken up quickly as they might be in surface water because the lack of oxygen limits the ability of microorganisms to use the PAHs as food. Instead, the PAHs stay on the bottom and infiltrate the water very slowly, except when turbulence from boats or floods churns the water and brings the PAHs back up.

Contamination in one area can also travel to another area. For instance, flooding can deposit PAH-laden

silts and sediments on previously uncontaminated land. The PAHs can then seep into groundwater, potentially causing consumers of this water to be exposed. This complex process can continue for decades until the PAHs are finally broken down by a combination of bacteria (biodegradation), light (photodegradation), and water (hydrolysis) (Hemond and Fechner-Levy, 2000).

We will now review the main classes of water contaminants observed in Southwestern Pennsylvania. As we do so, we will observe how the primary problems detailed in Category 1 of the chain of causation result in specific, measurable water contamination.

Pathogens

The most serious water quality threat to main stem rivers is the entry of human pathogens from raw sewage. The bacteria, parasites, and viruses contained in sewage can pose a significant threat to public health via ingestion or skin contact. In 1999 and 2000, *Cryptosporidium parvum*, a parasite, accounted for 44.4 percent of the outbreaks in the United States (Gerberding et al., 2002). Other outbreaks of known etiology were *E. coli* O157 (a bacterium that has infected and caused the death of children swimming in lakes) and *Shigella* (four species of bacteria).

Cryptosporidiosis, a disease caused by ingestion of parasite-infected water, has become this nation’s most important waterborne illness during the last 20 years. The *cryptosporidium* parasite travels through sewage systems, drainage basins, and manure piles and is very resistant to environmental conditions, wastewater treatment, or water purification (Robertson et al., 1992). *Cryptosporidium parvum* oocysts shed into the sewer system are released directly into our streams and rivers during combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), and wastewater treatment plant failures. This is the parasite that caused the Milwaukee outbreak.

Alarming, studies at and downstream from CSO outfalls in main stem rivers and tributaries near Pittsburgh have shown elevated levels of *cryptosporidium* and even higher levels of the disease-causing parasite *giardia* (States et al., 1997; Gibson et al., 1998). These infectious parasites threaten drinking water sources and those coming in contact with the water while fishing or during other recreational activities. Fishers have reported gastrointestinal disturbances following water contact subsequent to seeing CSO gates open during wet-weather events (Volz and Christen, 2007). The last major outbreak of waterborne disease in Allegheny County

is attributed to giardia; it occurred in McKeesport in 1984, and several hundred people became ill.

Pathogens also enter water through nonpoint sources (i.e., sources other than major outfalls or industrial release points). In urban areas the drainage of domestic pet and wildlife fecal matter from impervious surfaces adds to the amount of pathogens in stormwater runoff. It has been shown that fecal bacteria loads in urban streams are a function of the density of housing and population, impervious surface area, and domestic animal population (Young and Thackston, 1999). In rural areas, failing or illicitly connected septic systems, leachate from livestock pastures, and runoff from manure storage areas add pathogens to feeder streams. The EPA has determined that the primary contributor of pathogens to surface water and groundwater in rural areas is confined animal feeding operations (CAFO). These nonpoint fecal sources present an unknown risk of infection to rural residents, who may develop gastrointestinal, sinus, ear, and/or skin infections after drinking well water or following recreational or other skin contact.

Nitrates

Nitrates, naturally present in surface waters, can affect both human drinking water quality

and aquatic life. Excess nitrate in surface waters reduces oxygen levels in the water and kills fish. Nitrates usually enter water because of the widespread use of agricultural fertilizers, livestock pasturing, leachate from uncontrolled manure piles, faulty septic systems, and municipal waste (Anderson et al., 2000).

Ingestion of nitrates in excess of the maximum concentration level (MCL) of 10 parts per million can cause methemoglobinemia or “blue baby syndrome” in infants and children. This is a serious and potentially fatal syndrome that limits the ability of hemoglobin to deliver oxygen to the cells, turning the skin blue and affecting blood supply to the brain. There is also evidence to suggest an association between developmental problems in children and the presence of nitrate in their mothers’ drinking water (Fan and Steinberg, 1996).

Nitrates can also enter water through industrial sources. In a highly publicized incident, nitrates discharged into Connoquenessing Creek by AK Steel caused the EPA to issue an endangerment order (EPA, 2000a; EPA, 2000b) that forced the borough of Zelienople, Butler County, to depend on bottled water for months (Borough of Zelienople, 2004). (The Zelienople case has been documented in a framing paper

on regional water problems published by the Institute of Politics Environment Policy Committee; see www.iop.pitt.edu/water/.)

Limited stream and well sampling data indicate that 73 percent of samples taken from streams draining agricultural areas in Southwestern Pennsylvania exceeded background nitrate concentrations; 62 percent of all groundwater samples contained detectable nitrate; and one well contained nitrate in excess of EPA standards (Anderson et al., 2000). Children and babies living in rural areas and receiving drinking water from private wells thus may be at risk for the development of nitrate-related disease. Median nitrate concentrations increased by 25 percent in the Monongahela River and by 3 percent in the Allegheny River during the period 1975–2000.

Heavy Metals

Mercury

Elemental mercury is emitted in vapor form during the combustion of coal at conventional power plants and during the incineration of some wastes. This mercury can travel long distances in air, finally dropping to earth in precipitation or attached to particulate matter. When this mercury is deposited into water bodies it interacts with bacteria and becomes a related substance known as methyl-

mercury (discussed above under Category 1 in the section on power plant emissions), which accumulates as it moves up the food chain and becomes concentrated in fish that often become human table fare. Methylmercury exposure in the womb affects the fetus’s growing brain and nervous system, resulting in problems associated with memory, attention, language, and visual spatial skills. Still worse, concentrated exposure in utero can cause severe birth defects (EPA, 2007). In birds, methylmercury can change behavior, affect survival rates, reduce fertility, and retard growth and development. Methylmercury can also act as an endocrine-disrupting chemical, altering the birds’ ability to reproduce and develop normally (EPA, 2007).

Mercury advisories exist for fish in local water bodies. Methylmercury does not pose a serious risk at present to drinking water supplies, but due to the number of conventional power plants in West Virginia and the Ohio Valley regular monitoring of methylmercury in water should be performed. There is significant evidence that fish caught in local rivers could be contaminated with mercury in excess of the EPA’s limit of .3 parts of mercury per million parts of edible flesh (Volz et al., 2007a).

