



When the Water Runs Through It

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The Endless Hill is a water resource treasure

The Kittatinny Ridge was referred to by the Lenape Indians as the “endless hill.” The hard, conglomerate rock, made mostly of quartz is very slow to weather and the hill has persisted for millions of years. Over 390 trillion gallons of rain fall on and run through the 450 square miles of forests along the Ridge. The forests filter the water and help power companies, farmers, tourism, and businesses thrive, as well as 2.5 million residents. It also helps in creating and sustaining many jobs. Naturally regenerating forests have been filtering water for free for over ten thousand years. If forests aren’t present, clean water will be paid for by taxpayers.

The Kittatinny Ridge traverses a 185-mile course through Pennsylvania, from the Delaware River to the Mason Dixon Line. Its land area is approximately 1/10th of the acreage in the 12 counties it traverses. The hard rock on the Ridge allows limited to no infiltration of rain water. The lion’s share of rain water moves downhill and recharges the unconsolidated colluvium material and fractured rock at the base of the slope. Because the Ridge is elevated, the water follows the fractures in the rock downhill in a southwest direction and recharges streams and the valley aquifers. About 12% of the water is constrained physically in the rock itself by capillarity.

We all expect plentiful, clean water, and dry basements in our future without understanding where they come from and what they are worth. While water is a precious resource, like many resources it is often taken for granted and undervalued in policy debates and investment

decisions due to limited available information. Policy makers and residents must understand the critical role of water to the regional economy as it is difficult to have a strong economy without clean water, a healthy environment, plenty of open space and quality habitat.

The state Constitution imposes a duty to conserve and to maintain public natural resources for this generation and generations yet to come. We all have a stake in the use, enhancement and stewardship of the water resources influenced by the Kittatinny Ridge.¹

The water available on the Kittatinny Ridge is exceptional.

Forests makes up 95% of the land cover along the Ridge. The Ridge infiltrates approximately 10% of rainwater in 12 counties. The water on the Ridge is continuously pristine due to the forests ability to filter water and act like a sponge. When rainwater runs through these forests the Ridge produces clean water, habitat and stream flow. Without its forest cover what would happen to many streams, 13 lakes, 11,000 farms, and hundreds of permitted point sources meeting TMDL regulations? The water is:

- Headwater to many streams and creeks
- Drinkable
- Swimmable
- Exceptional and high quality stream designations
- Streams suitable for wild trout
- Attraction for recreation and tourism
- So clean and reliable that groundwater supply attracts spring water companies, breweries and pharmaceutical, and technology businesses that require very high quality water.

The forests provide a high-impact, low cost solution to many downstream problems. They provide many valuable cost free, benefits such as:

- Water supply
- Well water
- Stormwater management for MS4 permits
- Dilution and nutrient abortion for NPDES permits
- Flood damage mitigation
- Carbon sequestration
- Carbon storage
- Greenhouse gas absorption
- Recreational water-related activities
- Habitat and sustainable biological diversity
- Nutrient absorption

¹ Pennsylvania State Water Plan, 2008

- Pollination and biological control
- Regeneration

Even though these services are inherently renewable, they require natural diversity and productivity to remain in place. Once lost, these benefits are difficult and costly to replace and require taxpayer funding

Protecting the Kittatinny Ridge is serious business for all 12 counties, 9 of which are among the top 20 fastest growing counties in the Commonwealth.

to replace them. Nature also provides a form of risk management or insurance and it has been providing these natural system services 24 hours a day, 365 days a year for over 10,000 years. Many of these services are more reliable than engineered services at significantly lower cost to taxpayers.²

Protecting the water resources on the Kittatinny Ridge is serious business.

The water running through the Kittatinny Ridge is serious business because it impacts a substantial portion of the existing economy and future economic growth. Table 1 illustrates the substantial role water plays in the current economy.

Table 1. Percent of state activity

Power generation-(Megawatts)	15% ³
Population	20% ⁴
Farms	17.7% ⁵
Tourism (Tourism spending)	14.4% ⁶

In the next 25 years, the land surrounding the Kittatinny Ridge will have three of the top ten and nine of the top 20 twenty fastest growing counties in the Commonwealth.⁷ In Table 2, the counties with a blue bar are located on the Kittatinny Ridge.

