Chapter 5. *ISSUES AND CHALLENGES*

Westmoreland County has an abundant supply of surface and groundwater resources as illustrated in Chapter 3, but there are significant impacts on those resources as covered in Chapter 4. These impacts have resulted in numerous issues and challenges which are covered more thoroughly through watershed modeling and pollution accumulation modeling in this chapter.

WATERSHED MODELING

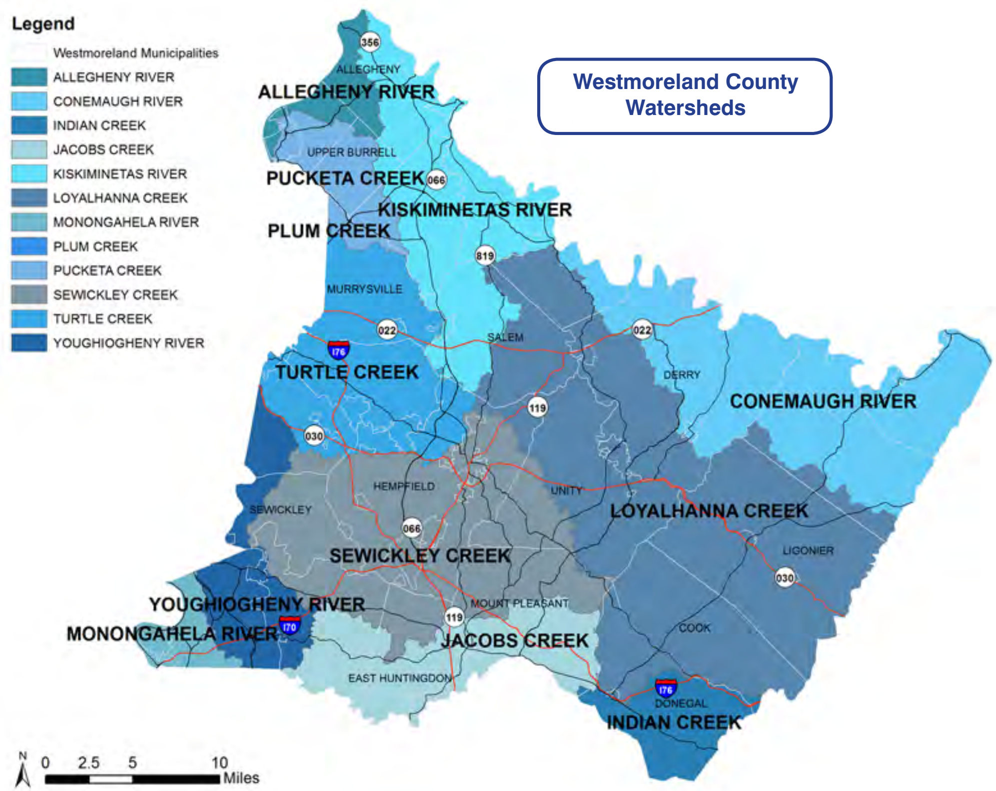
Watershed modeling is a tool that engineers and scientists use to study stormwater infrastructure and how it relates to land development and other activities. Westmoreland County has ten distinct major watersheds shown on the map below, some shared with adjacent counties. Each watershed has a unique set of problems and issues. US EPA and PA DEP have established the foundational rules and regulations for new development, redevelopment, and the management of stormwater resources. These rules, found in PA DEP's Chapter 102 NPDES regulations, require the control of increased rate of runoff (cubic feet per second) for the range of expected storms. They also require the control of increased volume of runoff (expressed usually in cubic feet) of the small, frequent two-year storm. Controlling the rate and volume of runoff from the small, frequent storm also results in control of pollution of stormwater, for many studies have shown that the small, frequent storms are the most polluted by runoff from developed surfaces.

The Westmoreland County IWRP offers tools and resources to satisfy those regulations at the watershed level. Furthermore, the IWRP addresses those areas of the county where stormwater has previously been unmanaged and uncontrolled through the model stormwater management ordinance and the watershed performance districts determined by this plan.

Although the IWRP considered the entire county, it includes a more in-depth look at the 10 priority watersheds/areas of interest (AOI) identified in the Act 167 Phase 1 report, especially those within the highly developed growth triangle in the western part of the county, and those within established, built-out older communities affected by water issues.

AOI's include:

1. Turtle Creek
2. Sewickley Creek
3. Kiskiminetas River AOI (Delmont/Beaver Run)
4. Conemaugh River AOI (Derry/McGee Run)
5. Loyalhanna Creek AOI (Latrobe, Ligonier)
6. Monongahela River
7. Pucketa Creek, Plum Creek, Allegheny River
8. Jacobs Creek
9. Youghiogheny River
10. Indian Creek



Paddle-boat rentals are popular at the Twin Lakes County Park Boathouse.

WHY WE STUDIED THE TEN WATERSHED AREAS OF INTEREST

Westmoreland County is naturally divided into watersheds – areas defined by landform which gather runoff from storms into a stream or other body of water. Ten major watersheds receive runoff from land in our county. Our river watersheds are the Allegheny, Kiskiminetas, Conemaugh, Monongahela, and Youghiogheny. Our creek watersheds are Indian, Jacobs, Loyalhanna, Pucketa, Plum, Turtle/Brush, and Sewickley. The Loyalhanna Creek watershed has the largest drainage area in the county of 298 square miles which includes all or part of 15 different municipalities from the southeastern part of the county to the north central. In contrast, the Plum Creek watershed drains only a few dozen acres of far northwestern Murrysville. Ultimately all the runoff in the county reaches either the Monongahela River via Indian, Jacobs, Sewickley, and Turtle/Brush creeks and the Youghiogheny River, or the Allegheny River via Plum, Pucketa, Kiskiminetas, and Loyalhanna creeks and the Conemaugh River. So our county, which lies upstream of the famous Golden Triangle at Pittsburgh, contributes directly to the Three Rivers.

Westmoreland's streams and waterbodies also help to form some of our political boundaries – the Conemaugh, the Kiskiminetas, and the Allegheny rivers form the northern boundary of the county while Jacobs Creek helps bound the southern edge of our county. However, many of our political boundaries have no relation to the physical boundaries of watersheds, and so many of our streams drain several municipalities, and many of our municipalities lie within several different watersheds. The natural flow of water does not heed man-made boundaries; for this reason, we conducted our stormwater study by watershed, and not by municipality.

The IWRP focuses on ten areas of interest (AOI) in Westmoreland County identified in Phase 1 of the Act 167 Plan and which were studied in detail for the IWRP and Phase 2. These ten AOIs, watersheds and sub-watersheds represent a cross-section of developing areas across the county, and were chosen based on various factors including a history of flooding and stormwater problems, land development activities, and environmental concerns. The need for study, while required by Act 167, is also necessitated by a historical lack of controls on land development across the county, resulting in encroachment on and degradation of our streams. The intent of the IWRP—to manage our county's water resources wisely—means these streams, their ecological environs, and the neighborhoods they flow through, need to be studied in more detail. The ten AOIs and the reasons they were chosen for further study are outlined here.

Countywide:

It is important to note that areas of Westmoreland County which were not studied in detail are still in need of stormwater management, not only for peak rate control but for runoff volume and water quality. Nearly every stream in our county, even those in rural areas, has reaches where it has been impacted by human activities. While rural residents may enjoy the unspoiled beauty of our countryside, they also may suffer from flooding or erosion damage. Furthermore, as the urban sprawl type of growth continues to spread along our major transportation corridors, these rural areas will find themselves targeted for large residential, commercial, and industrial projects. Conservation, and the wise use of natural resources, requires us to plan and study how the inevitable spread of development may be best managed. For these and many other reasons, our IWRP provides standards and sets requirements for all of the county, urban, suburban and rural areas, based on the ten priority watershed AOI findings.

Turtle Creek/Brush Creek AOI:

Turtle Creek is a 147 square mile watershed that spans the border between eastern Allegheny and western Westmoreland counties. The entire two-county Turtle Creek watershed was studied in 1990 as Westmoreland's very first Act 167 study, done in cooperation with Allegheny County. The 98 square miles of the watershed which lies in Westmoreland County makes up the AOI. Commonly called the Turtle Creek watershed, more of the Westmoreland County portion drains to Turtle Creek's main tributary Brush Creek than to Turtle Creek itself, but the watersheds were considered jointly. The AOI features much dense residential development, old and new industrial areas, major transportation routes including the main line of the Norfolk Southern railroad, the Pennsylvania Turnpike, and State Routes 22 and 30, and many commercial properties. The watershed is home to thousands of county residents and host to many flooding and water quality problems. Abandoned mine drainage (AMD), stream habitat loss due to human encroachment, severe historical capacity-limiting obstructions, and pollution from the built environment are important factors in this watershed.

Photo by Pictometry

The heavily-developed and industrialized Brush Creek valley in North Huntingdon Township.

Sewickley Creek AOI:

Sewickley Creek AOI is the entire 168 square mile watershed that drains the center-south portion of the county. While it is home to a concentration of many of our county residents, this area also is host to many farms and rural properties. Our county's commercial heart, the Route 30 corridor around Greensburg, lies in this watershed, as do the County Seat, Greensburg, the area's largest township by population, (Hempfield), and innumerable suburban residential subdivisions. The automobile and its impacts dominate this watershed, which features Interstate 70, the Pennsylvania Turnpike, (and their major interchange in New Stanton), US Route 119, and US 30. Industry and former coal mining sites are also common in this area. Major flooding events over the years have caused economic hardship and property damage, and the presence of AMD hinders aquatic life in many of the tributaries and main stem.

Photo - New Stanton Borough

New Stanton, PA and Interstate 70, circa 1960

Kiskiminetas River AOI:

The Kiskiminetas, or Kiski, River is formed by the confluence of the Loyalhanna Creek and the Conemaugh River and flows northwest to the Allegheny River. This watershed is not densely populated, and the study area is a small portion of it – a 15 square mile AOI draining into the Beaver Run Reservoir, a source of drinking water for much of the northern portion of the county. The study area encompasses the very busy intersection of PA 66 and US 22, the commercial area adjoining it, and the historic old town of Delmont, first settled about two hundred years ago. Development and redevelopment pressure in this area points to a need to address stormwater and other water issues.

Photo by Mark Jackson

Historic Delmont, PA – Pittsburgh Street looking east.

Conemaugh River AOI:

The Conemaugh River begins in Johnstown, and drains portions of four counties – Somerset, Cambria, Indiana and Westmoreland. Combined with the Loyalhanna Creek to form the Kiskiminetas River and draining a portion of Armstrong County as well, the entire Kiski-Conemaugh River Basin is 1,887 square miles. The Conemaugh Dam, a massive ACOE flood control project built upstream of the confluence with the Loyalhanna Creek after World War II, provides flood control for this river and for the Pittsburgh region downstream and is not part of the study area. The 14 square mile AOI for the Conemaugh watershed centers on Derry Township and historic Derry Borough, a town created by the Pennsylvania Railroad as the western terminus of its mountain division. The Derry area has numerous stream impacts due to industrialization, which need to be addressed as the area is gradually being redeveloped with more 'green' industry, homes, schools, and shopping districts.

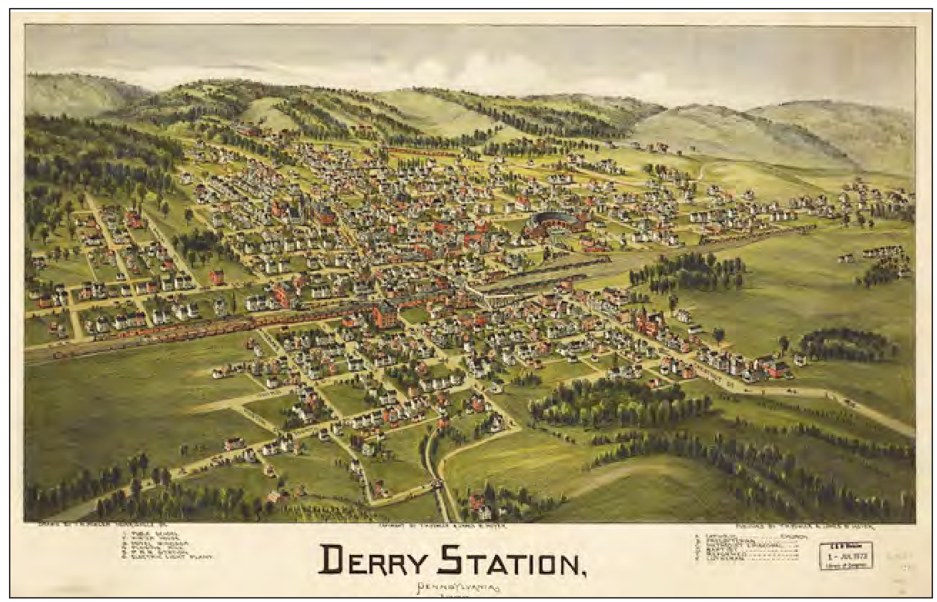


Image - Wikipedia/public domain

Derry Borough from the west.

Loyalhanna Creek AOIs:

The Loyalhanna Creek is our county's largest watershed at 298 square miles and drains nearly one-third of the county from the southeast to the north central part of the county. The Loyalhanna watershed contains woods, farms and urban/suburban areas that are not evenly distributed across the watershed. The IWRP included 2 separate AOIs in this watershed to focus on the existing urbanized areas. The northern, or downstream area in the watershed is rural in nature, is dominated by a US ACOE flood control channel and the Loyalhanna Dam built before World War II, and was not studied. The first AOI is located in the central portion of the watershed and features the urban area of Latrobe and portions of Unity and Derry Townships, a developed, industrial, and growing region. This area has various historical flooding and water quality problems affecting homes and businesses. The southeastern portion of the watershed is largely wooded, with the exception of the Ligonier area, and contains the second AOI, which covers the Mill Creek watershed and a portion of the Loyalhanna's upper corridor that contributes to flooding issues in the urban area of Ligonier.

Photo by Mark Jackson

Saint Vincent College near Latrobe, in the Loyalhanna Creek Watershed.

Monongahela River AOI:

The Monongahela River, known locally as the Mon, has long been the Pittsburgh region's industrial workhorse, carrying coal and raw materials to support the important steel industry. This north-flowing river drains land from West Virginia and Maryland as well as several counties in Pennsylvania. The 14 square mile AOI includes a portion of developing Rostraver Township that is tributary to the section of the Mon in Westmoreland County. Some of the tributaries included in the AOI have been impacted by coal mining, transportation infrastructure, and land development.

Photo by Mark Jackson

Boat launch on the Monongahela River at Monessen

Pucketa Creek, Plum Creek, Allegheny River AOI:

Pucketa Creek, Plum Creek, and the Allegheny River lie in the northwestern part of our county and the AOI covers a 46 square mile portion of these watersheds. This study area has had some historical flooding problems and is under continued pressure from land development and urban sprawl. This northwest area of the county, historic home to America's aluminum industry, has steeper slopes than other areas, with the associated rapid runoff and erosion that occurs from those sloping, clayey soils. A lack of historical stormwater management practices, combined with excessive floodplain encroachment, leads to a need for attention to stormwater management.

Photo by WCIDC

The new face of industry in the Pucketa Creek Watershed: Westmoreland County's Business and Research Park—no soot, no smoke, and hundreds of 'clean' jobs. WCIDC

Jacobs Creek AOI:

Jacobs Creek covers 98 square miles in Fayette and Westmoreland Counties with 75% of the watershed lying in Westmoreland. It originates in the forestland of the Laurel Mountains and forms a portion of Westmoreland County's southern boundary. The AOI lies in the midsection of the watershed, and encompasses a 30 square mile area. The AOI features an area known for coal mining, industry, and bustling small towns; one hundred years ago Henry Clay Frick had 999 beehive coke ovens in Standard Shaft, just north of the farming and business center of Mount Pleasant Borough. Leaving the Mount Pleasant and Scottdale areas, Jacobs Creek flows through the very scenic and very rural Creek Hills area before emptying into the Youghiogheny River. The main channel of Jacobs Creek is well-protected from flooding by a project completed by USDA-Soil Conservation Service which included construction of three flood control dams and a flood channel. However, the various smaller tributaries of this AOI suffer from degradation due to AMD, urban runoff, and agriculture.

Photo by Jacobs Creek Watershed Association

Wetland mitigation site in Jacobs Creek watershed

Youghiogheny River AOI:

Known locally as the Yough, and known nationwide as a scenic and recreation-focused river, this stream flows between steadily-developing Rostraver Township and predominantly rural South Huntingdon Township on its way to meet the Monongahela River at McKeesport, Allegheny County. The 47 square mile AOI takes into account the land in the Rostraver area draining directly into the Yough in the southwest corner of the county, and the smaller streams, including Cedar Creek and Pollock Run which serve to carry stormwater from the many residences and commercial areas of the township.

Photo by Downtown West Newton Inc.

Youghiogheny River from Route 136 bridge, looking downstream.