Lead, Copper, Cadmium, Chromium, and Other Heavy Metals

Heavy metals such as aluminum, zinc, lead, arsenic, chromium, nickel, cobalt, copper, and cadmium are produced during iron, steel, foundry, and other manufacturing processes. Lead also can enter surface water directly or indirectly, through deterioration of bridge surfaces covered with lead-based paint or through faulty removal of lead-based paint. Of these metals, arsenic (discussed further below) and chromium have been associated with the development of various cancers; lead is known to cause neurobehavioral problems, especially in children; and cadmium is a metalloestrogen, meaning that it can turn on the estrogen receptor mimicking hormonal estrogen. A comprehensive, ongoing program of water and sediment testing for heavy metals does not currently exist in Southwestern Pennsylvania and would be necessary to understand the extent to which these metals pose a health risk locally.

Arsenic

Arsenic is really a metalloid with some qualities of a metal. It has been found in well water in north-east portions of the Allegheny River drainage system. This source of arsenic appears to be related to glacial disturbance of rock

formations and subsequent leaching of this metalloid into groundwater; it is not a result of human land uses. As this natural process is occurring across an extremely large geographical area, keeping arsenic out of the water completely would be impossible. But technologies are available to keep arsenic concentrations below levels that would pose a health risk in our municipal water systems.

The acceptable standard for arsenic in water has recently been lowered to 10 parts per billion because of new risk assessments suggesting that chronic long-term exposure can lead to vascular problems. Both the U.S. Geological Survey (USGS) and DEP are studying the concentrations and extent of arsenic in surface water and groundwater in this area and throughout Pennsylvania. Rural residents of Butler, Lawrence, Armstrong, and Indiana Counties with no municipal water supplies could be at risk due to high arsenic concentrations, but individual wells are not routinely monitored in Pennsylvania.

Arsenic may enter both ground and surface water from other sources. Roxarsone and arsanilic acid are used in poultry production to enhance growth and to prevent bacterial infection. More than 70 percent of this arsenic-based material is excreted by the poultry, resulting in the release of approxi-

mately 2 million pounds of arsenic per year into the environment from U.S. poultry operations (Graham, 2005). Poultry operations in agricultural areas of Southwestern Pennsylvania could pose a threat to downstream residents who depend on well water.

Arsenic is also released in the production of sinter and the direct manufacture of both iron and steel; data on its distribution in river sediments are limited. Arsenic is implicated in the development of cancers of a number of tissues, including the bladder; it can also cause neuropathy and vascular disease (U.S. Geological Survey, 2000; ATSDR, 2005).

Volatile Organic Compounds (VOCs)

VOCs are commonly found in point-source effluents entering large feeder streams and main stem rivers from industrial plants and through municipal sources. VOCs can also enter the environment through nonpoint discharges because household solvents, furniture refinishing solutions, pavement cleaners, and many other commercially available products contain VOCs. They often find their way into water through inappropriate usage, storage, and/or disposal. Given their ability to run off into surface water or leach into groundwater from contaminated surface and

subsurface soils, along with their persistence in groundwater, it is surprising that monitoring of VOCs has not been widely implemented in Southwestern Pennsylvania.

VOCs also include industrial by-products such as benzene, toluene, and xylene, as well as compounds derived from gasoline, nonlatex paints and varnishes, cleaning solutions, and dry cleaning. Benzene is known to cause leukemia in humans. Another VOC, carbon disulfide, is known to cause neurological damage (ATSDR, 2006).

In one U.S. Geological Survey study, 24 of 25 samples collected in Deer Creek near Dorseyville, Allegheny County, contained VOCs, although not above individual drinking water standards. Groundwater from 92 percent of the wells sampled in the Allegheny-Monongahela drainage area contained at least one VOC, 60 percent contained two or more VOCs, and one well contained seven different VOCs (Anderson et al., 2000). Only 95 domestic wells throughout the entire region were sampled. There exist no drinking water standards for numerous individual VOCs found in this USGS study or for complex combinations of VOCs in water. The health risks from ingesting some VOCs, let alone the combinations of VOCs found in this study, are not known.

Contaminants Associated with Mine Drainage

Depending on the type of abandoned mine and how long it has been flooded, contaminants resulting from mine drainage include iron, sulfates, manganese, magnesium, aluminum, and arsenic. Though consumption of AMD-affected water can lead to gastrointestinal disturbances, they are not likely to be debilitating. However, AMD also can cause staining of fixtures and make the water's taste unpleasant, compelling residents to resort to bottled water for drinking. The long-term consequences of drinking various heavy metals or arsenic at levels found in AMD are only now being researched.

Pesticides and Herbicides

Pesticides and herbicides enter regional watersheds from agricultural applications and increasingly through suburban and urban lawn and garden uses (National Research Council, 2005). The U.S. Geological Survey study of water quality in Deer Creek detected pesticides common to lawn care. This discovery is not surprising because of the presence of many residential plans and golf courses in the watershed, interspersed with upland agricultural land usages. The herbicide detected in the highest amounts (exceeding one microgram per milliliter of water) in

the Deer Creek drainage is 2,4-D, commonly referred to as Weed-B-Gone. Prometon, the most detected herbicide in urban surface water and groundwater, was found in 90 percent of all samples taken in Deer Creek. The maximum level of the insecticide diazinon exceeded the aquatic life water quality standard, and four out of five stormwater samples of the pesticide carbaryl (commonly called Sevin) exceeded this standard. Pesticides and herbicides are long-lived chemicals, and the forms into which they decay often remain toxic.

Polychlorinated Biphenyls (PCBs) and Other Organohalogen Substances (OHSs)

PCBs can threaten human development, fertility, and immune systems and can also cause cancer. Western Pennsylvania rivers and water bodies are significantly contaminated by PCBs, which have been used extensively as coolants and lubricants in transformers and other electrical equipment (National Research Council, 2005). The presence of PCBs has led the Pennsylvania Fish and Boat Commission to urge limiting consumption of locally caught fish to no more than one meal per month in some areas. PCB contamination is a particular problem in the Shenango River basin due to contamination from the

Westinghouse Electric Superfund site in Sharon.

The pesticides DDT and chlordane, or compounds resulting from the breakdown of these pesticides, also have been found in fish at numerous sampling sites in the Allegheny-Monongahela basin (Anderson et al., 2000). Like PCBs, these are organohalogen substances (OHSs), meaning that they contain chlorine, bromine, or other halogen elements. These substances are suspected of causing learning and memory impairments, elevated breast cancer risk in premenopausal women, and male fertility problems in people who have consumed Great Lakes fish regularly. Many OHSs are not monitored in public drinking water supplies, and there are no data on their occurrence in private well water.