Estimates project that 100,000 more people will depend on these water resources in the next fifteen to twenty years.⁸ Population shifts, energy demands, farming practices, infrastructure

² US Environmental Protection Agency, (2012). *The Economic Benefits of Protecting Healthy Watersheds*. EPA 841-N-12-004, 1. Retrieved from http://water.epa.gov/polwaste/nps/watershed/upload/economic_benefits_factsheet3.pdf

³ Plants <http://www.powerplantjobs.com>

⁴ Center for Rural Pennsylvania, Pennsylvania Population Projections for 2010-2040.

⁵ https://www.nass.usda.gov/Statistics_by_State/Pennsylvania/Publications/Annual_Statistical_Bulletin/2009

⁶ Tourism Economics, 2014. *The Economic Impact of Travel in Pennsylvania*.

⁷ Center for Rural Pennsylvania, Pennsylvania Population Projections for 2010-2040.

⁸ IBID.

management, consumer sophistication, tourism, national and state water policies, and climate change will all influence how water resources are managed over the next several decades. In the Chesapeake Bay Watershed, 100 acres of forest are lost every day.⁹ This is the equivalent loss of a potable water supply for 540 homes (worth \$6,000 annually) and the CO2 offset of 100 homes every day (worth \$23,000 annually). We also lose millions of gallons of clean water dilution that allow industrial water users to maintain their NEPES permits and aquatic life to support a robust recreational economy.

Table 2. Top Twenty Fastest Growing Counties in the Next 25 Years ¹⁰

County	Estimated growth rate
Montour	24.6%
Lancaster	23.3%
Clinton	22.7%
Center	22.3%
Perry	21.7%
Philadelphia	21.7%
Berks	20.3%
Cumberland	18.9%
Huntington	18.5%
Indiana	17.3%
Montgomery	17.2%
Franklin	15.9%
Delaware	15.9%
Union	14.9%
Lehigh	14.9%
York	14.4%
Schuylkill	12.1%
Lebanon	11.7%
Dauphin	10.6%
Northampton	9.5%

⁹ Conservation Fund, 2006. State of the Chesapeake Bay Forests.

¹⁰ Center for Rural Pennsylvania, Pennsylvania Population Projections for 2010-2040.

Industrial users include companies like Kraft Foods, Air Product Chemical, Yuengling and Samuel Adams Brewery, Niagara Bottling, Nestles Water, Astra Zeneca (Pharmaceutical company), Fort Indian Town Gap.

Sometimes nature does it best.

Natural forests are one of the best water filters ever created, in large part due to their leafy canopy that intercepted rainfall, slowing its fall to the ground and the forest floor. The forest soils act like an enormous sponge, typically absorbing up to 18 inches of precipitation before gradually releasing it into natural channels and recharging groundwater. Soil infiltration rates range from 12.4 to 4.4 inches per hour.¹¹

Keeping the Ridge forested helps the water downstream stay cleaner.

Average interception of rainfall by forest canopy ranges from 10-40% depending on species, time of year, and precipitation rates per storm event.¹² Over 95 percent of the storms are less than 3 inches making infiltration possible in forests on a consistent basis.¹³

The high infiltration capacity of forest soils are able to quickly absorb large amounts of water. Rainstorms and melting snow in woodlands cause very little surface runoff, soil erosion and sedimentation. Turbidity is the term applied to water that has reduced clarity due to suspended sediments. This is often caused by stream bank erosion during storm events.

Because the Ridge is 95% forested, water is filtered and little water treatment is needed. For every 10% of the forests on the Ridge that are cleared, water treatment costs go up by 20%.¹⁴ Projects that help restore natural system functions like planting forests and riparian buffers provide between \$7-\$13 return to the local economy for every dollar spent. Protecting our natural systems is ecologically and economically effective.¹⁵

Water Regulations

The federal Clean Water Act, court orders and regulations finalized by the U.S. Environmental Protection Agency (EPA) in December 2010 impose a total maximum daily load, or TMDL, that requires Pennsylvania to reduce annual discharges of nitrogen, phosphorous and sediment

¹¹ Keys 1980 when a soil is converted to suburban turf grass.

¹² Pennsylvania Department of Environmental Protection. 2007. Pennsylvania Stormwater Manual. 363-0300-022.