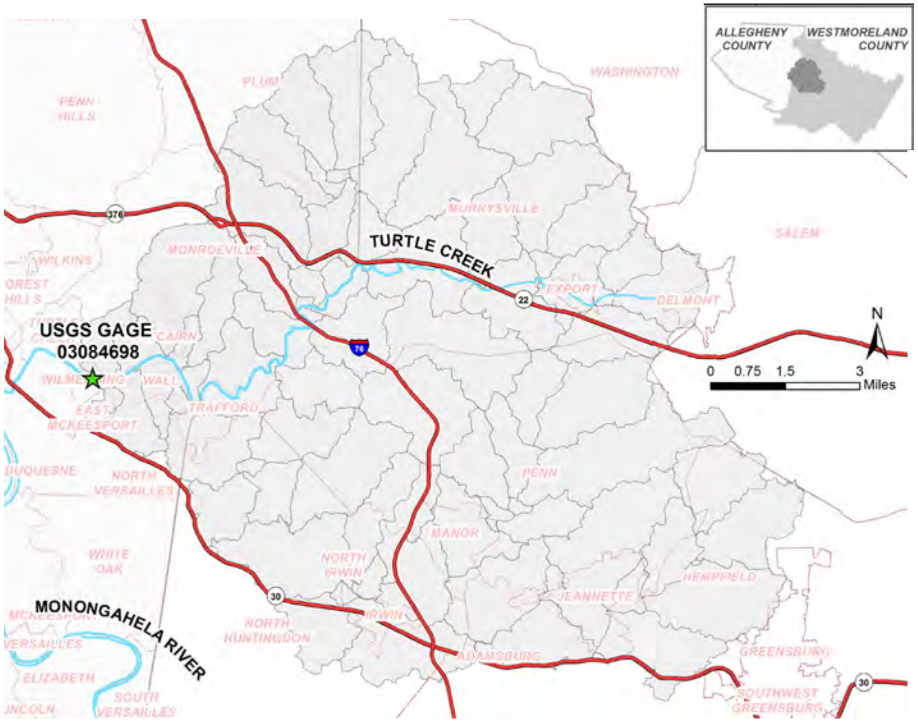
Indian Creek AOI:

Located in the far southeastern corner of Westmoreland County, Indian Creek begins high on Laurel Mountain near where the Pennsylvania Turnpike crosses the ridge into Somerset County. Despite paralleling the heavily-traveled Turnpike for several miles, Indian Creek is classified as a High Quality stream and supports a strong fish population. Historically, the Indian Creek watershed has been dominated by resource extraction—timbering, quarrying, coal mining, and oil & gas production are all found here. In recent years the Mountain Watershed Association has created facilities to treat abandoned mine drainage (AMD) and has also established the Indian Creek Valley Trail, following the path of the former Indian Creek Valley Railroad. Recreational uses of water have become quite important in this area as many tourists visit the area for camping, hunting, fishing, and skiing.

Photo by Stephen Simpson

Indian Creek

TURTLE CREEK WATERSHED AREA OF INTEREST



Source - Ethos Collaborative

WATERSHED SNAPSHOT

- ***Area: 98 square miles***
- ***Water Quality: Impaired for aquatic life, due to a myriad of pollution sources but primarily non-point sources of runoff from the landscape.***
- ***Characterization: Highways provide relatively quick transportation from this largely suburban area into the city of Pittsburgh.***
- ***An active Watershed Association in this area is working to address problems such as Abandoned Mine Drainage and excess stormwater.***

REGION OVERVIEW

The Turtle Creek Area totals 147 sq mi and is located in both Allegheny and Westmoreland Counties, as shown on the map to the left. The Area of Interest for this watershed was defined as the land within Westmoreland County that drains to the USGS gage (# 03084698, located in Wilmerding and marked by a star on the map, left). This Area of Interest is approximately 98 mi^2/ 62,720 acres and contains 227 miles of streams in Westmoreland county. For purposes of this plan, however, we modeled the entire region that drains to the Wilmerding USGS gage, an area which spans both Allegheny and Westmoreland Counties. The entire watershed draining to the Wilmerding USGS gage measures 123 mi^2 /78,724 acres in size and contains 268 stream miles. Turtle Creek continues downstream from Wilmerding, emptying into the Monongahela River in East Pittsburgh.

Why is this watershed of particular interest?

The Turtle Creek watershed boasts an illustrious energy, industrial and commercial legacy. This watershed is the original home of the Westinghouse Electric Corporation, an early innovator in developing electric power generation infrastructure. Local coal mines provided fuel to power the factories. However, this same success has also left the Turtle Creek watershed with a legacy of pollution, industrial landscapes and impacted waters. This watershed was identified in Phase I as an area experiencing growth, recurrent flooding, and rapid development.

Assets in the Watershed

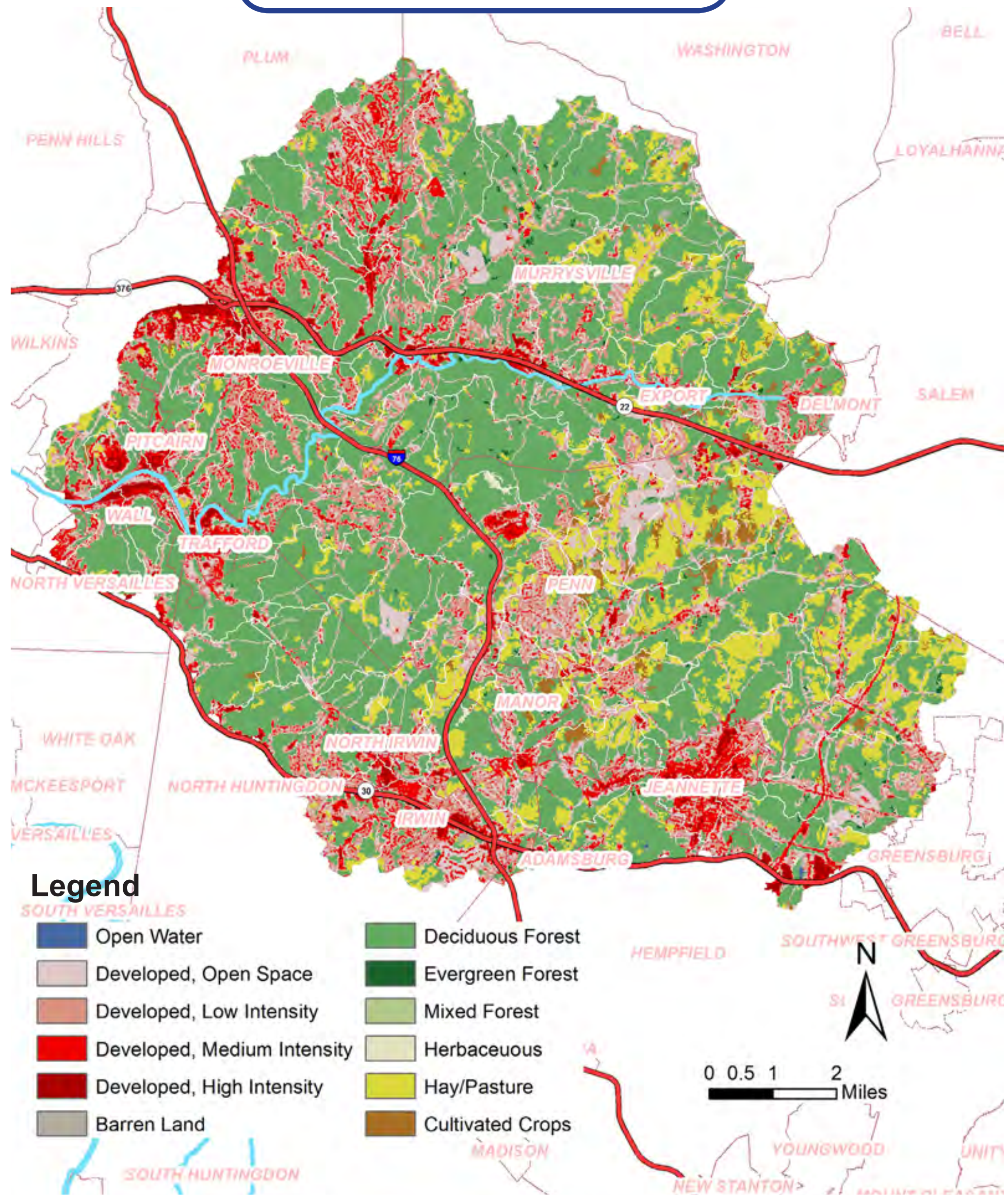
This watershed currently has an Act 167 Plan from 1990 that needs to be updated. The Turtle Creek Watershed Association maintains an active agenda of conservation, education, and partnerships to increase water quality through conservation and research management efforts addressing erosion, stormwater, sewage, and abandoned mine drainage. Please see http://www.turtlecreekwatershed.org for more information about their initiatives and programs.

Landcover / Landuse

Landcover in the Turtle Creek Watershed is mixed forested, agriculture, and urbanized land. The most highly urbanized areas include a swath of towns along the north/west boundary of the watershed (for example, Monroeville and formerly industrial areas such as Wall, Wilmerding, and Pitcairn) and another region along the southern border of the watershed (Irwin, North Huntington, Jeannette). The agricultural land is concentrated in the East and South regions of the watershed. Landcover data is based on the 2011 National Land Cover Dataset, created by the Multi-Resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.

Landcover Class	*Acres*	*Total Area (%)*
Open Water	22	0.03
Developed- Open Space	10310	13
Developed- Low Intensity	12560	16
Developed- Medium Intensity	6407	8
Developed- High Intensity	1750	2
Barren Land	117	0.2
Deciduous Forest	37976	48
Evergreen Forest	230	0.3
Mixed Forest	63	0.08
Herbaceous	81	0.1
Hay/Pasture	8272	10
Cultivated Crops	916	1

Turtle Creek Watershed
Land Cover Classification

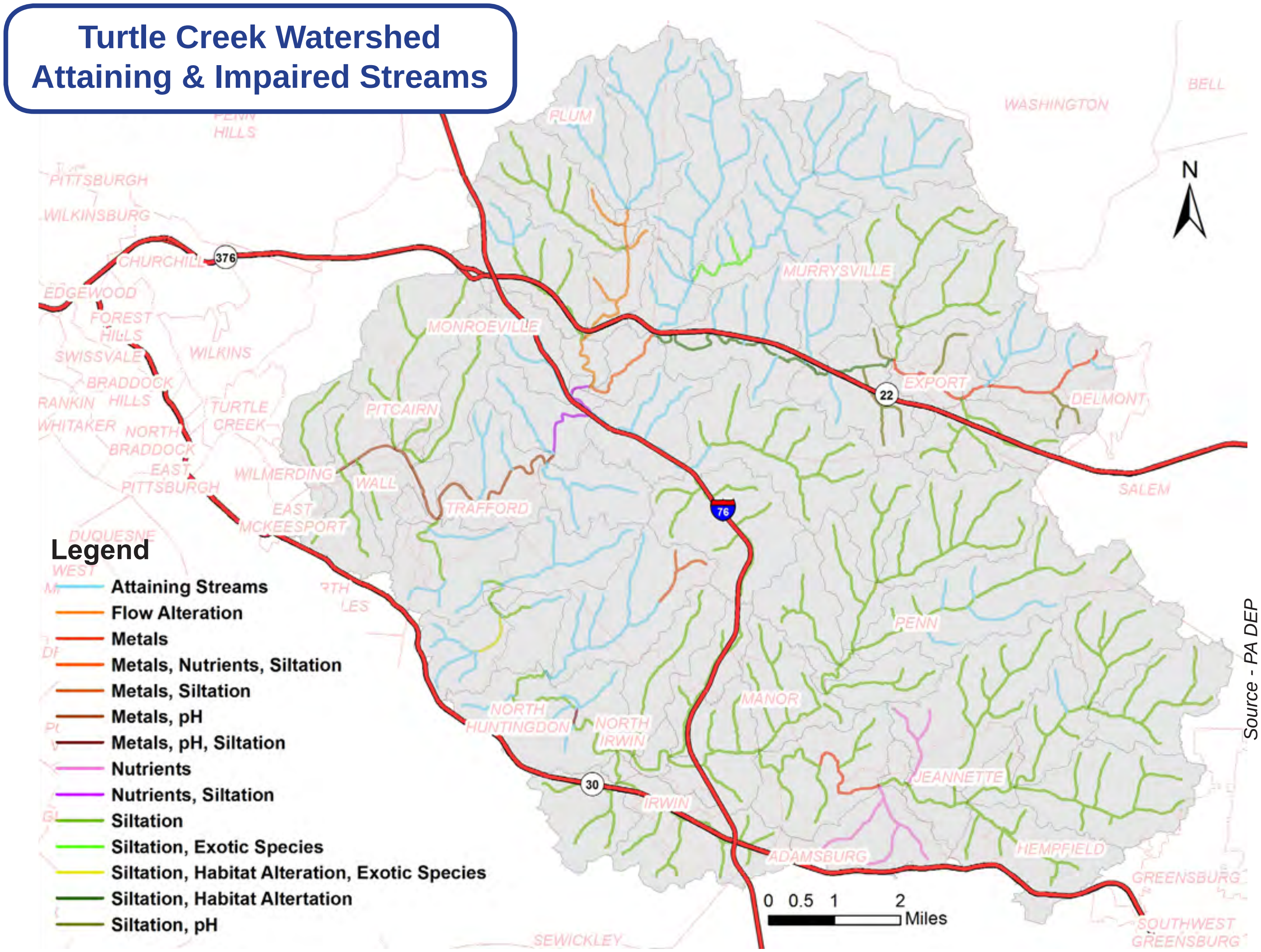


Source - NLCD 2011

CURRENT WATER QUALITY IN THE TURTLE CREEK WATERSHED

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection identified 85.8 stream miles as “attaining” their designated uses of providing a potable water supply and supporting aquatic life, 183.3 stream miles as “non-attaining,” and the remaining are unclassified. Identified impairment sources include Abandoned Mine Drainage, Agriculture, Urban runoff, and Erosion. Identified impairments include streamwater that contains metals, silt, high or low pH, nutrients and poor habitat quality. These are non-point sources, sourced not from one point source but instead from diffuse sources across the landscape.



TMDL status of the stream in this area of interest

All of the streams in the Turtle Creek Watershed are considered impaired and are under one of two TMDL’s, or Total Maximum Daily Load, agreements, either the “Turtle Creek TMDL” or the “Brush Creek TMDL.” Both of these TMDL’s seek to reduce pollution from Metals/ high pH from Abandoned Mine Drainage. Other impairments - such as nutrients and siltration from various sources - are not identified or managed under a TMDL.

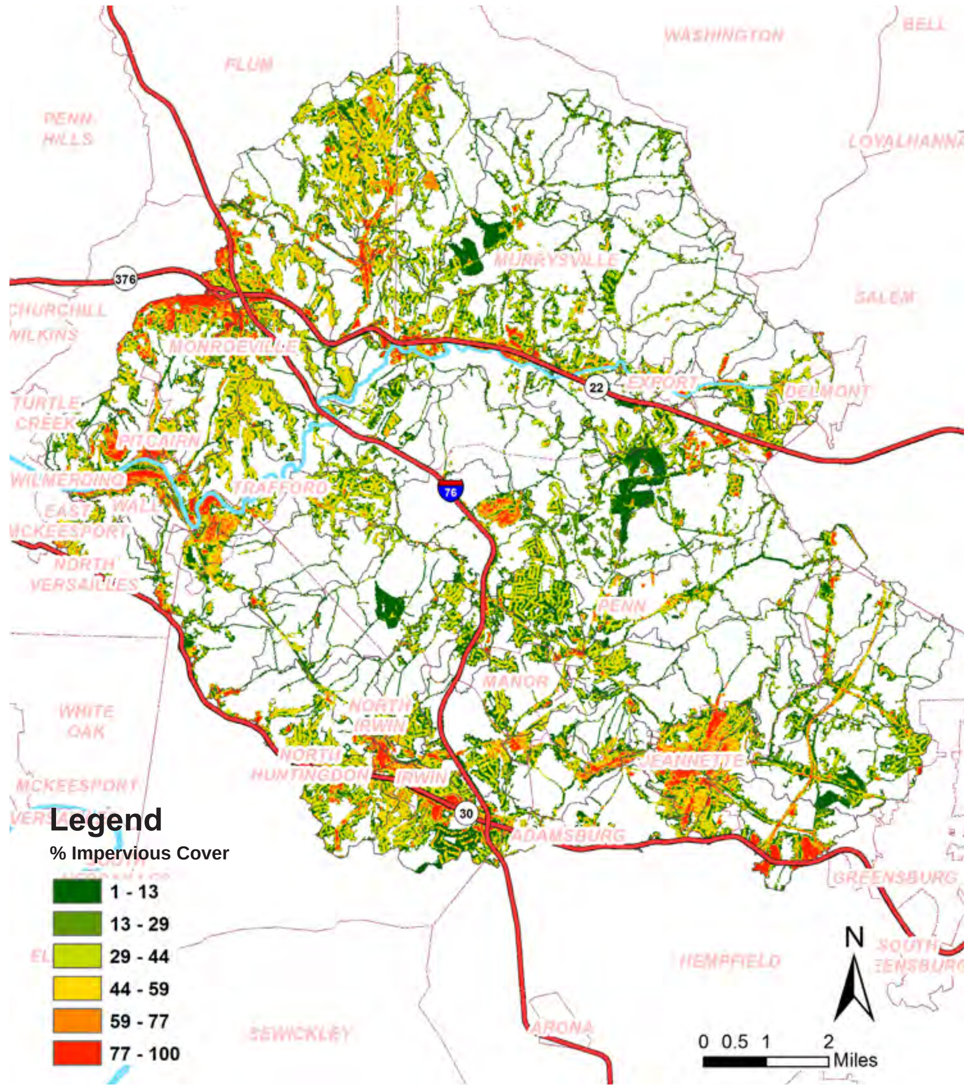
WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE TURTLE CREEK WATERSHED

As water accumulates and moves overland on impervious surfaces, it picks up pollutants from the surface of the landscape and delivers it to receiving waters. Development, particularly that which increases impervious surfaces on the landscape, increases the overland flow of water during storms and decreases infiltration to groundwater. Increased stormwater also increases the erosive force of overland flow, increasing sediment load and delivering it to downstream receiving waters. Here, a watershed map shows the concentration of impervious surface in the industrial/commercial areas.

As stormwater runoff increases, so does the water's capacity to carry sediment and nutrients such as Nitrogen and Phosphorus. Stormwater may drop sediment and pollutants when the flow/energy of the water decreases.

Both the sediment and the pollution are a threat to water. Accumulated nutrients can lead to harmful algae blooms, which may affect wildlife and water quality in receiving waters. The sediment accumulation represents the erosion and loss of valuable soil from upstream landscapes. The sediment is also a future threat as it continues to accumulate and potentially creates sandbars or other debris features in the receiving water body.