Endocrine-Disrupting Chemicals

Endocrine-disrupting chemicals (EDCs) are a newly defined category of environmental contaminants that interfere with the function of glands that release hormones directly into the bloodstream (Sumpter, 1998). The major glands that constitute the endocrine system include the pituitary, thyroid, parathyroids, and adrenals, as well as the ovaries and testes. These glands regulate many body functions such as

growth and development, sexual differentiation, metabolism, and fertility. Risk assessments based on animal studies or human effects implicate EDCs in the development of cancers, male reproductive disorders, birth defects, neurobehavioral problems (Sanderson and van den Berg, 2003), and gender imbalances. Many studies also indicate EDCs' negative effects on aquatic wildlife (Miyamoto and Burger, 2003). Some ingredients contained in personal care products, plastics, building products, glues, dietary supplements, and certain pharmaceuticals can be endocrine-disrupting and can mimic the effects of estrogen (Walters and Volz, 2007).

Sewage treatment plants release EDCs into local waterways with shocking results. Most notably, male fish exposed to wastewater treatment plant effluents have been found to have female features, including eggs in their testes. Reproductive abnormalities have been observed in fish in industrialized countries around the world (Eggen et al., 2003). The flesh and fat from channel catfish caught in areas of Pittsburgh with dense CSO concentrations caused twice as much growth in a human breast cancer cell line known as MCF-7 as did catfish caught upstream in the Allegheny River, where CSOs are less frequent. This evidence indicates that

pharmaceuticals and estrogen-mimicking chemicals are entering our rivers from local sewage systems—particularly from combined sewer overflows (Volz et al., 2007b). It may become necessary to remove EDCs from sewage treatment plant effluent in order to protect both aquatic life and human health.

Radon

Radon, a colorless, odorless, radioactive gas emitted during the decay of uranium, presents a problem in Southwestern Pennsylvania groundwater due to the region's underlying soil and geological characteristics. A 1999 National Academy of Sciences report suggests that the ingestion of water containing concentrations of radon can result in increased risk of lung cancer (National Research Council, 1999b). A local study found that more than half of groundwater samples tested contained radon levels above the EPA's proposed permissible standard, and 19 percent of samples contained at least three times the permissible level. Two samples exceeded the concentration level at which the local drinking water authority must initiate programs to reduce radon in indoor air and in drinking water. Although radon sampling is required for municipal sources,

there are no requirements to test for or remediate high radon levels in private wells.

CATEGORY 3— LOSS OF ECOSYSTEM SERVICES

There is a direct relationship between an ecosystem's health and its ability to retain and purify water. Thus, the problems to be described in Category 3 of the chain of causation can exacerbate both water contamination and flooding problems and heighten the impact of Category 1 problems.

Historically, Southwestern Pennsylvania has lost substantial ecosystem services due to the rapid industrialization and development required to support industrial activity and house families (Tarr, 2003). We have invested comparatively very little in reestablishing these healthful ecological habitats. But loss of ecosystem services is not only historical—it continues to occur today. For instance, forested lands with undisturbed surface soils and subsurface structures aid in the retention and purification of water and the recharge of groundwater aquifers. Disturbance of these forests and their soils and other native plants for purposes of commercial or residential development can result in erosion,

sedimentation, rapid stormwater runoff, depleted water quality, increased costs for water purification, and loss of important plant and animal species as well as recreational possibilities.

In healthy ecosystems, the natural processes performed over and over again by bacteria, fungi, plants, and animals break down both natural products and chemical contaminants. These natural processes, carried out in soil, wetlands, and forests, transform toxic chemicals into less toxic materials or even into carbon dioxide, water, and mineral salts. Additionally, trees, plants, and intact soil structures soak up and hold rainfall. An undisturbed layer of topsoil and subsoils assures slow transport and bacterial cleaning of water heading into lakes and streams and provides for the reliable recharge of groundwater aquifers.

In contrast, higher levels of water contaminants cause toxic materials to become concentrated in nature's food web. Some of these compounds affect wildlife by disrupting their endocrine system and result in declining populations. And when rainfall does not adequately percolate through soil to the groundwater, the water level of underground aquifers drops. Faster runoff into streams causes changes in natural drainage

patterns and can even change the flow pattern of large rivers.

Some may argue that well-planned residential and commercial developments can avert these problems through effective drain construction and landscaping. However, this is seldom the case. Topsoil used to cover the disturbed area is often not as deep as the original topsoil. Trees and shrubs generally are of insufficient height and root structure to offer much help in water retention; soils no longer contain as much biological capacity to break down introduced pollutants; and the transport times of contaminants to streams, lakes, and main stem rivers are usually shortened due to stormwater runoff, inadequate surface infiltration, slope changes, and loss of riparian habitat.

It takes years, if not generations, to rebuild the type of biological activity that the surrounding ecosystem once provided. Further development in our critical habitats and watersheds, even if the developer attempts to be environmentally sensitive, will invariably continue the historical process of reduced ecological services in the region. Barring large-scale reinvestment to recover these lost natural processes, a profound impact on the movement of water—and of the Category 2 contaminants introduced into the water—is unavoidable.

Example: Compounding Problems Resulting from the Interaction of Primary Water Issues, Water Contamination, and Loss of Ecosystem Services

Now that we have moved through the first three categories of the chain, let's look at an example of how these categories interact in real life.

Suppose that a housing development occurs in a critical watershed area. Water contamination problems (Category 2) may result from car and truck exhaust products; use of polynuclear aromatic hydrocarbons (PAHs) on the road and parking area surfaces; use of home pesticides, herbicides, and lawn and garden fertilizers containing nitrates; pet fecal matter; household hazardous wastes; and disposal of oil and grease products. Consequences within Category 3 may include wetland loss, deforestation, loss of topsoil and plant cover, loss of natural drainage patterns, stream and land erosion, habitat loss, reserve farmland loss, loss of groundwater recharge potential, increased surface water runoff, and groundwater leaching.

Alarmingly, new developments are often connected to outdated sewage treatment systems that cannot handle the volume of waste generated. Since we have degraded our ecosystem services, they can no longer break down contaminants or purify or hold water as they once did. As a result, the groundwater becomes contaminated with a chemical soup. Stormwater surges and flooding further increase the likelihood that contaminants and pathogens will degrade our drinking water sources; these contaminants also can be deposited downstream, thus threatening other groundwater sources.

CATEGORY 4— SECONDARY WATER MANAGEMENT OUTCOMES

Flooding and contamination of drinking water sources by pathogens and chemicals are actually the result of interaction among the primary problems covered in Category 1, the introduction of contaminants described in Category 2, and the ecosystem service losses noted in Category 3. Thus they are best viewed as secondary water management

outcomes, or examples of Category 4 in the chain of causation.