¹³ IBID.

¹⁴ Ernst, C., Gullick, R., Nixon, K. (2004). Conserving Forest to Protect Water. *Opflow* 30:1, 4-7.

¹⁵ Department of Recreation, Park, and Tourism Management, The Pennsylvania State University Keystone Fund Report; www.tpl.org/Pennsylvania; (2012). *The Economic Significance and Impact of Pennsylvania State Parks: An Updated Assessment of 2010 Park Visitor Spending on the State and Local Economy, 2012*.

Trust for Public Land. (2013). Pennsylvania's Return on Investment in the Keystone Recreation, Park, and Conservation Fund, DCNR.

entering waters of the state including the Chesapeake Bay Watershed by 2025 in order to meet water quality standards. The Federal Clean Water Act and the Pennsylvania Clean Streams law requires wastewater dischargers to have a permit establishing pollution limits, and specifying monitoring and reporting requirements. This is called The National Pollution Discharge Elimination System (NPDES Permit System)

The volume of clean water that come from the Ridge is a foundation for downstream water quality and why many businesses can meet current permit requirements. Put another way, dilution is still one answer to pollution. With expected growth, the forests along the Ridge play an increasingly important role in water quality.

Municipalities that are designated MS4 communities (Municipal Separate Storm Sewer Systems) by EPA and DEP are tasked with finding ways to reduce stormwater runoff. Some municipalities face fines and enforcement for combined sewer overflows that cause untreated sewage to flow into waterways when pipes do not handle increased volumes of stormwater during rain events. One of the most effective and cheapest solutions involves canopy trees like those on the Ridge.

The Kittatinny Ridge provides well-head and headwater protection to 12 counties without maintenance costs. What's more, healthy watersheds that maintain protected riparian corridors are expected to be more resilient to the anticipated effects of climate change. When green infrastructure is connected with healthy habitat, these green corridors allow residents and businesses to realize the full potential and natural balance of Pennsylvania's ecosystems and economy.

The recently rescinded riparian buffer policy and Pennsylvania's lack of emphasis on well head protection puts water resources at risk for current and future residents and businesses. Promoting strong conservation and forest protection along the Kittatinny Ridge is a critical hedge against inadequate and uncertain public policy. Our lack of strong water resource policies supporting strong integrated water resources management will have long-term negative effects on our quality of life, health, cost of living and economy. To counter this threat, businesses and conservationists can partner to ensure a better future. Many businesses recognize the value of a healthy environment. More investments in naturally smart business ventures that incorporate integrated water resources management will create a healthier environment and economy.

The state Water Plan entitled "A Vision for Pennsylvania's Future" emphasizes stewardship of the state's water resources and references the

The two highest priority water management practices are:

1. Protect and restore natural, regenerating forests, particularly in headwater areas.
2. Protect and restore wetlands and 100 foot wide riparian buffers.

state Constitution as vesting a right to pure water and the values of the natural environment for all Pennsylvanians.

The two highest water management priority practices are to retain forests, particularly in headwater areas along the Ridge and maintain wetlands and vegetated riparian buffers. For policy makers to reduce their risk and make smart choices, data on the role of water to the health, safety and welfare of residents, farms and businesses is essential.

Land Development

As our landscapes grow and develop, the health of our streams and rivers have been impaired. What we do on the land, or what we cover it with, affects the quantity (volume and velocity) and quality (pollution levels) of the rainfall that enters our waterways.

When it rains on imperious areas, rainwater washes pollutants such as nutrients, chemicals and heavy metals of streets, lawns or bare soil into storm drains or directly into creeks and streams.

As land development occurs, and a higher percentage of the land surface is impervious, the ability of natural systems to reduce impacts goes down (Figure 1). With increases in impervious surfaces, the value of natural system services goes down, especially when imperious cover reaches 20% or more (Figure 2). Strategically, forests in headwaters and riparian corridors are critical to maintain natural system services and healthy, sustainable watersheds, particularly in suburban landscapes.