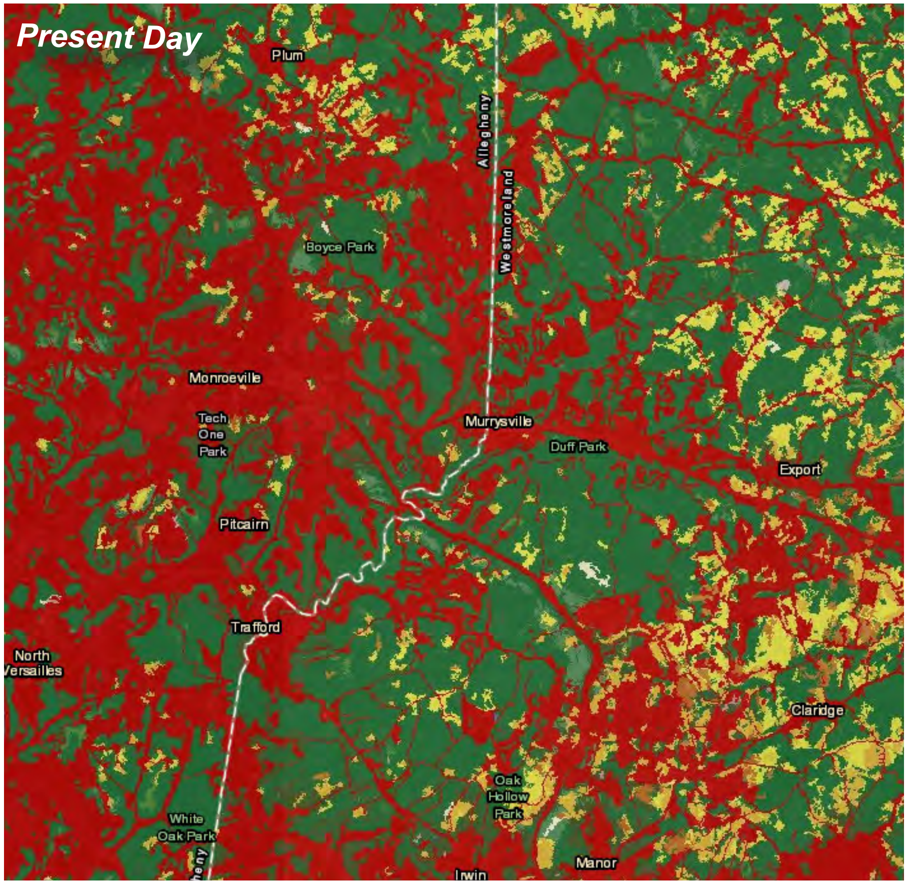
Turtle Creek Watershed Impervious Cover

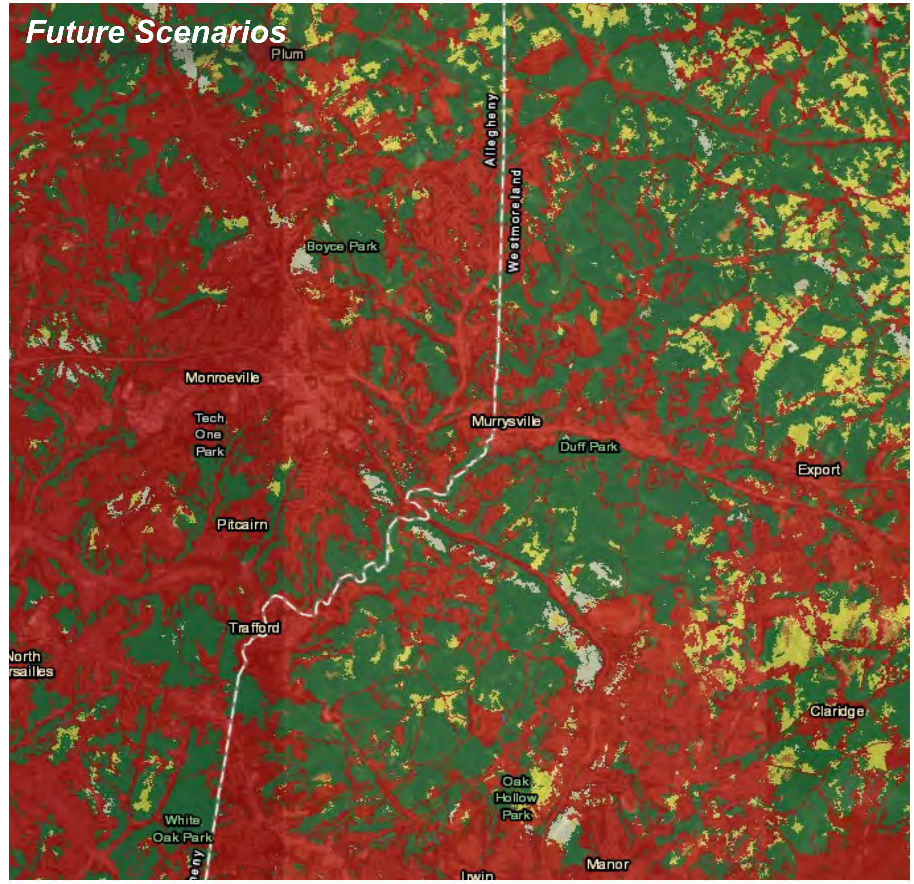


Source - NLCD

FUTURE TRENDS IN THE TURTLE CREEK WATERSHED

This watershed will likely see increasing development and a reduction in forested and agricultural land. These land-use trends will likely add to stormwater runoff and non-point pollution loadings. There is tremendous opportunity to carefully plan now in order to mitigate the potential increase in flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source - ESRI

Legend

National Land Cover Database

- Open Water
- Perennial Ice/Snow
- Developed
- Barren Land (Rock/Sand/Clay)
- Forests
- Scrub/Shrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Herbaceous and Woody Wetlands

Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted increase in impervious surfaces. This analysis of land use change in the Turtle Creek Watershed specifically estimates

- A 25% *INCREASE* in developed land
- A 20% *DECREASE* in forest cover
- A 38% *DECREASE* in agricultural cropland

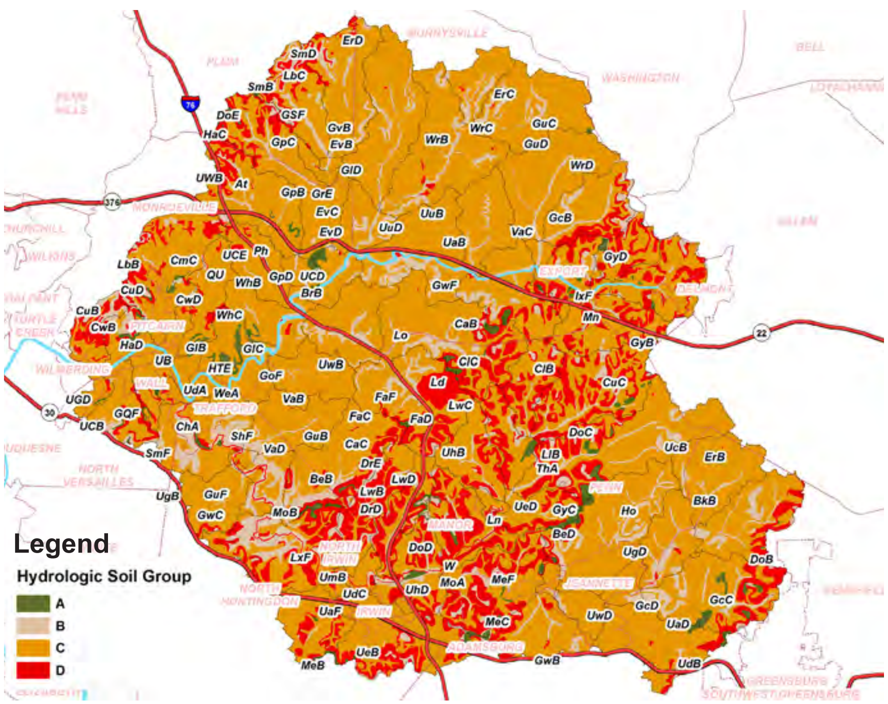
HYDROLOGIC WATERSHED MODELING:

INPUT PARAMETERS, MODEL CALIBRATION & FINAL RELEASE RATES FOR THE TURTLE CREEK WATERSHED

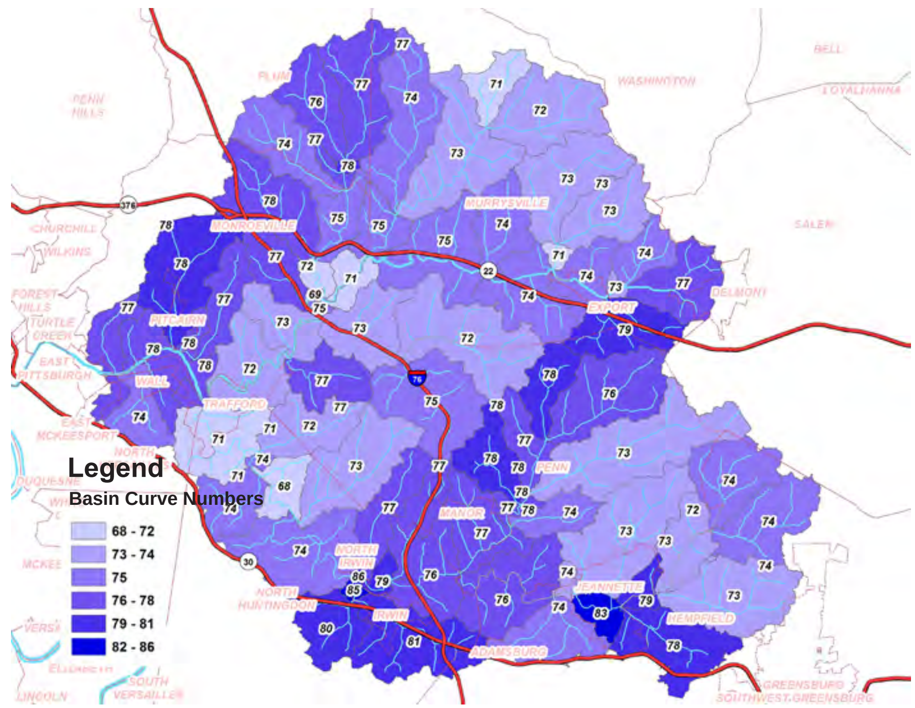
Controlling water now and in the future requires an understanding of current conditions and pollution sources. The Parameters below and on the following pages were used in hydrological models to help us understand the contribution of different sub-watersheds to the flow of the whole, and possible future changes.

Hydrologic Soil Groups in the Turtle Creek Watershed The map below is color-coded by the Hydrologic Soil Group, which indicates a soil's water holding capacity. Group A soils have low runoff potential and high infiltration rates, while Group D soils show the highest runoff potential with very low infiltration rates. Also shown are the specific soil names, please see appendix for a list and descriptions of individual soil types.

Basin Curve Numbers ("CN's") in the Turtle Creek Watershed are an empirical parameter that help predict direct runoff/infiltration from a parcel of land during a rain event. In the Turtle Creek Area of Interest, these range from 68 to 86. Watersheds with a higher curve number indicate higher runoff potential, leading to greater flooding and pollution delivery to streams. Regions with more impervious surface generally have a higher CN value.



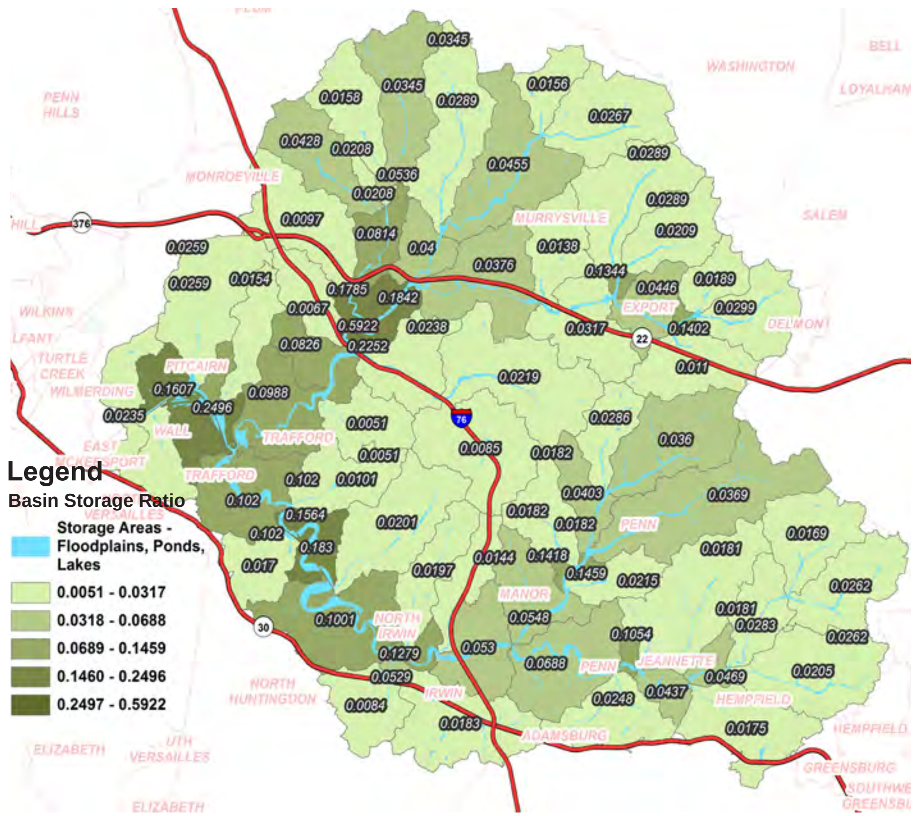
Source - PASDA



Source - Ethos Collaborative

Average Basin Slope (%) in the Turtle Creek Watershed
Generally most regions in this watershed show a moderate slope, with an average sub-basin slope ranging from 11 range of values from 11.82% to 33.15%. Steeper slopes are found in the stream valleys and shallower slopes on the upland regions. Slope steepness contributes to overall runoff calculations, as steeper regions generally experience greater runoff during rain events.

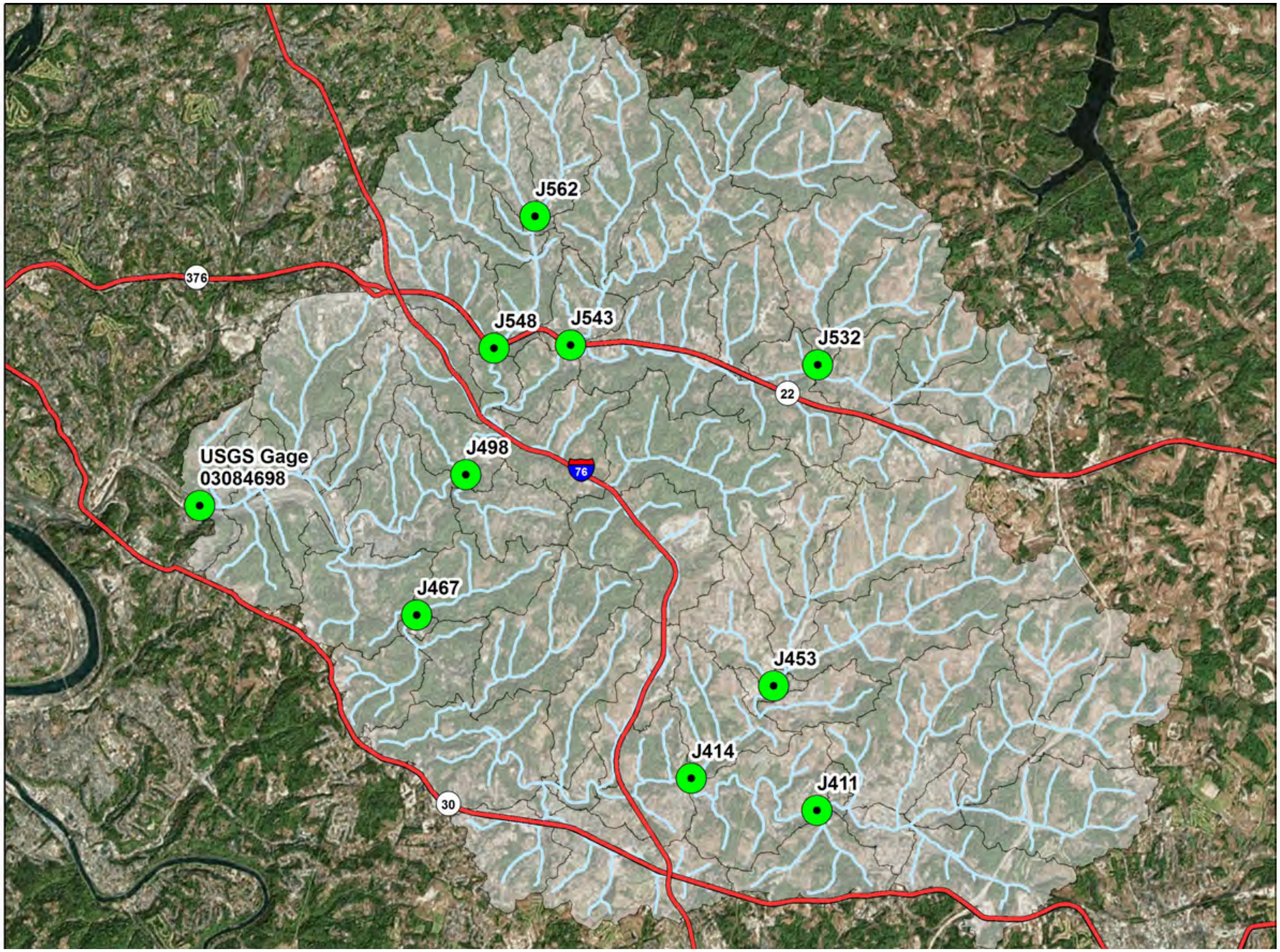
The Basin Storage Ratio in the Turtle Creek Watershed indicates the proportion of each sub-watershed that can store water. Storage areas include lakes, ponds and floodplains. Storage ratios range from 0.0008 to 0.1999, therefore the storage amount available in each sub-watershed varies from 0.08-20 of the sub-watershed area. Greater storage in a sub-watershed indicates a region that can absorb/store more water in a storm, instead of directly increasing stream discharge.