Modern stormwater engineering practices are designed to move water away from new developments as swiftly as possible into receiving streams and rivers. While this approach protects the development and its immediate neighbors, it causes flooding at critical discharge points downstream (French, 2006). The frequency and severity of floods are increasing in many older urban and suburban communities.

Development in critical watersheds and paving with impervious surfaces decrease the production of clean surface water and groundwater. Again, surface water is shunted away as quickly as possible to receiving waters and does not have a chance to soak into the ground. Since there is less surface moisture and downward pressure, the production of groundwater slows and underground aquifers fall—sometimes so far that users of well water no longer have reliable water quantity. Because the ecosystem is less able to break down contaminants that may cause cancer, birth defects, or other environmental disease, these contaminants build up in water, leading to increased exposure of humans, birds, animals, and fish to toxic and hazardous substances. The routes of human and animal exposure vary according to the class of chemicals or metal in the environment. Generally, contaminants in water can enter the body via ingestion and skin absorption (fish are exposed through their gills), but certain chemicals such as solvents can be inhaled in the shower if contained in the water supply.

Erosion resulting from increased runoff and stream flows leads to an increase in water sediments and dissolved solids. Sediments can especially choke small streams, making them unsuitable for many

types of aquatic life including game fish. The addition of sediments to water makes it more difficult and costly to purify drinking water and more likely that contaminants or pathogens will be attached to the sediments, making them carriers of toxic substances or disease-causing agents.

Human pathogens enter receiving waters and main stem rivers from combined and sanitary sewer overflows (CSOs and SSOs) as well as from pet fecal matter. Recreationists are exposed to these pathogens in our surface water. Groundwater can also become contaminated by pathogens, resulting in exposure for well water users. Anglers who like to eat the fish they catch—and there are thousands of them in Southwestern Pennsylvania—could be consuming carcinogenic and toxic contaminants, risking the unfavorable health outcomes noted in relation to the individual contaminants in Category 2. Exposure of anglers to toxic contaminants can occur because old industrial chemicals like PCBs, the pesticide DDT, and methylmercury from power plant emissions can accumulate in the flesh and fat of fish. For instance, 25 percent of the fish caught near Kittanning have methylmercury above the EPA standard of 3 parts per million. Families eating these fish have increased

risk of neurological and developmental problems in children (Volz et al., 2007a).

Inattention to our flooding underground mines creates potentially catastrophic conditions that could lead to mine blowouts (often from hillsides above populated areas). The challenge of dewatering these old mines in an environmentally sensitive manner remains formidable. Finally, our patterns of development, which include burying watercourses and disturbing our most productive and sensitive watersheds, contribute to the loss of various forms of natural life. Streams do not have the biological diversity to support high-end aquatic predators like trout, so fishing recreationists must depend on costly stocking to ensure the continuance of their sport. Habitat loss can put other species in the food chain at risk of population loss or even extinction.

CATEGORY 5— TERTIARY WATER MANAGEMENT OUTCOMES

If left unchecked, secondary water management outcomes, individually or in combination, can in turn cause significant tertiary public health, medical, environmental, social, emotional, and economic consequences. For instance, flooding can lead directly

to the loss of human life, personal injury, and/or property damage. The high humidity and water levels left in insulation, drywall, and other building materials following flooding encourage the growth of molds, which can exacerbate environmentally induced asthma, especially in children. The social and economic underpinnings of communities are disrupted, and psychological disturbances like post-traumatic stress disorder (PTSD) are often reported. Increasingly, public funds are needed for downstream storm-water management and flood insurance programs. Increased sediments in water along with contaminants and pathogens add to the cost of water purification, again usually paid for by the general public. Despite our region's surplus of water, these water quality problems can have an impact on available water quantity and ultimately on sustainable economic growth. Moreover, destruction or degradation of natural habitats diminishes their recreation potential and kills native aquatic life and plants.

Increasing exposure to toxic and carcinogenic chemicals and metals increases the risk that some in our population will develop a disease that is either caused or exacerbated by water contaminants. Persistent exposure via water to organic compounds, toxic metals, and

endocrine-disrupting chemicals could increase levels of cancer and other systemic diseases in our population (MacKenzie et al., 1994; National Water Quality Inventory Report, 2000). The population groups most vulnerable to environmental disease are the unborn, children, the elderly, and those at the lower end of the socioeconomic spectrum; thus, water problems are environmental justice issues. The possibility of a large-scale waterborne epidemic from *Cryptosporidium parvum* or another form of pathogen always looms, too. We know we have high levels of cryptosporidium and giardia in our water downstream from CSOs and SSOs. An epidemic of gastrointestinal disease like the one seen in Milwaukee could make hundreds of thousands of people ill and could kill hundreds of immunocompromised persons, such as those with HIV/AIDS or receiving chemotherapy. More likely are outbreaks of disease among recreational river users; these outbreaks are on the rise in the United States and have been reported by fishing enthusiasts in the Pittsburgh area (Volz and Christen, 2007).

Costly legal actions are yet another type of severe water management outcome. The U.S. Environmental Protection Agency has recently finished negotiating terms of a consent decree with the Allegheny County Sanitary Authority

(ALCOSAN). If we are continually in violation of Clean Water Act regulations, we remain in great jeopardy of having a solution to our sewage problems imposed on us by regulatory agencies or by the courts. A federal district court ordered the Massachusetts Water Resources Authority to bring 86 CSOs in the Boston area into compliance with the Clean Water Act. We have more than 700 unresolved CSOs in Southwestern Pennsylvania.

HOW TO BREAK THE CHAIN— STAKEHOLDER PERSPECTIVES

Threats to water management create opportunities for new and innovative programs to counter these threats. Opportunities for Southwestern Pennsylvania include:

- Developing a coordinated regional approach to water management
- Holistic, watershed-based social-ecological-economic thinking
- Growing and coordinating our watershed groups and other nonprofit organizations
- Integrated water planning
- Educating public officials and citizens on the link between water management and public health issues

- Using our considerable university and professional expertise
- Encouraging better stewardship of both public and private property
- Broad-based educational programs
- Enlisting anglers and other recreational groups as advocates

These opportunities are reviewed on the following pages.

Treat Water as a Regional Asset with a Regional Approach

Whether through a regional authority, countywide cooperation, consolidation of authorities, or just sharing resources, stakeholders interviewed for this project consistently called for changing the fragmented water and sewer system now present in the region.

Currently the region's water and sewer infrastructure is owned by as many as 1,000 governmental and private providers and about 1.2 million homeowners. Coordinating so many entities to solve regional water management problems is problematic if not impossible. Although no one wishes to force a particular solution on any municipality or authority, an effective regional system is probably not achievable if all of them retain their complete autonomy.