Surface water quality and availability can be compromised by increases in impervious surfaces and forest loss associated with urbanization, energy development, and surface mining; by point and non-point source pollution and increased sediment loads from these land uses; and intensive agricultural land uses. The impact of climate change on water quality and availability is likely to vary regionally, but average temperature increases may broadly result in reduced availability. Forest and wetland restoration efforts can have strong positive effects when sited appropriately.¹⁶

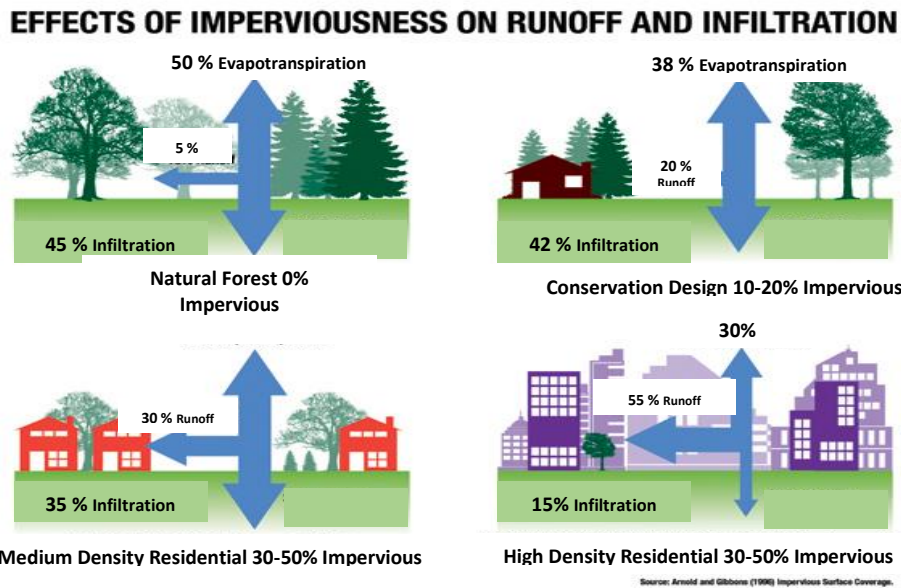
The amounts, velocities, and variability of flowing water in streams and rivers—especially the ‘normal’ or base flow and peak storm flows—have a profound influence on how water is utilized and what societal benefits and risks are associated with the great abundance of Appalachian streams and rivers. The risk of flooding, what kinds of outdoor recreation and tourism are supported, and freshwater habitat quality are all affected by these streamflow characteristics. In turn, flows are strongly influenced by the surrounding landscape and by precipitation patterns. In particular, the loss of forest cover from urbanization, mining, forest pathogens and other factors can elevate runoff, increasing downstream discharge rates, peak

¹⁶ <http://applcc.org/ecosystem-risks-benefits/key-ecosystem-services/water>

storm flows, and stream velocity. The frequency of extreme precipitation events is also expected to change over time; the effects of these events on streamflow will depend heavily on impervious surface cover, vegetation cover and characteristics, forest management practices, and other land use factors.¹⁷

Healthy, productive soils support a wide variety of ecosystem services, including agriculture and silviculture, hydrological regulation, clean water, and carbon storage. Soil loss and

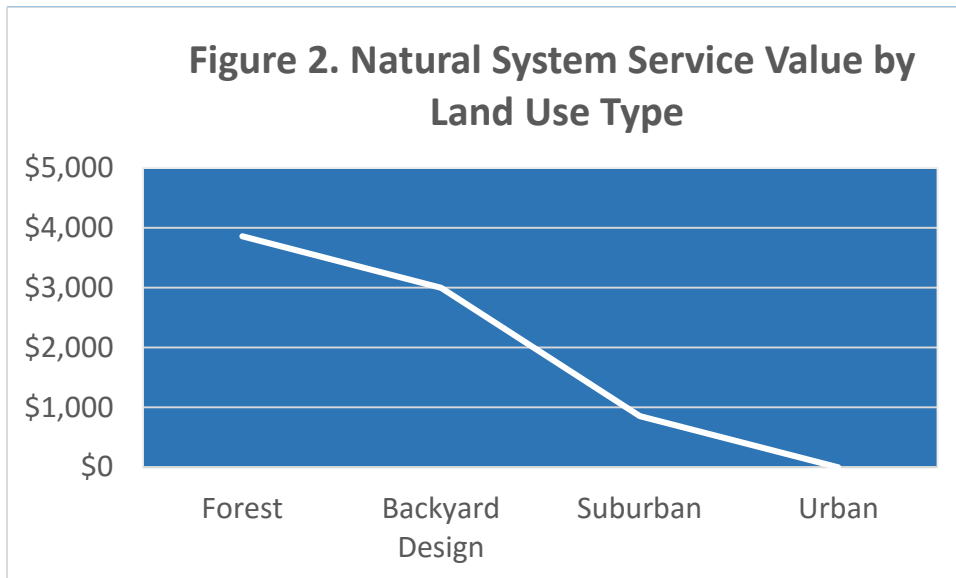
Figure 1. Land Development Impacts in Southeastern Pennsylvania