Source - Ethos Collaborative

MODEL CALIBRATION IN THE TURTLE CREEK WATERSHED

The USGS gage (03084698) in Wilmerding provided an accurate basis for calibration of the HEC-HMS model results in the Turtle Creek Watershed. In addition, ten sites were chosen as “areas of interest,” and model results at these sites were compared to Stream Stats data for the same sites. This approach allowed the calibration of hydrological models, in the absence of multiple stream gage locations in the watershed. Calibration sites were located at important stream junctions throughout the watershed. Individual sites are designated with “J”, below.

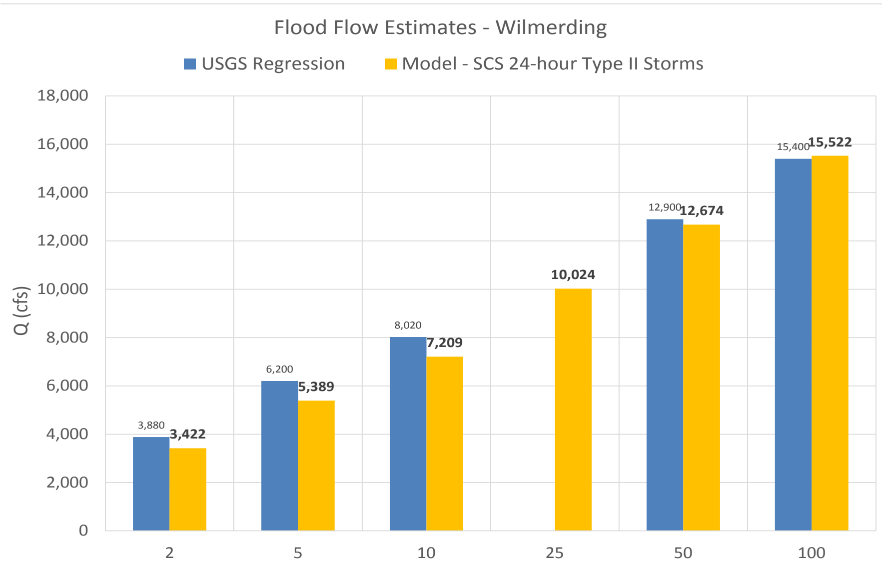


Source - Ethos Collaborative

CALIBRATION AND VALIDATION:

Comparison between modeled discharge and measured discharge for design storms

The availability of USGS discharge measurements for the Turtle Creek gage at Wilmerding provided solid data to calibrate and validate the HEC-HMS models. Below, modeled versus measured discharge (CFS) for 2, 5, 10, 25, 50, and 100 year storm events provide evidence that the model estimates large flows well, when compared to measured large flows.



Source - Ethos Collaborative

Turtle Creek

STATISTICALCOMPARISON:

Model Results versus Gage Results for Specific Storm Events

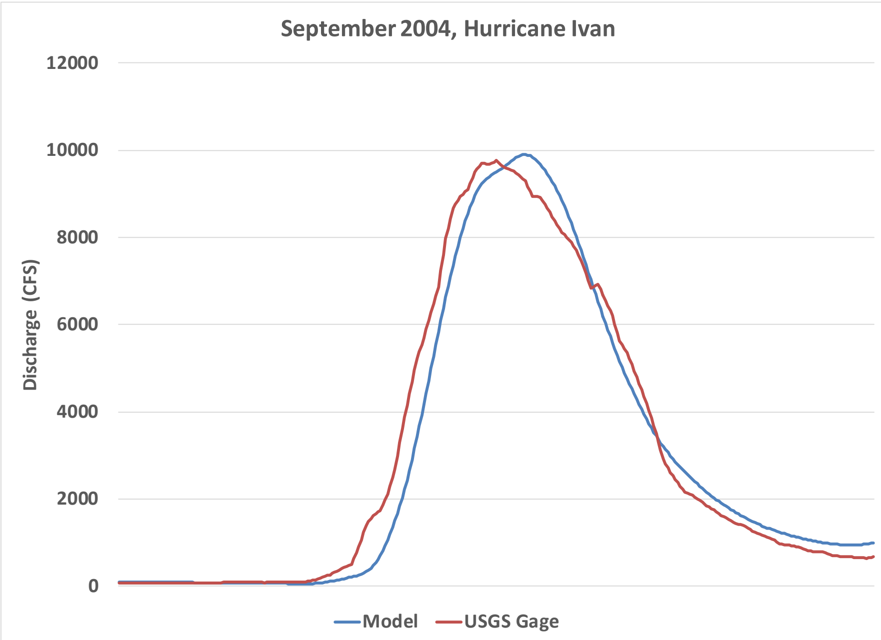
Statistical evaluation of individual storms allowed us to quantify the degree of difference between model results and measured data.

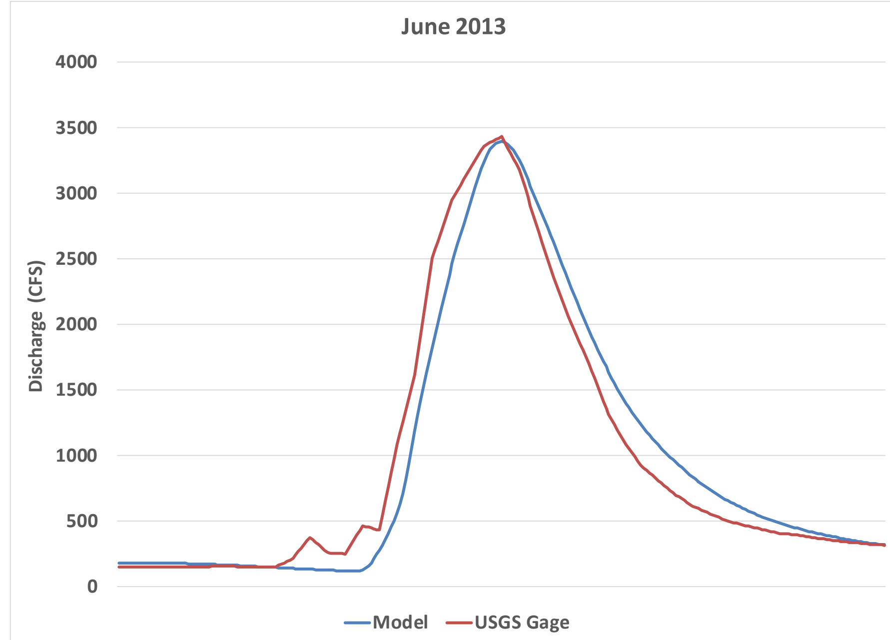
- ***Pearson's Correlation Coefficient (r)*** measures the strength of a relationship between two variables. The "r" values shown below indicate a very strong positive relationship between modeled and measured discharge values.
- ***Percent Bias (PBIAS)*** calculates the difference between the mean (average) of the model versus the gage data. In general, it provides an estimate of how the model over or under predicts the actual data.
- ***Nash-Sutcliffe efficiency (NSE)***, assess model accuracy, where the closer the NSE is to 1, the closer the model is to actual data. In the chart below, the calculated NSE ranges from 0.97 to 0.40.

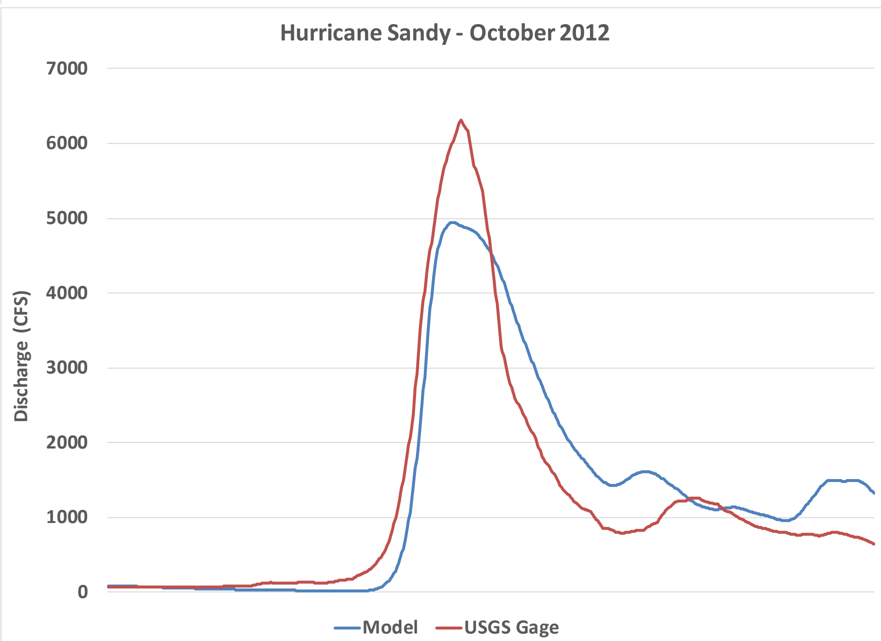
Event	*Pearson's Correlation Coefficient (r)*	*Percent Bias (PBIAS)*	*Nash-Sutcliffe efficiency (NSE)*
Ivan 2004	**0.99**	**-4%**	**0.97**
June 2013	**0.98**	**0%**	**0.95**
July 2013	**0.97**	**-28%**	**0.88**
Sandy 2012	**0.93**	**8%**	**0.87**
August 2007	**0.93**	**3%**	**0.85**
January 2005	**0.99**	**0%**	**0.98**
January 2013	**0.95**	**-15%**	**0.88**
December 2008	**0.95**	**-10%**	**0.85**
November-December 2010	**0.99**	**59%**	**0.40**
December 2012	**0.95**	**-5%**	**0.90**

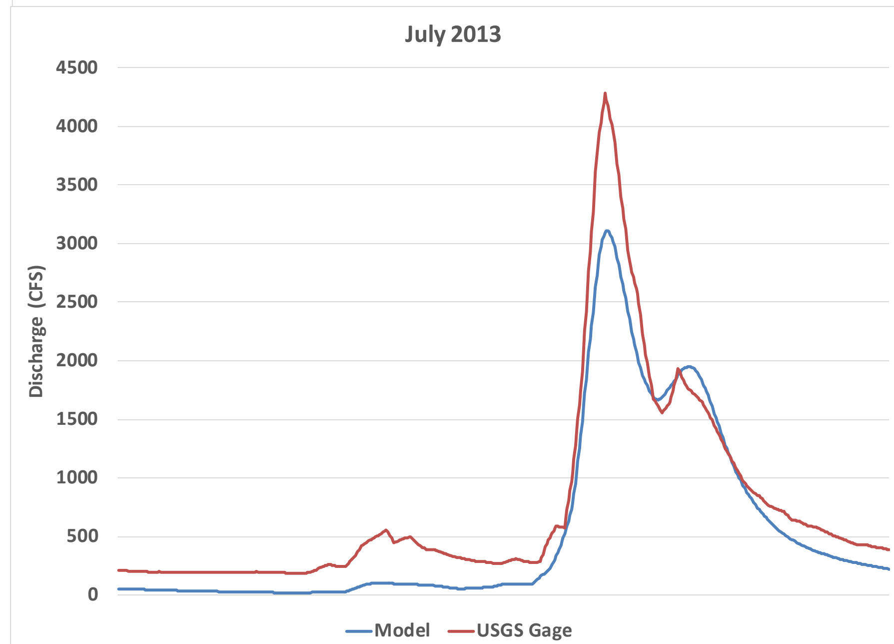
Source - Ethos Collaborative

When combined with the actual storm hydrographs (right), these statistical parameters help to define the degree to which HEC-HMS over or under-predicts the data. For example, the hydrograph for the July 2013 storm (right) shows that the blue modeled data line is largely under the red gage line. The "r" value for this storm indicates good correlation between the data. The Percent Bias of -28% indicates that the model is under predicting, and the NSE is 0.88, again suggesting overall that the model achieves a good degree of accuracy.







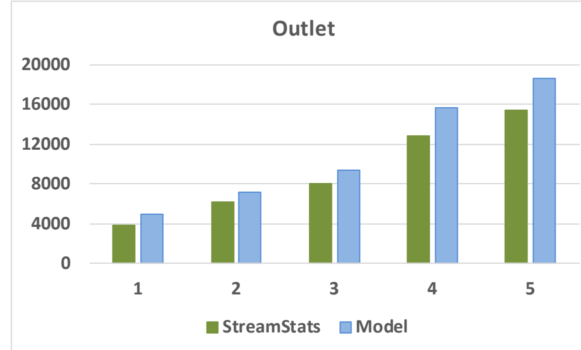


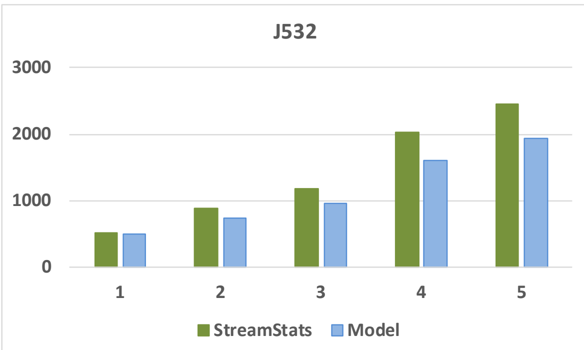
Source - Ethos Collaborative

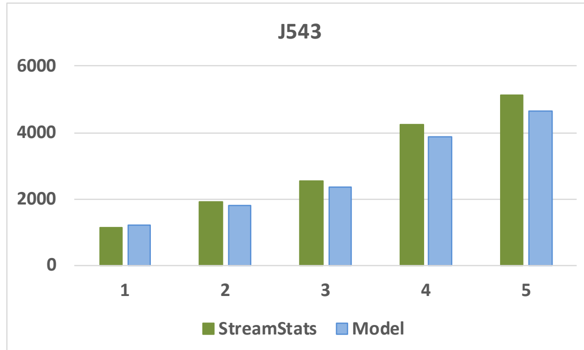
COMPARISON BETWEEN STREAMSTATS AND MODEL RESULTS

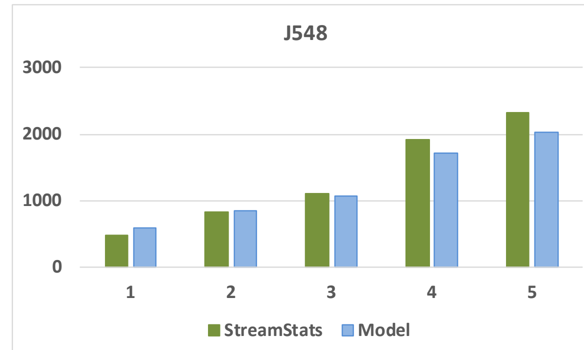
In the Turtle Creek watershed, we first used the gage data to validate and calibrate the HEC-HMS model. We then compared the results from the HEC-HMS model to StreamStats for different stream reaches. This allowed us to determine the feasibility of using StreamStats discharge data, in the absence of gages throughout the watershed. This was particularly important in watersheds without stream gages installed in them.

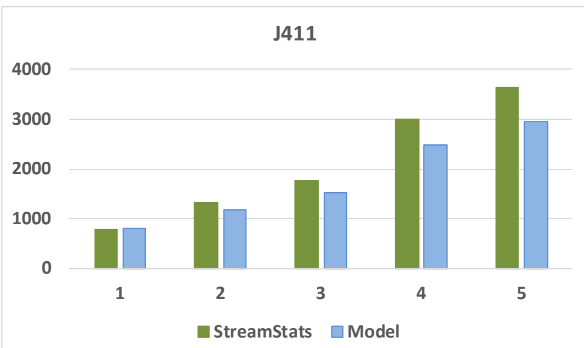
The graphs below show how StreamStats and the hydrological model discharge results compare for the 2, 5, 10, 50, and 100 year storms. There is a good correlation between model results and Streams Stats data, which suggests this is a reasonable approach to the lack of discharge data in other watersheds.