Carnegie Mellon's Jared Cohon wants to see the region strive for a water plan that encompasses the entire 11-county area, though planning may have to occur "in pieces" on the way to a regionwide plan. Based on his broad experience in environmental management, Cohon strongly urges that we treat water as a regional asset by establishing a regional organization that can handle the economic, social, ecological, engineering, and political aspects of the problem. Cohon previously chaired the Southwestern Pennsylvania Water and Sewer Infrastructure Project Steering Committee; its recommendations in 2002 included a regional goal- and priority-setting organization that would plan and prioritize water and wastewater investments, help communities solve water and sewer problems, deliver public education programs, and advocate on regulatory and funding issues (WSIP, 2002).

Dave Dzombak of Carnegie Mellon University said the Pennsylvania Economy League's suggestion of using three existing organizations—3 Rivers Wet Weather for technical assistance, the Southwestern Pennsylvania Commission for regional planning, and the Greater Pittsburgh Chamber of Commerce for advocacy—is "logical and very practical." But, he added, a voluntary system may not work.

Dzombak believes that a source of substantial, dedicated funding is needed to fix our water problems and that we can learn from other metropolitan areas that have formed multicounty regional water management planning structures, such as Atlanta, Minneapolis-St. Paul, and Louisville. He also cited the larger-scale water authorities being formed in Mississippi following Hurricane Katrina: "They're trying to take the devastation of what they suffered and make some positives out of it." Dzombak said this process takes considerable political will, but warned that if we don't move soon we may be compelled by a court order to take certain steps on a mandated timetable, thereby losing the flexibility to tackle these problems with a homegrown approach.

Greg Tutsock, former director of the Pittsburgh Water and Sewer Authority, called the three-state Chesapeake Bay compact, which has brought funding for central Pennsylvania communities to fix long-standing sewage and agricultural runoff problems, an excellent model for collaboration. He believes working collectively is necessary "to leverage federal funding to facilitate and pay for upgrades to infrastructure, and for the monitoring and assessments that will be needed over the next 15 years."

Deb Simko is more adamant about the need to regionalize our approach to water problems. She said that until we "get our act together" most of the water funding in the state will go to the Chesapeake Bay problem. "We have been told over and over again by federal and state government," she explained, "that we don't have our legislators and municipalities behind us. So if we could form some kind of alliance that encompasses everyone, we will have a stronger voice and the money will stop going only to the Chesapeake Bay" instead of the Ohio River basin.

Commissioner Bracken Burns sees a window of opportunity for regional water policy making as a result of the attention generated by the ALCOSAN-EPA consent decree that is "putting real numbers on the problem—in the billions" and the interest shown by Southwestern Pennsylvania Commission (SPC) and the Regional Water Management Task Force. He said, "I think that there is an energy surrounding this issue right now that I never saw before. And we'd better act now, because if this initiative fails, the next time someone says 'Let's do this,' others will say that we already tried back in 2006–07 and it didn't work, so there won't be enough energy to get it up and going again." Burns would like to see one sewer and

water authority for the region with taxing and management authority, so that it can provide services, combine resources, and look at problems more globally.

Glotfelty doubts that the region could agree on having a single entity manage its sewer and water infrastructure, but she feels the number of separate organizations could be reduced. "I don't want to be negative about an 11-county regional authority, but it could be two counties working together, or four," she said—"whatever makes sense and where the problems can interrelate." On the other hand, Glotfelty does see a role for a multicounty planning authority similar to what SPC does for transportation. To function effectively, this body would have to be "far enough up from the day-to-day operational stuff to see how all the issues fit together," and it would need some means of generating revenue.

Schombert questions whether correcting Allegheny County's CSO and SSO problems is possible without the political will to change the county's sewer governance system. Plenty of money will be needed—perhaps \$4 billion. Schombert estimates that the ALCOSAN communities own a total of 4,000 miles of pipes, with another 4,000 miles in private ownership. "And that raises another issue," he stated—"the

private lines may be the worse half." Schombert said the basement dewatering business specializes in draining water from homeowners' basements, often into the sanitary sewer system; this activity, along with the common practice of connecting roof, retaining wall, and other drainages to sanitary sewer lines, overwhelms the system and must be eliminated.

Holistic Watershed Social-Ecological-Economic Systems Thinking: Protecting and Rehabilitating Ecosystem Resources and Planning for Sustainable Development

Historically, economic development planning has been premised on the use of land, labor, and capital to produce goods and services. This model has overlooked the negative impacts of the gradual, long-term degradation of natural resources. These negative impacts—on public health, wildlife, aquatic life, and recreation—include very real economic losses. Holistic social-ecological-economic systems thinking that takes these factors into account creates opportunities to preserve and repair ecological assets, improve water quality, decrease stormwater runoff and flooding, increase the aesthetic value of our waterways, and plan for sustainable economic development.

Southwestern Pennsylvania is extremely fortunate to have an

abundance of rainfall and is thus able to regenerate some of its natural ecosystems and improve water quality through dilution of contaminants. Nevertheless, economic expansion is often limited because of the additional water purification and treatment capacity needed to protect public health from existing pollution and prevent further water quality degradation. This present weakness can be turned into an opportunity if we begin to incorporate regional water management, sustainable development, and transportation projects in a way that protects natural assets.

The decline of our industrial and population base enables us to locate new residential and commercial activity in areas with existing water, sewer, and transportation infrastructure. Placing development in the urban core or at "brownfield" and "greyfield" sites allows protection of upstream watersheds and the replenishing of natural habitats, even in suburban areas.

Jackie Bonomo of the Western Pennsylvania Conservancy said that, because of the region's industrial history and more recent commercial and residential developments, "there is a deficit now in the balance between development and restoration, so we have to focus on restoration

first as a prerequisite for a good economy." She urged that new development be confined to selected regional and urban areas that need economic renewal, in accordance with a comprehensive plan that strengthens our "underserved river towns" and conservation reserve programs. To mesh restoration and preservation with economic development, Bonomo recommended a strategy under which companies can buy upstream credits for preservation in order to receive permission for economic expansion downstream.

New Castle, the largest municipality in Lawrence County, is a place where people can drop a line and catch fish right in the heart of the city. Lawrence County Commissioner Dan Vogler would like to keep it that way. Vogler believes redevelopment of formerly industrialized areas of New Castle with existing sewer and water infrastructure is the way to protect what he considers the jewels of his county: Slippery Rock Creek and the Neshannock River. Both of these watercourses provide fishing and boating opportunities and are thus economic assets for the county. "Through more dense development in the old urban core of New Castle we can have less stress on outlying areas," he said, "retaining their rural character while reinvigorating the economy of our largest city." Vogler sees the

recreation potential of the county's environmental assets growing as water quality improves. He said that wise rural stewardship and the creation of more state game lands would help Lawrence County to grow a recreational economy and sustain watersheds for downstream communities.