compaction can impede forest regeneration. Soil chemical properties, water content, and microbial communities are all negatively affected by some invasive plants across large areas, compromising native plant communities and restoration efforts.¹⁸

¹⁷ IBID.

¹⁸ IBID.



Kittatinny Ridge Water Budget

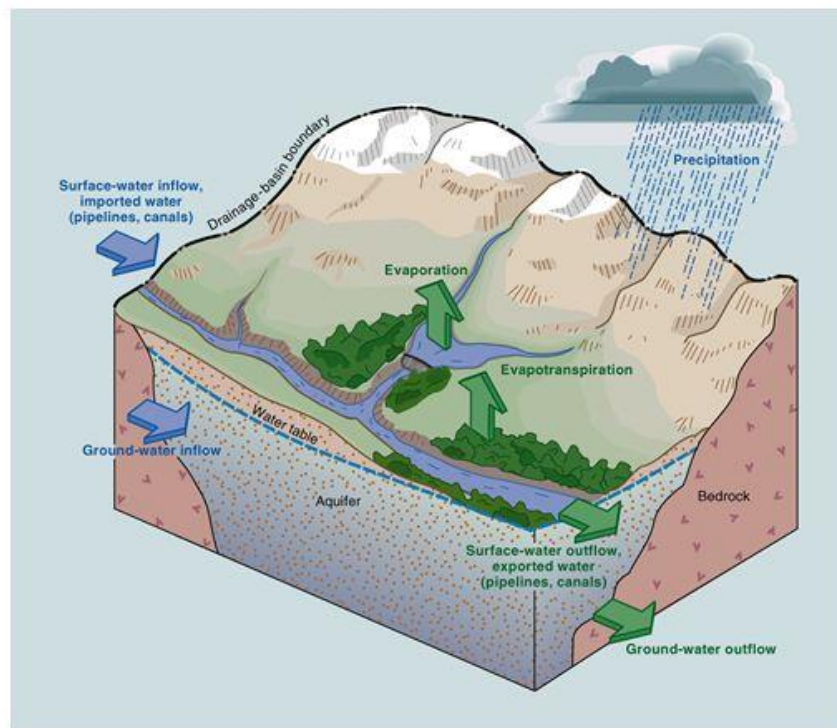
A water budget accounts for the inputs, outputs, and changes in the amount of water by breaking the water cycle down into components. It provides scientific measurements and estimates of the amount of water in each component and calculates the movement of water among the different components. The result is a *budget* that is a hydrologic record comparable to deposits, withdrawals, and changes in the balance of a checking account. As with a monetary budget or checking account, knowing where, when, and how much is flowing in or out of an account can provide a means for calculating how much is left for other uses (water availability) and where stresses to the budget (the unpaid bills or water shortages) exist or are developing.

Many factors affect water use and availability – including, of course, the natural processes that drive the water cycle. However, a host of other societal and technical factors related to environmental management and water supply can influence the availability of water in the environment – including surface water such as lakes, rivers, and wetland as well as groundwater, such as aquifers. Water use is also a factor driving availability, and is itself affected by more than simply the demand for consumption – with laws, regulations, economics, and other environmental factors influencing its use. With all of the factors complicating water availability, it may seem a bit hard to imagine how the USGS approaches the question of water availability through a purely scientific approach.