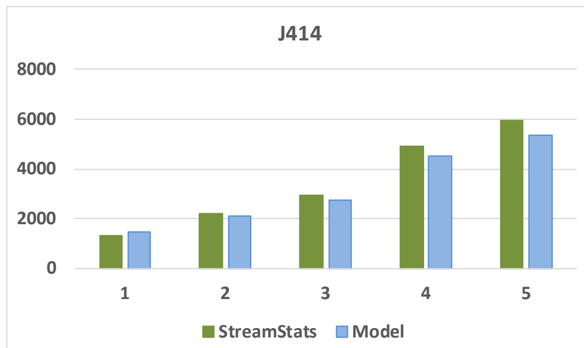


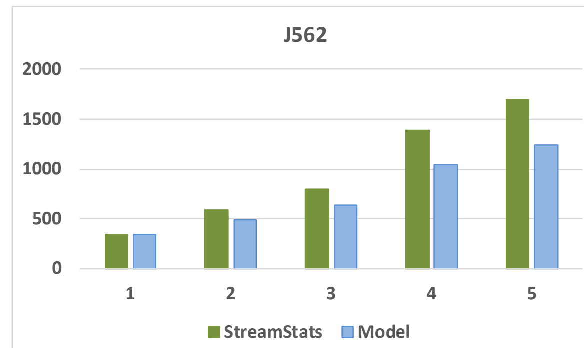


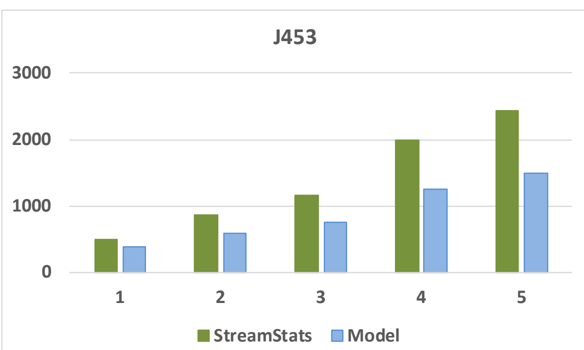


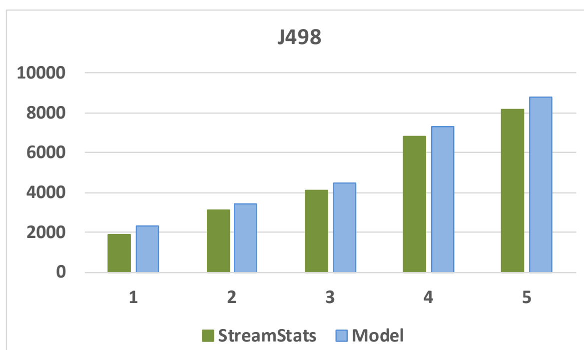


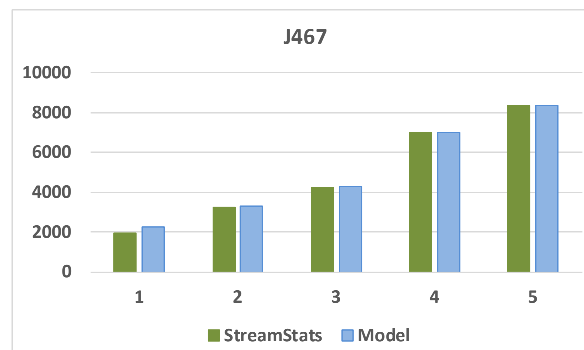












Source - Ethos Collaborative

RECOMMENDED RELEASE RATE MAP FOR THE TURTLE CREEK WATERSHED AREA OF INTEREST

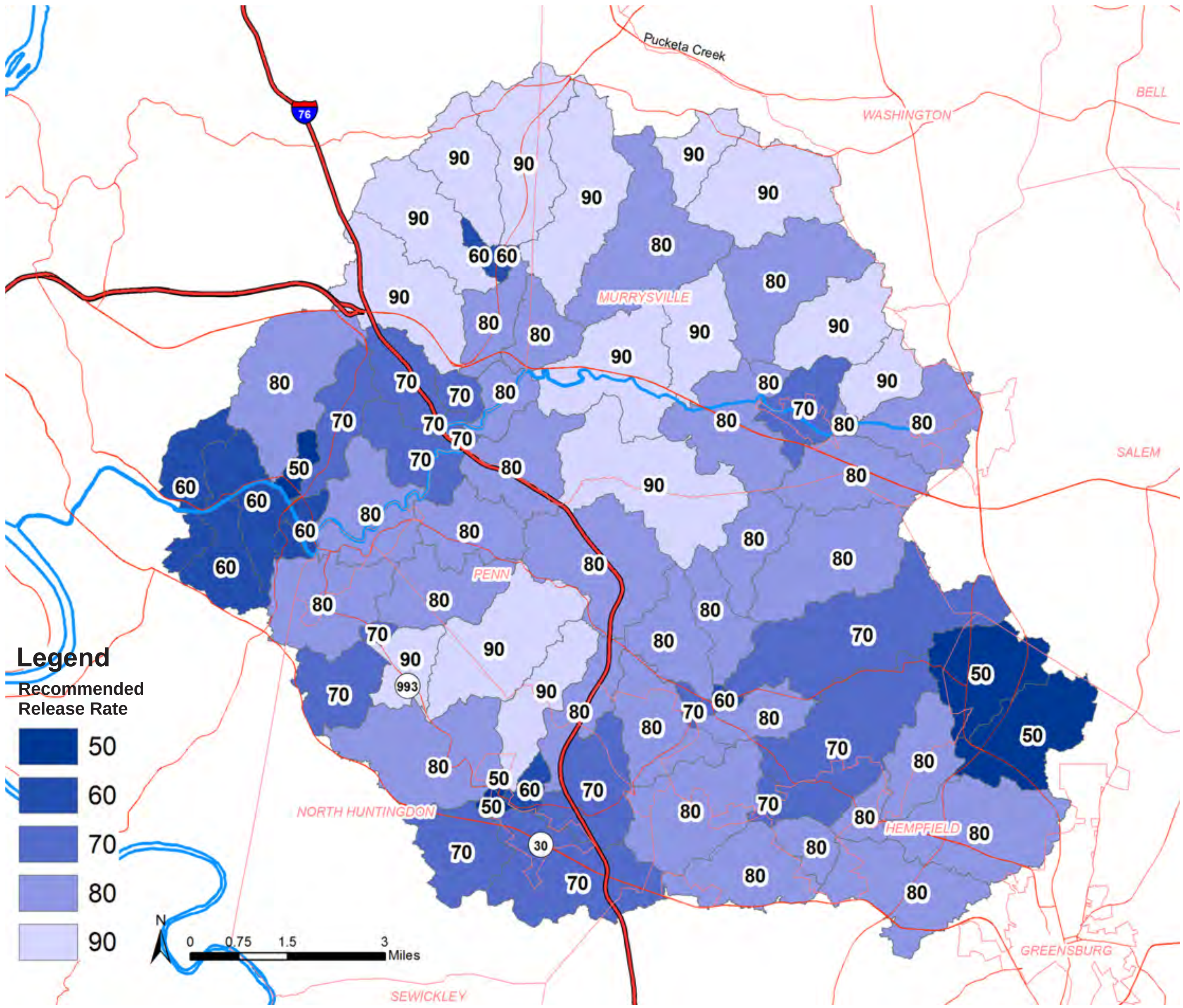
Release rates are a tool that help determine the timing of when water can be released from a watershed. Final calculated release rates are shown to the right. Darker colors and lower release rates indicate regions where future development must reduce runoff rates.

A release rate of 50% for a sub-watershed indicates that the rate at which stormwater moves out of the watershed and downstream must be reduced by half (50%) in any future development.

In contrast, a release rate of 100% indicates that, with future development, stormwater can move off of the sub-watershed at the same rate that is does in the present. In other words, lower release rates require an increased control of runoff.

Release rates were calculated based on a hydrologic model of the area of interest using HEC-HMS, the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System, in conjunction with GEO-HMS (a GIS extension that allows for the manipulation of spatial data).

The methodology to calculate release rates focuses on the basin-wide contribution of upstream land on downstream flooding. In order to control more localized flooding, individual municipalities may enact stricter stormwater runoff controls.



Source - Ethos Collaborative / WCD

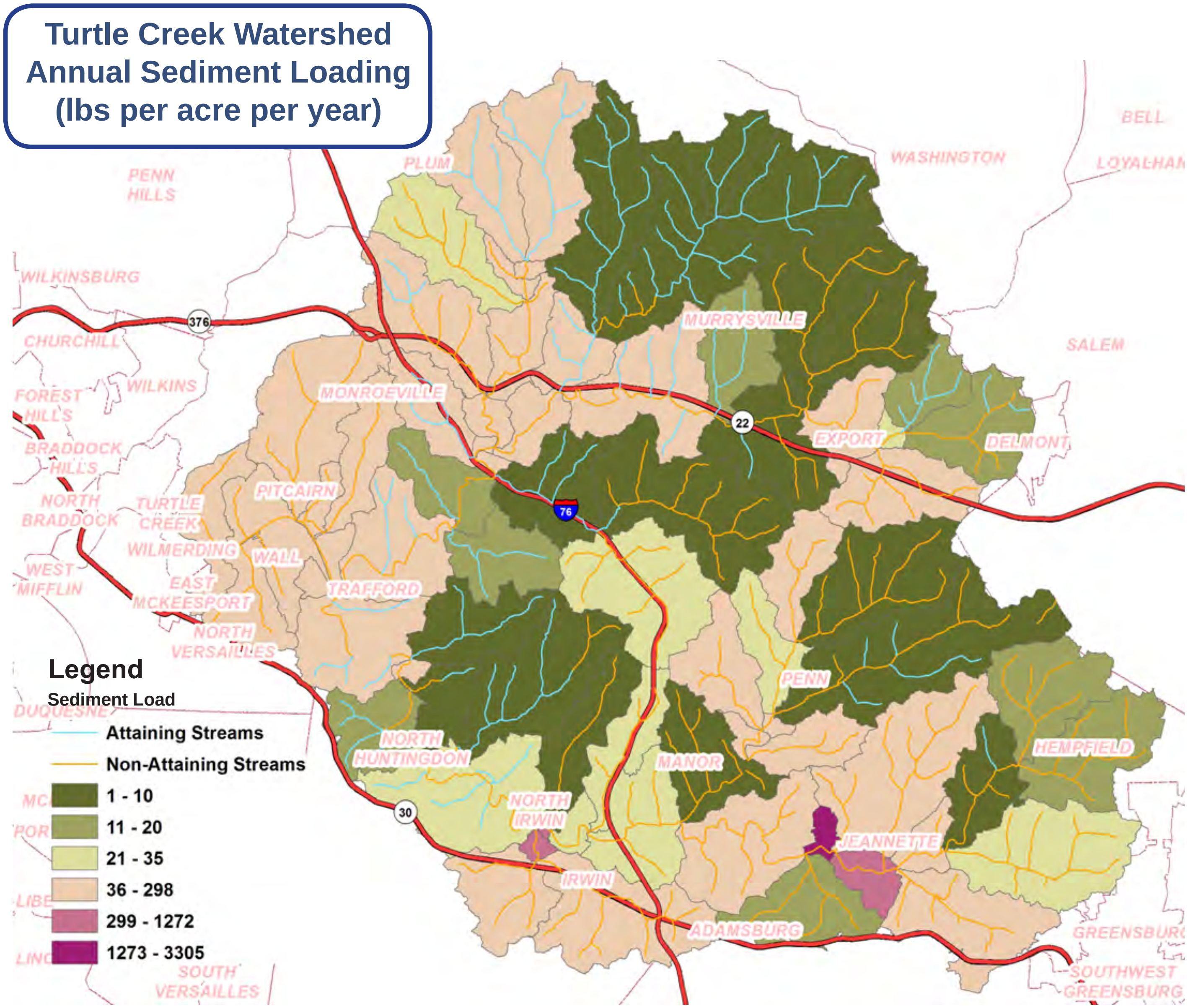
LANDSCAPE POLLUTION ACCUMULATION MODELING

To understand where and how pollution-bearing runoff moves across the landscape, we modeled accumulation using ArcGIS in conjunction wtih a specialized terrain analysis toolset, (TAUDEM). This analysis allowed us to understand both pollution contributions and pollution reductions due to the underlying landscape. Please see the Methodology Appendix for further details about this process.

TOTAL SUSPENDED SOLIDS (TSS)

Sediment, or Suspended Solids, encompasses any number of particulate pollutants or natural particles, from a myriad number of sources. Shown below is the estimated sub-watershed export of sediment, in pounds per year.

- Impervious surfaces collect solids during dry weather and then during wet weather contribute to high TSS loads draining from these watersheds. These regions have little in the way of riparian buffers or other landscape features that help to slow, infiltrate, and absorb water.
- Significant contributions of TSS are also found in sub-watersheds where agricultural activities such as grazing and plowing take place. These regions in particular would benefit from the increase in riparian buffers as a way to capture water and associated pollutants before it reaches the stream.

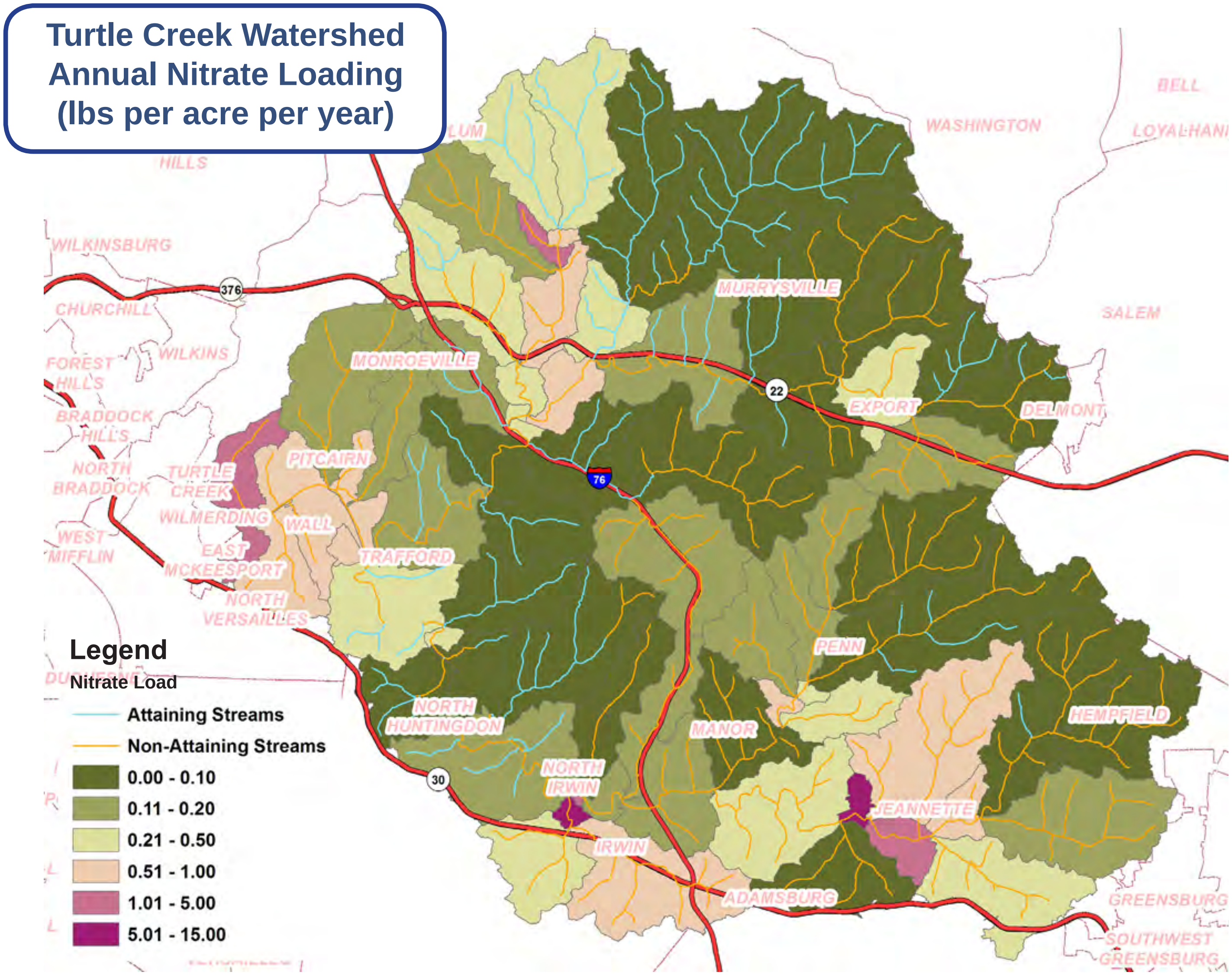


Source - Ethos Collaborative

NITRATE ($TNO3^-$)

Nitrogen, here expressed as nitrate (NO_3^-), is a nutrient essential for plant and animal growth. Historically, biologically available nitrogen was a limiting factor in ecosystems, however industrial activities have increased biologically available nitrogen to the point where it is now considered a pollutant in many regions. Shown on the map to the right is the modeled sub-watershed export of nitrate, in pounds per year.

- Agricultural activities and residential areas both contribute fertilizer-sourced nitrogen to the watershed. Fertilizer applied to croplands and residential lawns can be washed from the land surface into streams.
- Nitrogen can be found in urine excreted from grazing animals. Urine-sourced nitrogen is biologically transformed to nitrate, which can then be transported downstream.
- Fixed nitrogen is emitted to the atmosphere when fossil fuels are burned. This nitrogen is deposited as nitrogen oxides or NOx, on the landscape, with concentrations found in near-road areas.
- Wastewater contains biologically available nitrogen. Wastewater treatment plants may not remove all of the nitrogen before treated water is discharged to streams. Septic systems may contribute biologically available nitrogen to groundwater.

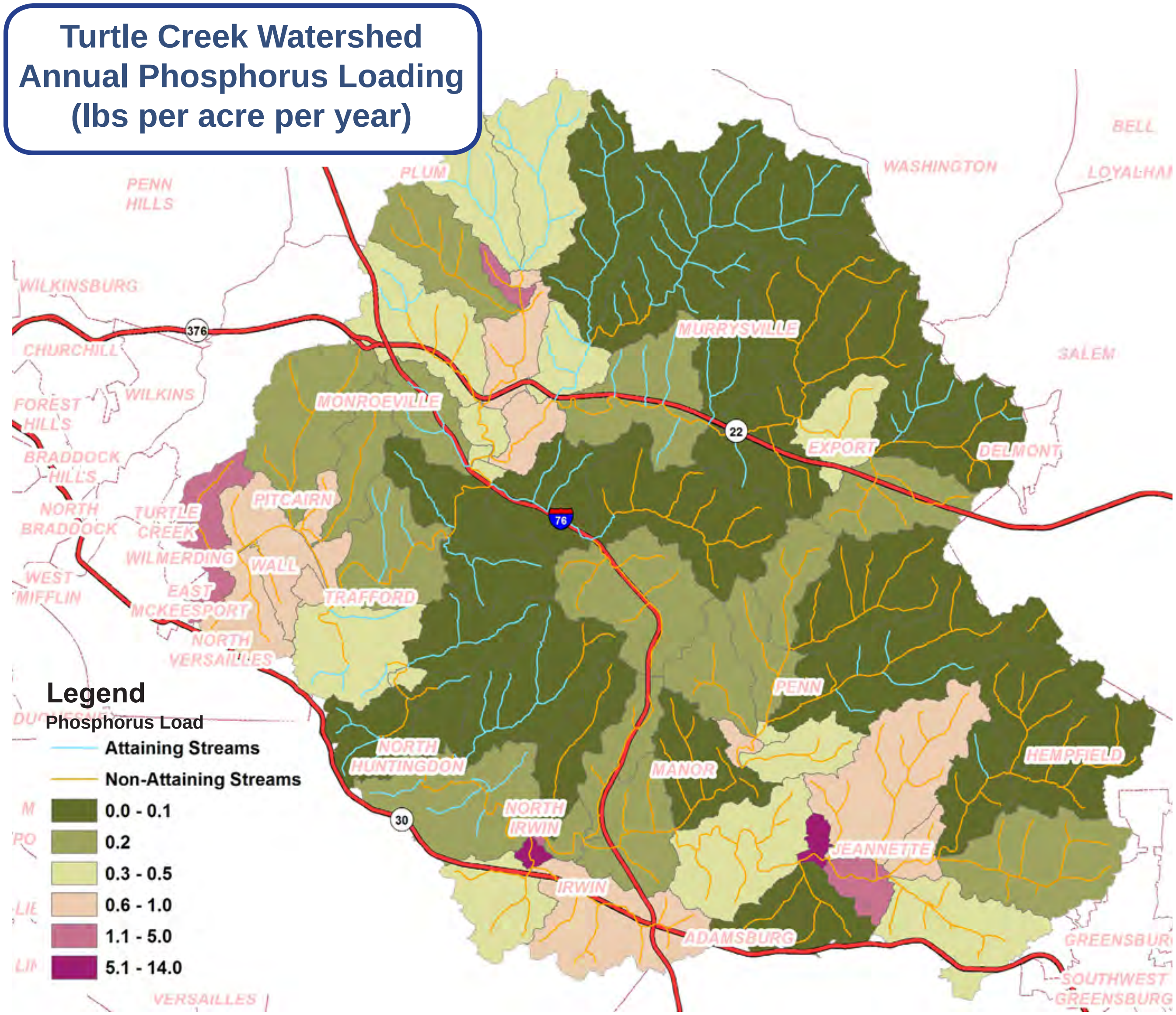


Source - Ethos Collaborative

TOTAL PHOSPHORUS (TP)

Phosphorus, here expressed as Total Phosphorus (TP) is a nutrient essential for life   Phosphorus, like Nitrogen, used to be a limiting nutrient, however industrial activities and fertilizer both contribute excess phosphorus to ecosystems. Phosphorus contributes to algae blooms in water bodies, eutrophication, and overall habitat deterioration. Shown on the map is the modeled sub-watershed export of TP in pounds per year.