Yarone Zober, chief of staff for Pittsburgh Mayor Luke Ravenstahl, has seen a growing "green" commitment during the past decade, including recognition that water is one of Pittsburgh's greatest assets. But he deplored the "continued emphasis on placing new development in green spaces" and agreed with Vogler that redevelopment of urban areas will put less pressure on undeveloped land and help the economy of the urban core. Zober noted that residential property values rise when there is a convenient connection to greenways and waterways.

Davitt Woodwell of the Pennsylvania Environmental Council said the council has helped to complete a unique set of maps and manuals, known as the Natural Infrastructure of Southwestern Pennsylvania, which shows existing natural resources and assesses their quality. This tool, he suggested, could be used extensively to identify areas for future sustainable development and areas where no development should occur. The

council seeks to establish project-specific strategies and partnerships so as to preserve water resources, especially in watersheds under stress such as the Pine Creek watershed of Allegheny County.

Glotfelty emphasized the connections among water quality and sustainable economic development. "We didn't appreciate our rivers as assets until the industries were gone," she said. "Now millions of dollars of investment are coming in because the water quality is improving and being along the river is seen as a real amenity."

Arnowitz pointed out, "We have little permitting oversight for cumulative effects on a total watershed." He cited Slippery Rock Creek, with many mining pollution sources along its length, as an example. Arnowitz is also concerned about water quality in Deer Creek, which flows into the Allegheny River at Harmarville. Deer Creek, he said, "is a comparatively high-quality stream in Allegheny County, but is threatened by the Pittsburgh Mills mall and other developments. Holistic watershed approaches, taking into account all pollution sources and the potential effects of development on the watershed, need to be kept in mind during municipal planning."

Simko, who grew up in the Allegheny River valley, seconded Arnowitz's concern, calling Pittsburgh Mills "a disaster for river communities and local water quality." Nearby New Kensington, she noted, has been identified as a Keystone Opportunity Zone needing redevelopment. Simko believes that placing new developments in the old downtowns can make them the focus for further riverfront activity, saving the inner-core communities and helping to rebuild their sewer and water infrastructure.

Grow and Coordinate Our Social Capital—Nongovernmental Organizations, Watershed Groups

Many statewide, regional, and local nongovernmental organizations are involved in watershed and course preservation, stream and river rehabilitation, and education. Nongovernmental organizations include large watershed preservation bodies such as the Pennsylvania Environmental Council (PEC) and the Western Pennsylvania Conservancy, as well as local watershed groups such as the Shenango River Watchers and the Deer Creek Watershed Organization; also represented are activist groups like Clean Water Action and foundations like The Heinz Endowments, which support many of these entities financially.

These nongovernmental organizations represent social capital. They have great experience in the protection, mitigation, and remediation of rivers, streams, and groundwater supplies. Many are deeply involved in the practical aspects of improving water quality, including river and stream ecology, contaminant sampling and analysis, and data management. These organizations have great knowledge of specific watersheds; coordinating their efforts and knowledge offers a fantastic opportunity to benefit the whole region. If a holistic watershed management plan could be agreed upon, the entity overseeing implementation of the plan could enlist the assistance of local organizations to help it accomplish regional or subregional goals.

Organizing and coordinating these entities is difficult because many of them rely heavily on volunteer leadership. Funding for watershed groups is available through Pennsylvania's Growing Greener program and various local foundations, but more efforts should be made to fund the formation of watershed groups and their ongoing viability.

Deb Simko knows the experience of watershed groups well through her work for the Western Pennsylvania Coalition for Abandoned Mine Reclamation

(WPCAMR), a coalition of 24 county conservation districts and more than 90 watershed organizations. The coalition has helped the state Department of Environmental Protection (DEP) complete an EPA-required assessment of all streams in the state. “The state knew it didn’t have enough manpower to take samples in all the streams,” Simko explained, “so it came up with a Growing Greener initiative that empowered local citizen groups to take water samples and do their own assessments. Now there are roughly 400 watershed groups across the state, and many of them have become empowered through doing their own assessments.” Only a handful of Southwestern Pennsylvania’s watershed organizations have paid staff, however; many of them are dependent on a few dedicated volunteers, so if those people move away or retire, the organization could go out of existence unless new leaders emerge.

In the Beaver River watershed, the Mahoning River Consortium (Mahoning River Consortium, 2006) and the Shenango River Watchers (Shenango River Watchers, 2005) are active in promoting river remediation activities so that both human and aquatic river uses are enhanced. The Buffalo Creek Watershed Alliance is an interstate

organization, as Buffalo Creek originates in Pennsylvania but flows into the Monongahela River in West Virginia. PA CleanWays of Allegheny County received a grant from the American Water Environmental Grant Program to perform tire and debris cleanup along the Monongahela River, assisted by the Three Rivers Rowing Club, Venture Outdoors, Friends of the Riverfront, and the Student Conservation Association.

Along French Creek, a tributary of the upper Allegheny River, the Pennsylvania Environmental Council (PEC) is moving out of its usual realms of science and public policy. Here the PEC is doing public education about the creek, its resources, and its history. In 2006 it started managing a nearby market house in Meadville as a way to link local agriculture with local market opportunities. The PEC has used its expanding local role to call for better agricultural practices, such as taking nitrates out of the watershed.

In Allegheny County, 3 Rivers Wet Weather aims to improve water quality in Allegheny County by advocating community cooperation regarding CSOs, SSOs, untreated sewage, and stormwater overflows. This organization was created through collaboration between the Allegheny County Health Department (ACHD) and ALCOSAN and receives in-kind

support and financial assistance from them. ACHD and ALCOSAN share the responsibility of appointing 3 Rivers Wet Weather’s five-member board, which must include one state representative and two municipal officials (3 Rivers Wet Weather, 2005). This approach follows the model of “privatizing” public responsibilities to nongovernmental or quasigovernmental organizations that can devote consistent focus to their area of expertise with minimal bureaucratic interference (Volz, 2002). Such an arrangement has great potential for promoting improved regional water management.

Integrated Water Planning

Once we have brought together a critical mass of organizations and people using holistic social-ecological-economic watershed thinking, then we need to develop an integrated water management plan that takes into account the often-conflicting objectives of our subregions. This plan should encompass all facets of water management: quality and quantity, stormwater management, flooding, sewage, and water provision. Preparing the plan will not be easy because we have hard choices to make—not least because we have neglected many problems for so long.