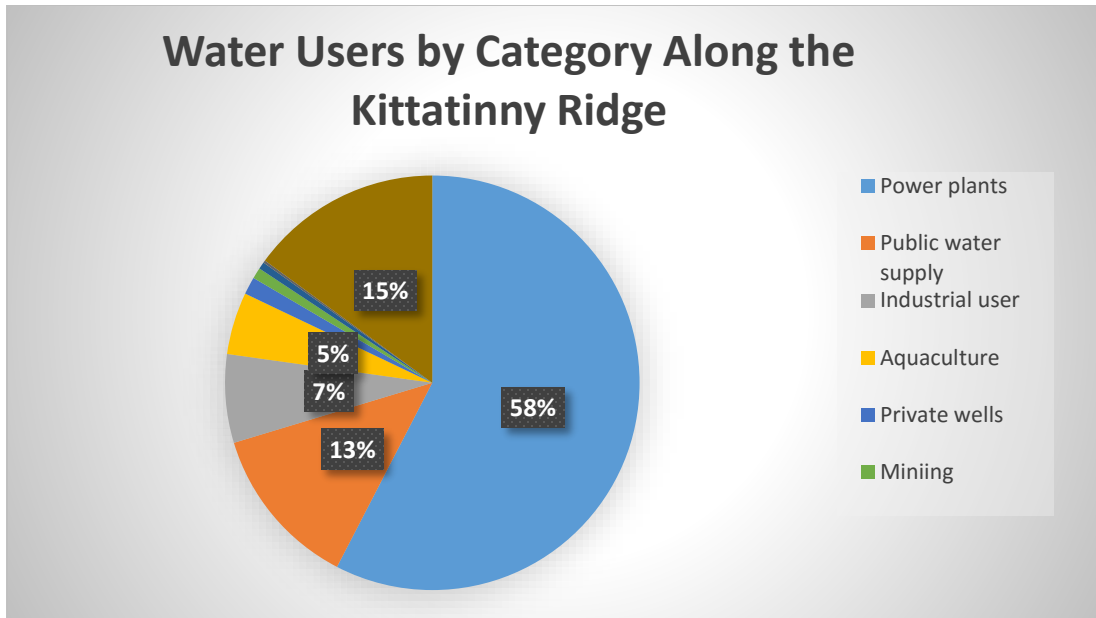
The water budget for the Ridge estimates that 3.9 billion gallons of water flow through the 500 square miles of the Ridge each year. The Ridge is 95% forested so the water is naturally filtered and very clean. Approximately 859 million gallons go to deep groundwater recharge and a similar volume feeds local streams at near 55 degrees Fahrenheit (underground temperature). This supports a very healthy aquatic environment and recreational fishery. The runoff from the Ridge is negligible due to forest cover, thus minimizing taxes expended for flood clean up and stormwater management.

Water Users

Figure 1. Components of a simple water budget for part of a watershed.



The largest water users on the Ridge are power plants, municipal water supply, Industrial users, aquaculture, private wells, mining and livestock. Water provides over \$1 billion to the local economy each year. As growth continues, so does demand for clean water, energy, recreation, natural resources, open space and food.



Ways to Manage the Water Resources on the Kittatinny Ridge

1. Maintain native species and biological diversity on the ridge to help forests naturally regenerate and be more resilient to climate change.
2. Maximize canopy cover on the Ridge to maximize water infiltration, reduce nutrients and maintain stream temperatures for aquatic organisms.
3. Maintain all wetlands.
4. Identify exceptional value and high quality streams for maximum protection.
5. Maintain riparian buffers (100 feet) to reduce sediment and provide shade and food for aquatic organisms.
6. Manage forests for fire protection.
7. Avoid the use of chemicals on the Ridge.

Water Goal Action Plan

1. Develop a Water Budget for the Ridge
 - List of all point sources (NPDES permits and MS4 permits)
 - Determine water value by county
2. Expand ROE land cover categories
 - Large forests – Climate change resiliency and regeneration
 - Exceptional value and high quality streams- (NPDES Permit compliance)
 - Urban forests and wetlands (MS4 permits)
3. Expand ROE criteria to include
 - Regeneration costs---PA Forest Service
 - Biological diversity---PA Game Commission
 - Trout fisheries costs and penalties—PA Fish and Boat Commission
4. Complete County ROE and Begin Municipal level ROEs
 - Educate officials
 - Map ROE
 - Align ROE with County Comprehensive Plans
 - Value (ROE) for municipal ordinances (Riparian buffer, cluster zoning, open space referendums)
 - Set preservation priorities and connect habitat (Official Maps)
 - Value restored areas