- Higher amounts of phosphorus are exported from the urban sub-watersheds. Here, phosphorus is sourced primarily from lawn fertilizer and roadway deposition. These sources produce both particulate and dissolved forms of phosphorus.
- Soil erosion is another contributor of phosphorus to streamwater. Erosion depletes the soil of valuable nutrients like phosphorus and transports the nutrient downstream,.
- Crops lands export Phosphorus to downstream environs, sourced from fertilizer applied to the fields. Fertilizer-sourced Phosphorus is likely in particulate forms, and therefore structural BMP’s that filter and/or detain sediment and particles can help to mitigate downstream export.
- Wastewater contains phosphorus from human waste and detergents. Wastewater treatment plants may not remove all of the phosphorus before treated water is discharged to streams.



Source - Ethos Collaborative

OPPORTUNITIES FOR EFFECTIVE STORMWATER MANAGEMENT IN THE TURTLE CREEK WATERSHED

Based on Modeling Watershed Hydrology and Pollution Sources to Inform Smart Water Management:

Effective water management protects valuable resources and built infrastructure.
The groundwater and rivers in this area serve as drinking water sources and support the local ecosystem. Effective stormwater management measures should consider ways water management that decreases soil erosion, sedimentation in receiving water bodies, and pollution reaching water bodies. Sensible, proactive water management also protects our built infrastructure, such as roads, buildings, and bridges, from destructive flooding.

To increase water quality, we must decrease overland water flow.
As the overland flow of water increases, so does the load of pollutants and sediment downstream. Slowing and decreasing overland flow during a storm decreases downstream flooding and the subsequent transport of water-borne pollutants. Water detained by increasing infiltration to groundwater also encourages retention, or the uptake and filtration of pollutants by biota and soil. Together, the processes of infiltration and retention increase water quality through decreasing erosion and downstream transport.

Conceptual Ideas for BMP's/Landscape Restoration: Highlighting the potential for water and pollutant capture and retention.
The following are conceptual ideas and potential locations for Best Management Practices, or BMPs, at different points in the watershed. These potential sites were identified by local residents. It should be stressed that these conceptual ideas are not currently under consideration for any specific project. Instead, these highlight potential sites for restoration, based on relatively simply spatial analysis methods. These sites are located in the residential/commercial regions of the watershed, which export the bulk of the pollution.

Photo by Rob Cronauer

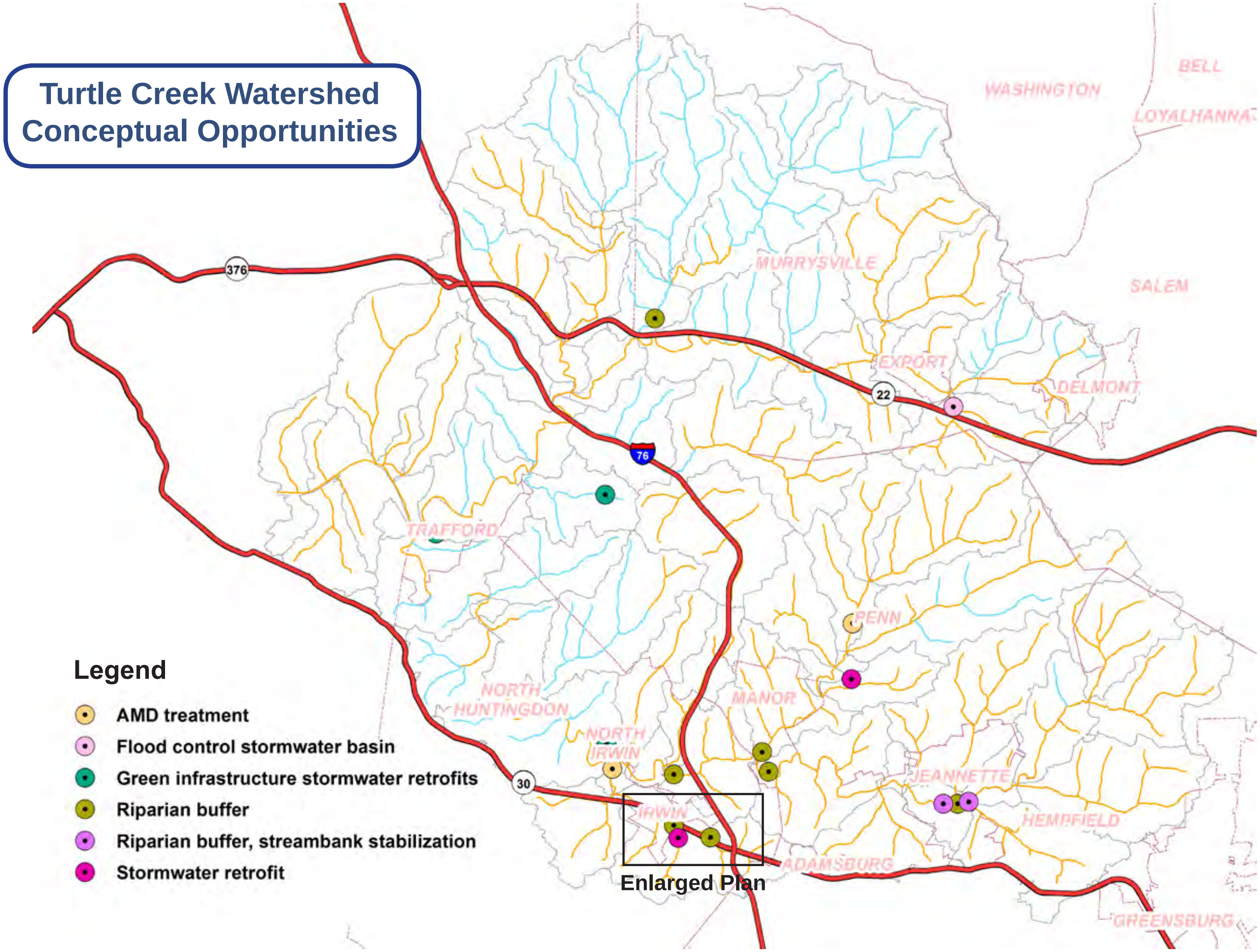
Westmoreland Heritage Trail along Turtle Creek - Before

Photo by Rob Cronauer

Westmoreland Heritage Trail along Turtle Creek - After

Water Quality and Stormwater Issues in the Turtle Creek Watershed

Thirteen sites in the Turtle Creek Area of Interest with known stormwater or water quality issues are identified below. This list was compiled based on reports made by local property owners to the Westmoreland Conservation District and should by no means be considered an exhaustive list. Identified issues include untreated Abandoned Mine Drainage (AMD), stormwater runoff and associated erosion, as well as the identification of sites appropriate for Green Infrastructure such as stormwater retrofits, riparian buffer restoration, and stream restoration. When coupled with the landscape-based nutrient accumulation and decay modeling, this list can help to identify and prioritize projects for future conservation efforts.



Source - Ethos Collaborative / WCD

CONCEPTUAL OPPORTUNITIES IN THE TURTLE CREEK WATERSHED: RIPARIAN BUFFER RESTORATION/STORMWATER RETROFIT

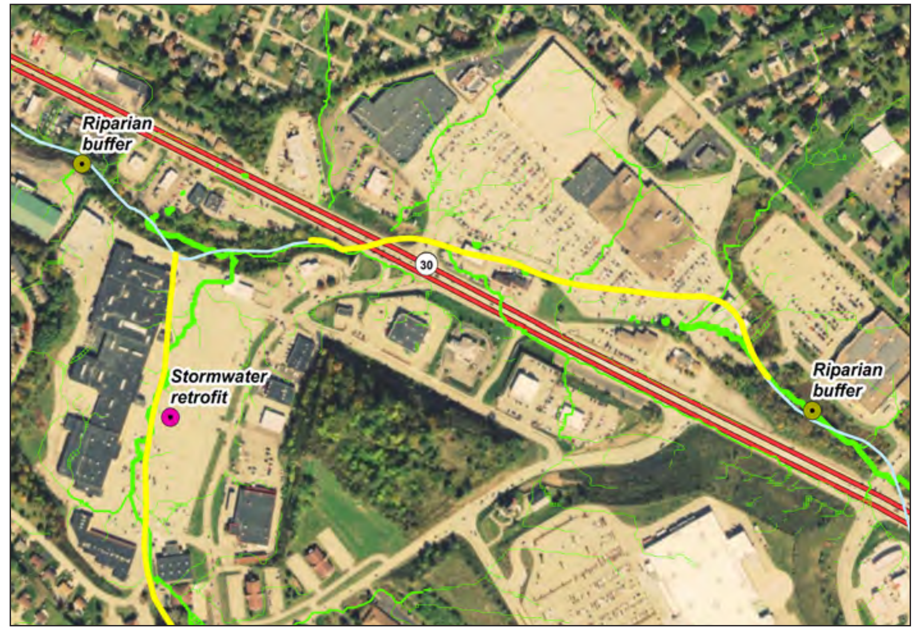
These three sites are located near the border of Irwin and North Huntington, along the commercial Route 30 corridor. The stream reach moving through this area drains a region with a high proportion of impervious surface.

Water Quality Goals:
During rain events, water rushes from the impervious surfaces into storm sewers and the stream network. This water can increase downstream flooding, as well as deliver sediment and pollution including dissolved and particulate Suspended Solids (TSS), Phosphorus (TP), and Nitrate (TNO_3^-).

Stormwater Management Potential:
Identified needs include increasing the riparian buffer on above-ground portions of the stream and retrofitting an existing stormwater detention basin into a retention/infiltration basin.

Landscape Elements to Consider:
The map above shows the area of interest, close-up. The above-ground stream portions are shown in blue, the stream sections that flow through underground storm sewers are shown in yellow. Green thickening lines show surface flow paths, indicating the accumulation of stormwater and pollutants flowing across the landscape and into streams. There is little tree canopy / riparian buffer between these pollution sources and the stream course.

Water Quality Impacts of Stormwater Management:
Stream restoration efforts should focus on water quality improvement through slowing the water to encourage particle filtration/settling, water infiltration, and increasing biological processing interactions. This would help to decrease stream loads of TSS, TP and $TNO3^-$ that are contributed from the impervious surfaces. Restoring/augmenting the riparian buffer on both sides of the above-ground stream would help to mitigate the influx of nutrients and sediment.



Enlarged plan of opportunity sites

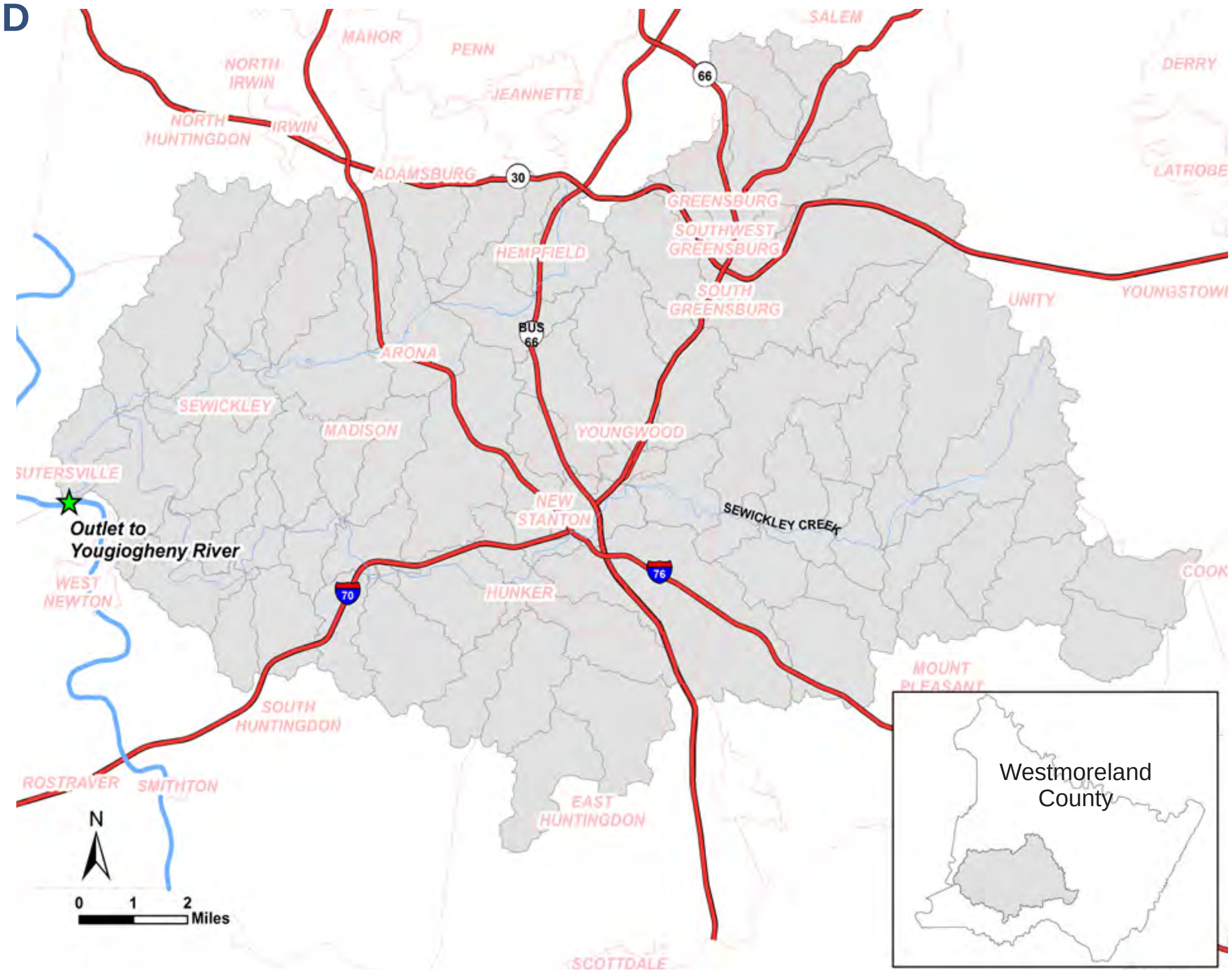
Source - Ethos Collaborative

SEWICKLEY CREEK WATERSHED AREA OF INTEREST

REGION OVERVIEW

The Sewickley Creek Area of Interest is approximately 167 mi^2 and contains 508 miles of streams that drain southwest into the Youghiogheny (outlet indicated by a star on the map, left). Landcover in this watershed is predominantly deciduous forest and hay/pasture, with a concentration of urbanized land and associated impervious surface around the towns of Greensburg and New Stanton. Sub-watersheds were delineated ranging from 0.07 to 2.56 square miles in size. Most sub-watersheds were in the range of 1-2 square miles.

Why is this watershed of particular interest?
During Phase I assessment, this watershed was identified as an area of interest due to recent, rapid growth and the potential for more and numerous recurrent flooding problems.