Jared Cohon, who describes himself as an environmental systems analyst, has been a pioneer in the research specialty known as multiple criteria program planning, or the development of mathematical models that address multiple conflicting objectives related to environmental questions. He proposed using this approach to engage Southwestern Pennsylvania’s more rural counties as part of a regional water management organization and to resolve resource-allocation tensions between urban, suburban, and rural areas. In most of Greene County, for example, it is not economical to install municipal sewer infrastructure; an alternative might be “forward thinking about multi-lot systems.” Cohon called for an iterative process by which the plan, as it takes shape, is brought back to stakeholder groups for review. This, he said, is the path to developing consensus.

For Arnowitt, balancing the needs of all Southwestern Pennsylvania residents is both a moral problem and a problem of equity. Having observed some distrust between the city of Pittsburgh and the remainder of Allegheny County, Arnowitt said it is important that “one side is not seen as paying more than its share.” Any regional structure, similarly, would need appropriate regionwide

representation that would ensure that “the environmental concerns of people can be incorporated—not just economic concerns.”

Schombert stressed the lack of comprehensive regional land-use planning in Pennsylvania, an omission that seriously hampers water management. As one example of the result, he said, during the 1980s Allegheny County municipalities used federal funds to place public sewer lines in areas where they would not otherwise have been financially feasible. As a result, development proliferated in these areas, creating new water-related issues such as stormwater drainage and flooding problems. Citing a Brookings Institution report, Schombert observed that, when one counts the infrastructure, right-of-way, and road extensions, the average amount of land used to build a new home is greater in Pennsylvania than anywhere else in the nation. The Brookings Institution reported in 2003 that Pennsylvania is undergoing “one of the nation’s most radical patterns of sprawl and abandonment” (McMahon and Mastran, 2005). Schombert believes that integrated, regional water and land-use planning can address such inefficiencies.

An integrated plan will require the harmonizing of many different perspectives, as illustrated by the

comments of two prominent environmental advocates, Ron Rohall and Simko. Rohall is a consulting forester, practicing in the Laurel Highlands region, and chairs the Ohio Basin Regional Water Resources Committee. When asked about the main threats to water quality in his area, he described three of them—abandoned mine drainage; driveways, farm lanes, and old logging roads that add to sediment release; and sewage from malfunctioning on-lot and community systems. Rohall advocates attacking all three problems simultaneously: “Remediate the abandoned mine drainage, get the sediment pollution under control, and get the poop out of our streams.” On the other hand, Simko said, “People in rural areas aren’t going to care about the sewage problem until they get drinking water” free from AMD, so she would prefer to see source quality and abandoned mine drainage issues tackled first.

Educate Public Officials and Citizens on the Direct Relationship between Water Management and Public Health Issues

The connection between water quality problems and human disease—or even death—should be more broadly highlighted so as to build awareness of the urgency

of the situation and the political will to change systems or pay for needed upgrades.

Simko said other areas of Pennsylvania have made efforts to link water quality information with public health outcomes. She said local councils of governments and the Hershey Medical Center have partnered in such an initiative in north central Pennsylvania, a region where abandoned mine drainage threatens tourism potential as well as human health.

The University of Pittsburgh’s Graduate School of Public Health has an academic center of excellence for environmental public health tracking. This center, supported by the federal Centers for Disease Control and Prevention, is working with county and state health departments and academic institutions around the country to develop environmental indicators that can be associated with health problems geographically so as to identify and combat patterns of environmental disease. Water issues are part of the environmental public health program, and groups of scientists are studying the impact of arsenic, lead, copper, chlorination by-products, and pathogens in water. All groups interested in promoting improved water management in our area should be aware of this academic

center at the University of Pittsburgh (www.upace-epht.publichealth.pitt.edu).

Use Local University and Professional Strengths

Water-related academic programs exist in at least nine postsecondary institutions within Western Pennsylvania. In addition, several of these schools focus on the translation of technical information into policy solutions. These skills are central to addressing our water problems. Moreover—partly due to the extent of environmental degradation this region has experienced—we have many local individuals with advanced training in environmental engineering and health.

Cohon pointed, like many others, to John Schombert and Allegheny County Health Department Director Bruce Dixon as people with high-level expertise. He also spoke of a Carnegie Mellon University spin-off company called Red Zone Robotics, which is developing a robot that could crawl through sewers to inspect them and even fix damaged pipes. Efforts to commercialize such research could contribute to improvements in water management and add to the growing high-technology sector of our economy.

Encourage Stewardship of Both Public and Private Property

In many parts of the country both government and watershed organizations are teaching small landholders how to care for watercourses that meander through their property. This instruction includes setting aside some strip of their property next to the watercourse and allowing native plants and trees to grow there; refraining from channelizing the stream and from building in areas that naturally flood; discontinuing herbicide, pesticide, and fertilizer applications; and allowing for the introduction of fish, amphibians, and insects.

In addition to instruction on environmental stewardship, landholders can be offered incentives to maintain land in an undeveloped state. This action would be especially helpful in maintaining the tops of our most productive watersheds like the Allegheny Ridges. Said Rohall: "People who own land in the headwaters and many other landowners need to get an economic return from the land. Without allowing for this return, we put the forests they own, which protect the integrity of the watershed, under increased threat of being converted to uses that increase runoff and pollution." He said timber harvesters and landowners could be taught to use harvesting

techniques that allow for economic gain and also allow the ecosystem to function by holding water and letting it recharge the groundwater aquifers.

Policy makers, once a watershed plan is devised, could determine, in conjunction with groups like the Pennsylvania Environmental Council and Western Pennsylvania Conservancy, which areas should be set aside from development for watershed protection, water recharge, water purification, plant and animal sanctuaries, and aesthetic and recreational purposes. Landowners could get some return on their investment for keeping their land as a natural ecosystem serving the public good.

Educational Programs

Decades ago, a famous television ad showing a Native American looking at litter along the roadway and shedding a tear, moved children to stop their parents from throwing trash out the window. Today, the savings we should gain from implementing better coordination in water management could be invested partly in funding educational programs on watersheds and their value.

So-called "community-based participatory" approaches to education on issues of public concern have paid considerable dividends across the country and the world (Parkes and Panelli,

2001). They function best when the concerns of watershed groups and other stakeholders are integrated, combining explanations of the natural ecosystem with discussion of related issues such as rural and community development, public health promotion, and natural resource management.