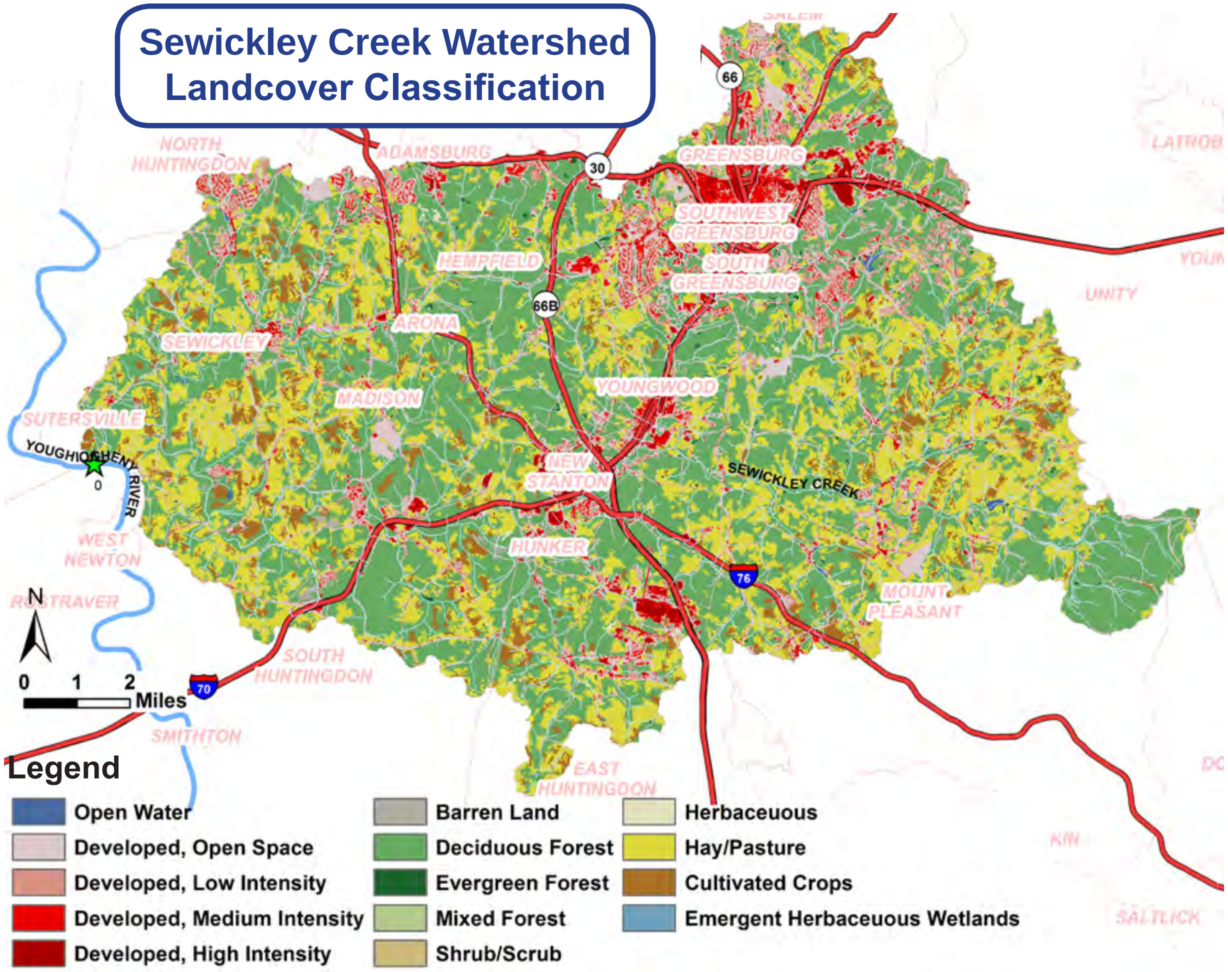


Source - Ethos Collaborative

WATERSHED SNAPSHOT
- ***Area: 167 square miles***
- ***Water Quality: Impaired for Aquatic Life and Recreational Uses***
- ***Characterization: This area of interest features heavily developed commercial corridors and the county seat City of Greensburg***
- ***Highways provide relatively quick transportation from more rural outskirts to urbanized areas.***

Photo by Tom Keller

Sewickley Creek Watershed Association volunteer tree planting at Jack's Run



Source - NCLO

Assets in the Watershed

Although some regions are undergoing rapid development, there is significant potential to guide this development in the future. The forested and farmed land uses still comprise over 76% of the watershed as a whole. The Sewickley Creek Watershed Association helps to guide and encourage sustainable development of this land.

Landcover / Landuse

Landcover in this watershed includes a significant amount of urban growth, and the potential for more. There is a concentration of urbanized land and associated impervious surface around the Westmoreland County Seat, the city of Greensburg, the highway interchanges in Hempfield and New Stanton, and the regions along State Route 30. This region also has a significant amount of land that is used for hay/pasture and croplands. Landcover data is based on the 2011 National Land Cover Dataset created by the Multi-resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.

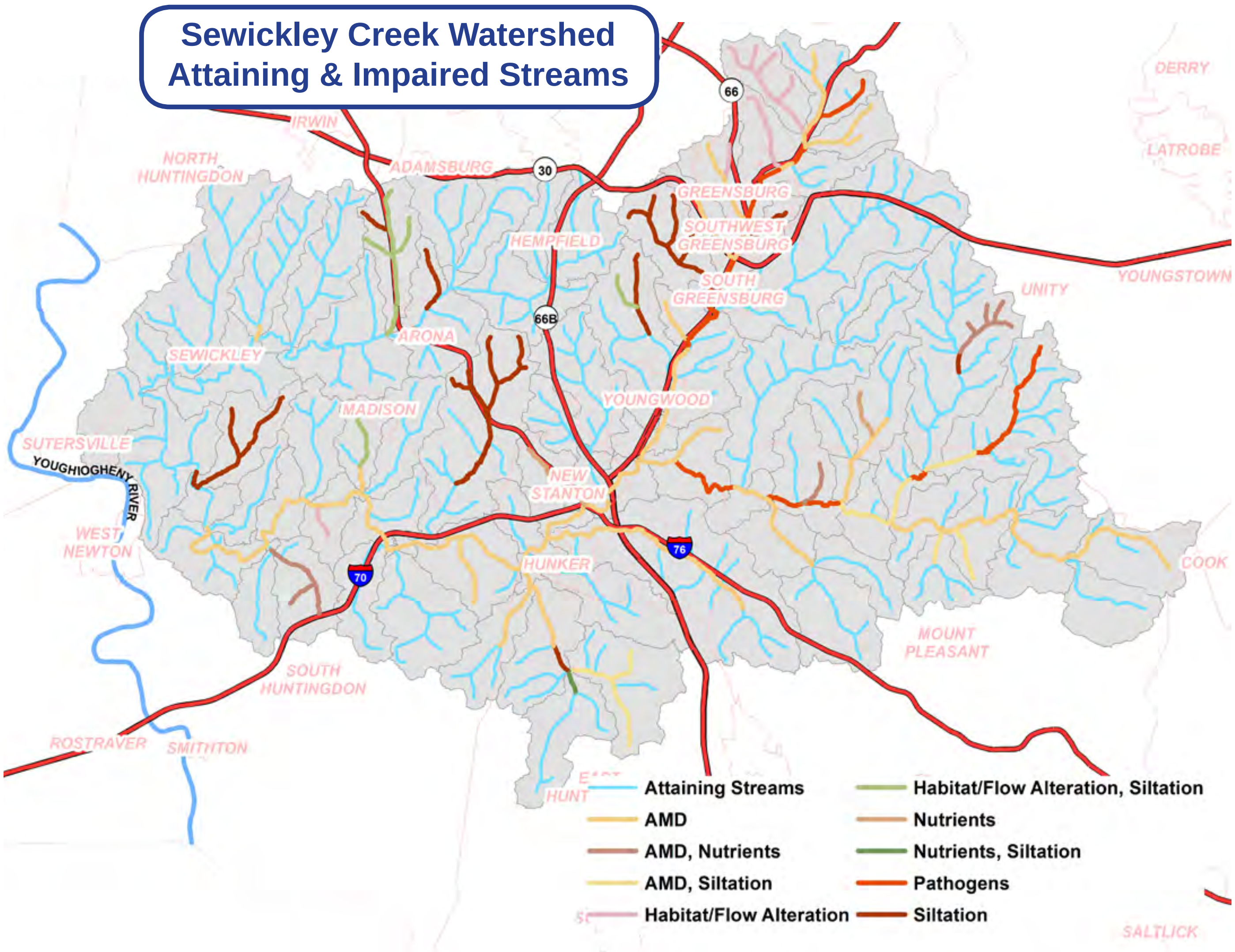
Landcover Class	*Acres*	*Total Area (%)*
Open Water	172	0.2
Developed- Open Space	10150	9.5
Developed- Low Intensity	8775	8.2
Developed- Medium Intensity	4393	4.1
Developed- High Intensity	1520	1.4
Barren Land	416	0.4
Deciduous Forest	47570	44.4

Landcover Class	*Acres*	*Total Area (%)*
EverGreen Forest	267	0.2
Mixed Forest	106	0.1
Shrub/Scrub	7.5	0.007
Herbaceous	152	0.1
Hay/Pasture	28230	26.4
Cultivated Crops	5306	5

CURRENT WATER QUALITY IN THE SEWICKLEY CREEK WATERSHED

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection identified 229 stream miles as “attaining” their designated uses of supporting aquatic life, 127 stream miles as “non-attaining” for the designated uses aquatic life (106 stream miles) and recreation (21 stream miles). The remaining stream miles are unclassified. In a watershed of this size, there are numerous Identified impairments from agricultural land, Abandoned Mine Drainage, runoff and nutrients from residential/urban areas within the watershed, and wastewater. Below, the map classifies the streams based on major impairment. These are considered non-point sources, originating not from one identifiable point but instead from diffuse sources across the landscape.



TMDL status of the streams in this area of interest

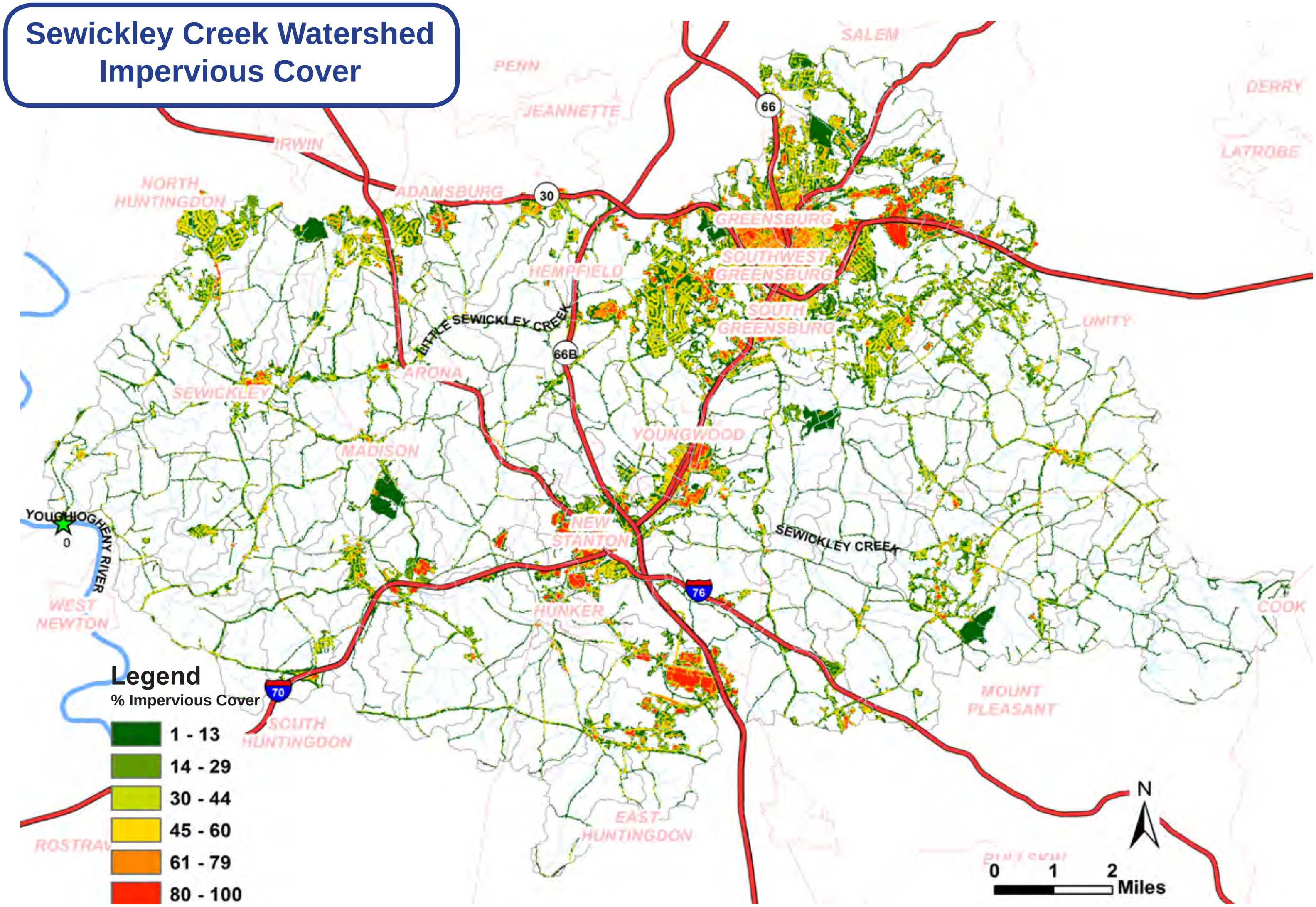
All of the streams in the Sewickley Creek Area of Interest are under a TMDL, (Total Maximum Daily Load) agreement, The “*Sewickley Creek Watershed TMDL.*” This TMDL is a seeks to reduce pollution from Metals/ high pH (from Abandoned Mine Drainage) and Total Dissolved Solids. The other impairment sources are not addressed by TMDL agreements.

The Abandoned Mile Land Inventory identified 170 known sites in the Sewickley creek watershed, with a scant 30 of these classified as reclaimed. There are also 41 known Abandoned Mine Discharges. These discharges add sediment, change the pH of the water, and generally contribute to poor aquatic habitat conditions.

WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE SEWICKLEY CREEK WATERSHED

As water accumulates and moves overland on impervious surfaces, it picks up pollutants from the surface of the landscape and delivers it to receiving waters. Development, particularly that which increases impervious surfaces on the landscape, increases the overland flow of water during storms and decreases infiltration to groundwater. Increased stormwater also increases the erosive force of overland flow, increasing sediment load and delivering it to downstream receiving waters. As stormwater runoff increases, so does the water's capacity to carry sediment and nutrients such as Nitrogen and Phosphorus. These contributed to downstream pollution problems. In the end, water from this region reaches the Gulf of Mexico, where nutrients and pollution collect and create an area of poor habitat quality.

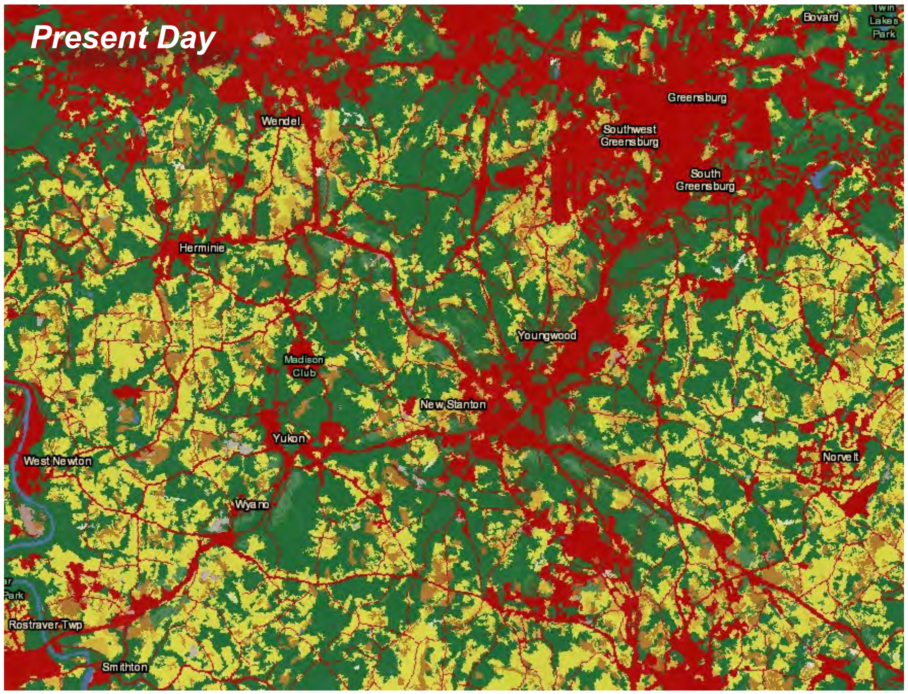
Sewickley Creek Watershed Impervious Cover

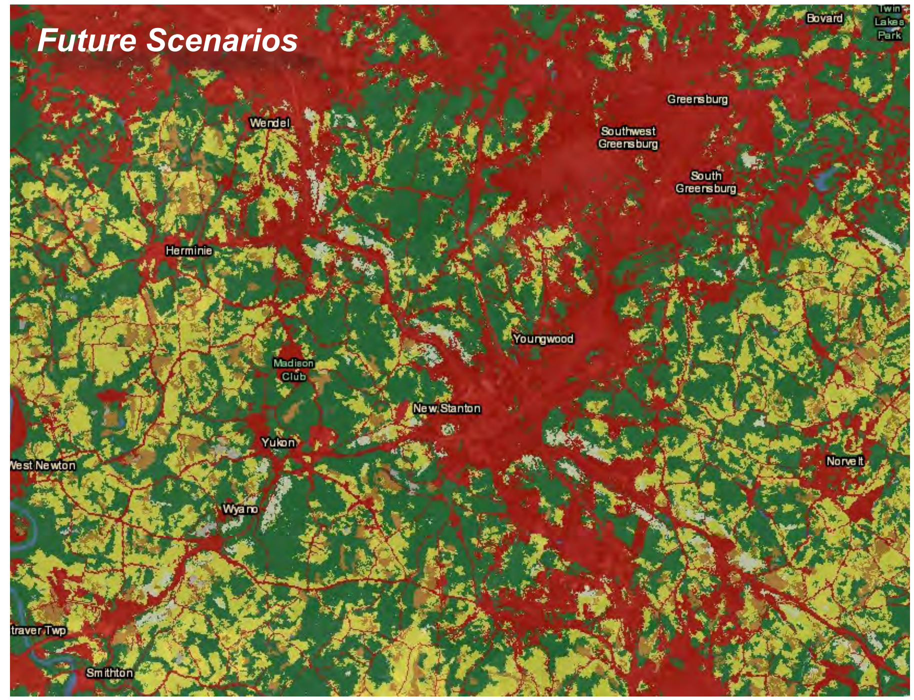


Source - NLCD

FUTURE TRENDS IN THE SEWICKLEY CREEK WATERSHED

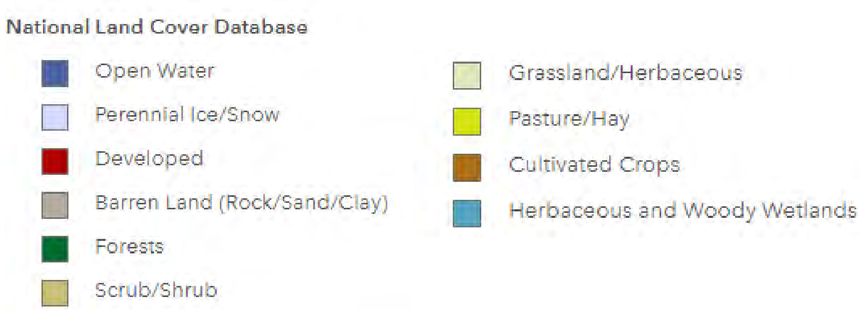
This watershed will likely see increasing development and a reduction in forested and agricultural land. These land-use trends will likely add to stormwater runoff and non-point pollution loadings. There is tremendous opportunity to carefully plan now in order to mitigate the potential increase in flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source - ESRI