Watershed education should become a central feature of K–12 education in the region because our surface water is so central to our sense of identity and economy—and because people need to know how CSOs and legacy pollutants are affecting our water. The Pennsylvania Department of Conservation and Natural Resources has a watershed education program for students and teachers in grades 6–12. This program promotes classroom and field research, hands-on ecological investigations, networking, partnerships, stewardship, and community service (www.watersheded.dcnr.state.pa.us). The U.S. Geological Survey provides much information on its education Web site that can be included in elementary and secondary school watershed education programs (<http://water.usgs.gov/education.html>). The Pennsylvania Fish and Boat Commission also has useful educational modules on water pollution, wetlands, aquatic habitat, and other issues (http://sites.state.pa.us/PA_Exec/Fish_Boat/education/catalog/cat0index.htm).

Citizens, local officials, and even state and federal legislators do not always understand the connections between what we put on our lawns, on icy roads, or down our drains or toilets and our water quality. 3 Rivers Wet Weather, the Pennsylvania Environmental Council, and watershed groups are making some inroads, but more systematic, large-scale educational efforts are needed. The New Jersey Department of Environmental Protection, Division of Watershed Management, has devised one possible model. This program offers training and materials for teachers, classroom presentations by AmeriCorps volunteers, a volunteer watch and monitoring program, a program for young anglers about the dangers of eating fish from contaminated areas, many specific technical publications, and a large teacher conference promoting networking (www.state.nj.us/dep/watershedmgt/outreach_education.htm#urbanfish).

Enlist Anglers and Other Recreational Groups

As frequent observers of area waterways, anglers are excellent river inspectors; they could thus assist regulators and regional policy makers in efforts to comply with the Clean Water Act and in making policy decisions. All Bassmaster

groups that were present at the Southwestern Pennsylvania focus group meeting in May 2007 wished that they could be part of a solution to the problem of water contamination and stormwater surges. They said that they could help in identifying consistent sewer overflow problems, CSOs that remain jammed open even after wet-weather events, and industrial discharges (Volz, 2006). Anglers have a deep desire to protect their recreational habitat; so do hunting organizations. Both groups can exert considerable political influence on behalf of the importance of clean water.

CONCLUSION: LET'S NOT DROWN TOGETHER

Twenty years ago my friends at the Sylvan Canoe Club looked at the depressing mess floating down the Allegheny River and wondered, "Can our water quality problems be fixed?" Since then we have seen many encouraging improvements. Sewage authorities are upgrading their systems by

detaching stormwater drains and eliminating combined sewer overflow points. Boaters, water skiers, and Jet Ski users have been enjoying their recreational activities on our rivers. Anglers are out on rivers, streams, and lakes throughout the region, and many of them are keeping their catch for dinner. Existing marinas are expanding, and new riverside developments are occurring.

Yes, our water quality has gotten much better. Yes, we still have substantial challenges. And yes, our water problems can be fixed, and our region's people must work together to fix them if we are to thrive. Moving to the upstream suburbs does not exempt us from the impact of Clean Water Act regulations, or from being required to work with downstream communities in achieving cost-effective and environmentally sound solutions. We must address our regional water management issues jointly, and in conjunction with our economic and transportation initiatives, so that our substantial water quality challenges do not drown our region's future.

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Abbreviations

2,4-D – Weed-B-Gone

3RWW – 3 Rivers Wet Weather Demonstration Project

ACHD – Allegheny County Health Department

ALCOSAN – Allegheny County Sanitary Authority

AMD – Abandoned mine drainage

ATSDR – Agency for Toxic Substances and Disease Registry

CAFO – Confined animal feeding operations

CBP – Community-based participatory approaches

CDC – Centers for Disease Control and Prevention

CMU – Carnegie Mellon University

CSO – Combined sewer overflow

CSTE – Council of State and Territorial Epidemiologists

CWA – Clean Water Action

DCNR – Pennsylvania Department of Conservation and Natural Resources

DEP – Pennsylvania Department of Environmental Protection

DER – Pennsylvania Department of Environmental Resources

EDC – Endocrine-disrupting chemical

EPA – U.S. Environmental Protection Agency, represented in Southwestern Pennsylvania by Region III, which has headquarters in Philadelphia

FC – Fecal coliform bacteria

GSPH – University of Pittsburgh Graduate School of Public Health

HFA – Hydrofluoric acid

MCF-7 – A human breast cancer cell line used to identify the presence of estrogen-mimicking chemicals

MCL – Maximum Concentration Level

NAS – National Academies of Science

NGO – Nongovernmental Organization

NRC – National Research Council

OHS – Organohalogen Substance

PA – Pennsylvania

PAH – Polynuclear aromatic hydrocarbon

PCB – Polychlorinated biphenyl

PEC – Pennsylvania Environmental Council

PFBC – Pennsylvania Fish and Boat Commission

POC – Persistent organic contaminant

PPM – Parts per million

PWSA – Pittsburgh Water and Sewer Authority

SPC – Southwestern Pennsylvania Commission

SSO – Sanitary sewer overflow

USGS – U.S. Geological Survey

VOC – Volatile organic compound

WaterQUEST – Center for Water Quality in Urban Environmental Systems, Carnegie Mellon University

WPC – Western Pennsylvania Conservancy

WPCAMR – Western Pennsylvania Coalition for Abandoned Mine Reclamation

WSIP – Southwestern Pennsylvania Water and Sewer Infrastructure Project

Key Informants Interviewed and Their Organizations

Mr. Myron Arnowitt, Western Pennsylvania Director, Clean Water Action

Ms. Jackie Bonomo, Vice President, Conservation Programs, The Western Pennsylvania Conservancy

The Honorable Bracken Burns, Chair, Washington County Board of Commissioners and Chair, Southwestern Pennsylvania Commission

Dr. Jared Cohon, President, Carnegie Mellon University and Chair, Regional Water Management Task Force

Dr. David Dzombak, Professor, Civil and Environmental Engineering, Carnegie Mellon University

Ms. Caren Glotfelty, Director of Environmental Programs, The Heinz Endowments

Mr. Ronald Rohall, Chair, Ohio Basin Regional Water Resources Committee

Mr. John Schombert, Executive Director, 3 Rivers Wet Weather Demonstration Project

Ms. Deb Simko, Private Watershed Consultant and Member, Regional Water Management Task Force

Dr. Kenneth Smith, President, Geneva College and Member, Regional Water Management Task Force

Mr. Gregory Tutsock, Executive Director, Pittsburgh Water and Sewer Authority

The Honorable Daniel Vogler,
Chair, Lawrence County Board of
Commissioners

Mr. Davitt Woodwell, Vice President,
Western Division, Pennsylvania
Environmental Council

Mr. Yarone Zober, Chief of Staff,
Mayor's Office, City of Pittsburgh

Angler Focus Group Participants

Rick Baraigh

Daniel Lou Black

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