Legend



Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted increase in impervious surfaces. This analysis of land use change in the Sewickley Creek Area of Interest specifically estimates

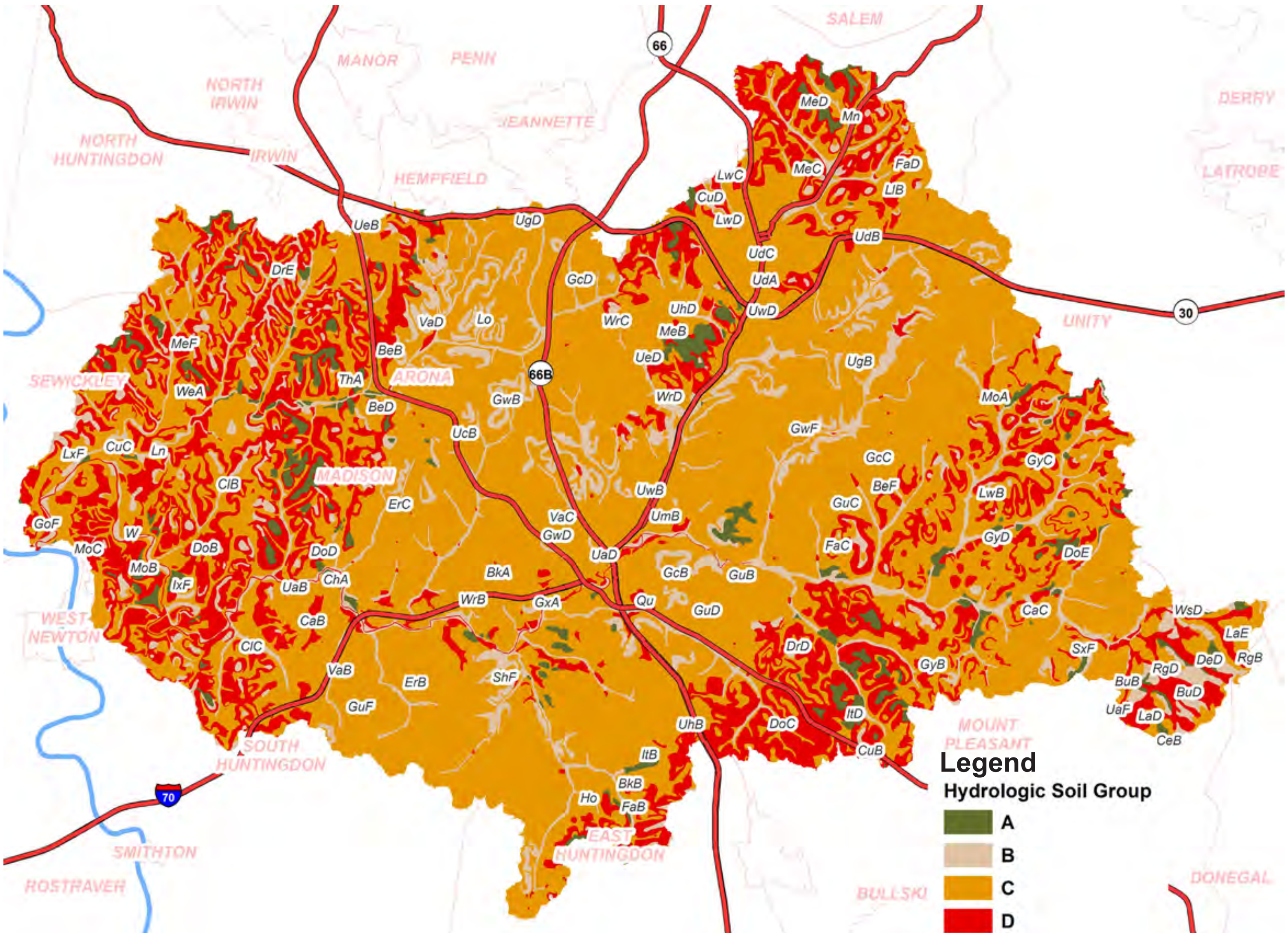
- A 21% *INCREASE* in developed land,
- A 11% *DECREASE* in forest cover
- A 9% *DECREASE* in agricultural cropland

HYDROLOGIC WATERSHED MODELING:

INPUT PARAMETERS AND MODEL CALABRATION & FINAL RELEASE RATES FOR THE SEWICKLEY CREEK WATERSHED

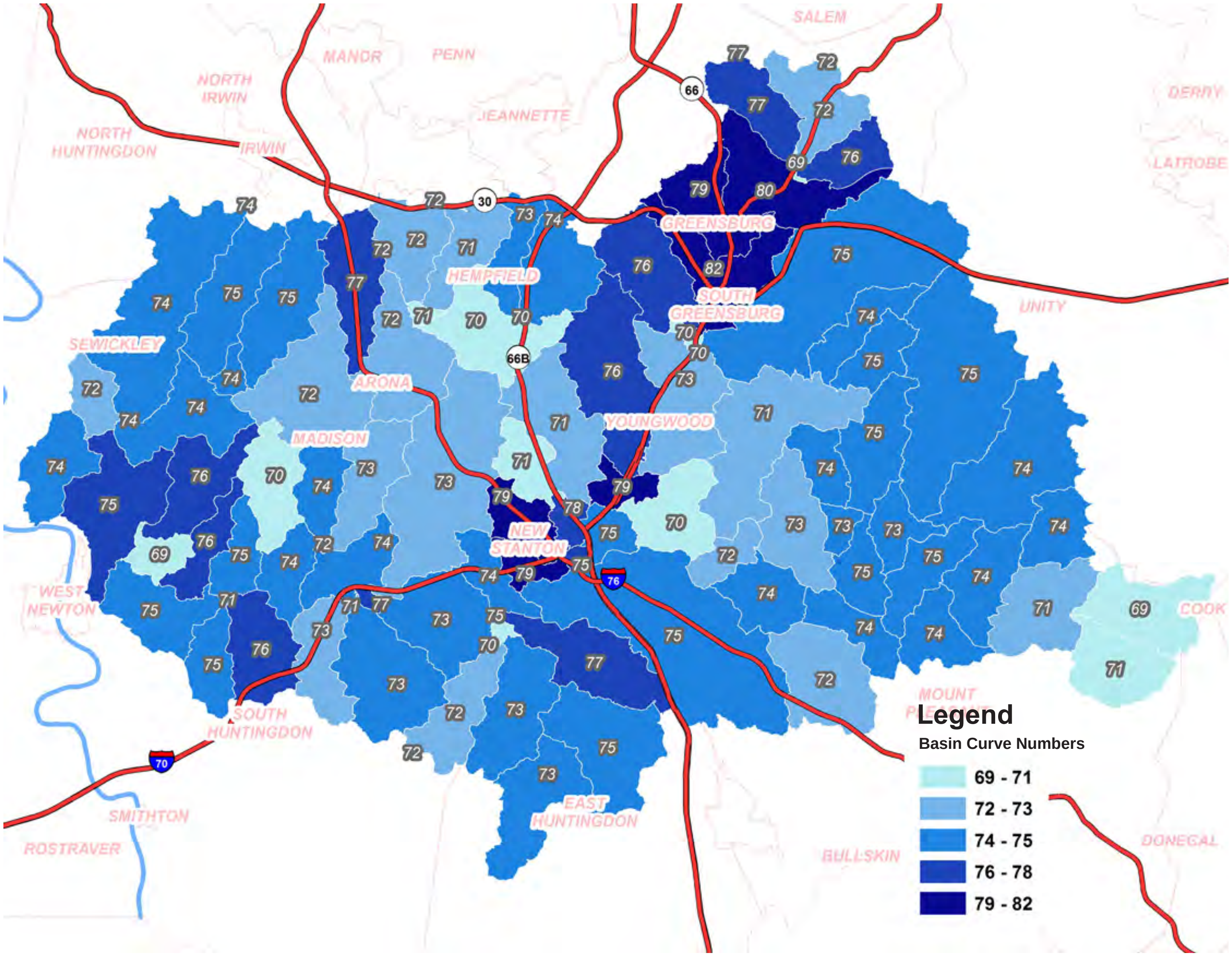
Controlling water now and in the future requires an understanding of current conditions and pollution sources. The ***Parameters*** below and on the following pages were used in hydrological models to help us understand the contribution of different sub-watersheds to the flow of the whole, and possible future changes.

Hydrologic Soil Groups in the Sewickley Creek Watershed. The map below is color-coded by the Hydrologic Soil Group, which indicates a soil's water holding capacity. Group A soils have low runoff potential and high infiltration rates, while Group D soils show the highest runoff potential with very low infiltration rates. Also shown are the specific soil names, please see appendix for a list and descriptions of individual soil types.



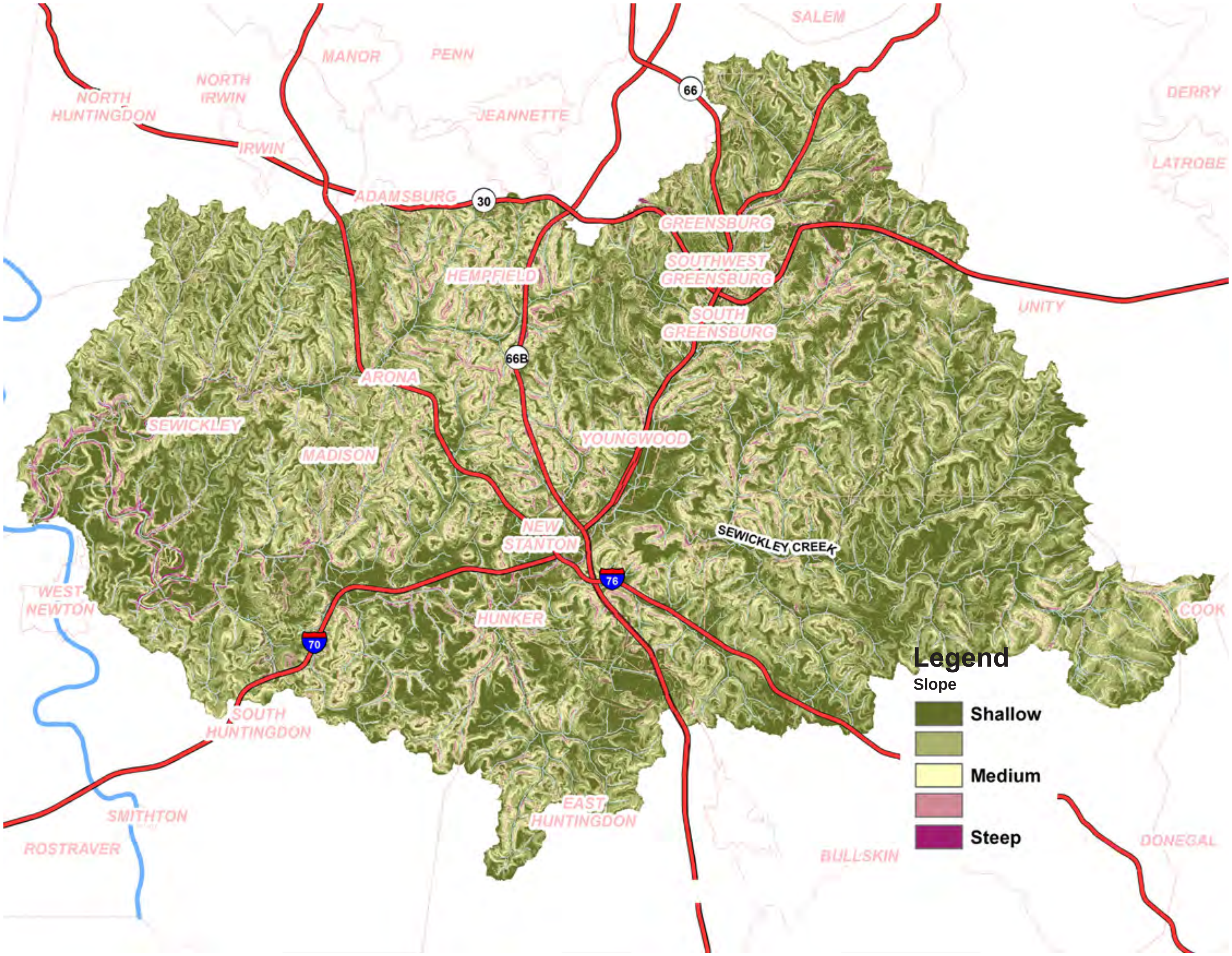
Source - PASDA

Basin Curve Numbers ("CN's") in the Sewickley Creek Watershed are an empirical parameter that help predict direct runoff/infiltration from a parcel of land during a rain event. In the Kiskiminetas are of interest, these range from 65 to 78. Watersheds with a higher curve number indicate higher runoff potential, leading to greater flooding and pollution delivery to streams.



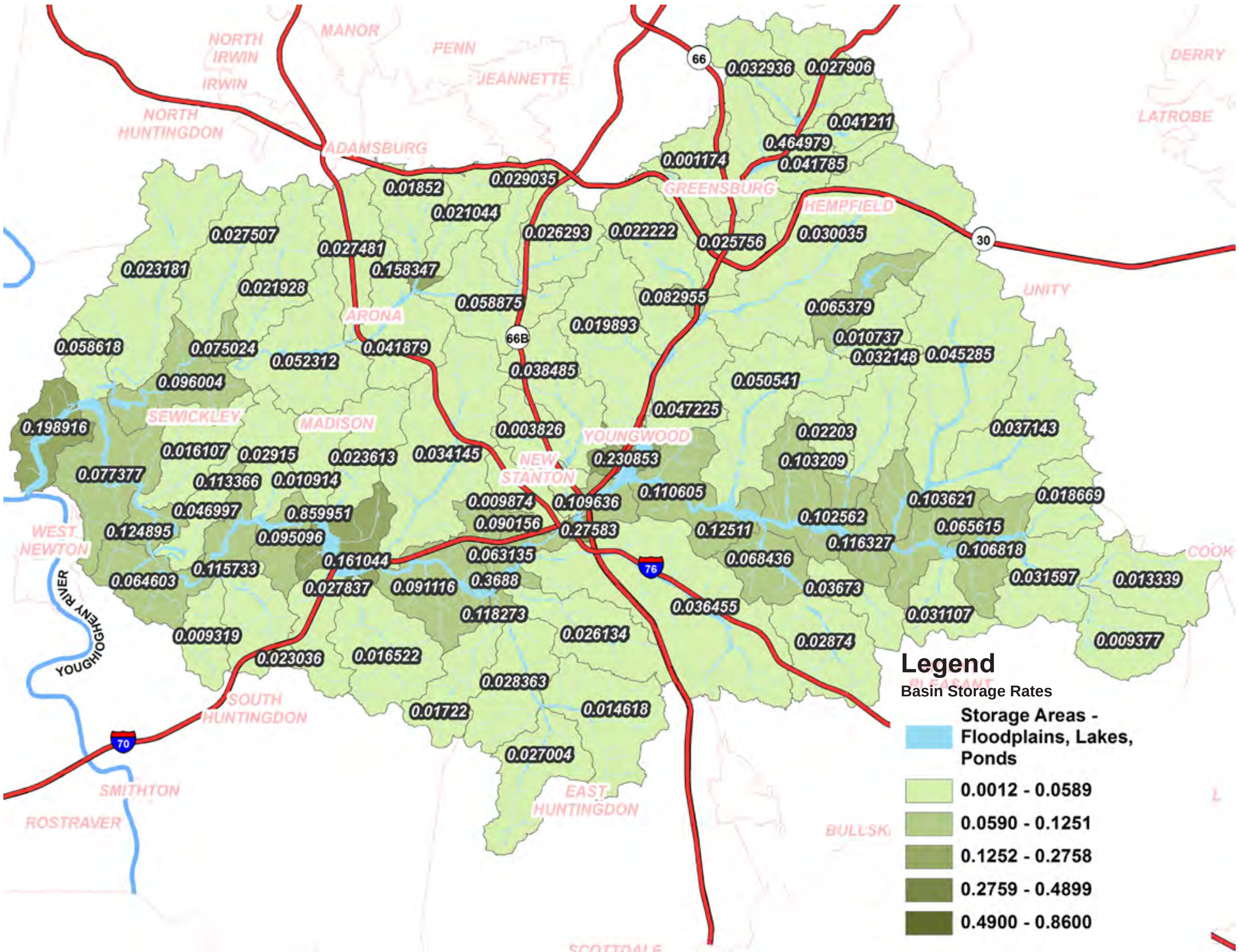
Source - Ethos Collaborative

Average Basin Slope (%) in the Sewickley Creek Watershed. Generally most regions in this watershed show a moderate slope, with a basin-wide average slope of 14%. Steeper slopes are found in the stream valleys and shallower slopes on the upland regions. Slope steepness contributes to overall runoff calculations and the calculation of basin release rates, as steeper regions generally experience greater runoff during rain events.



Source - Ethos Collaborative

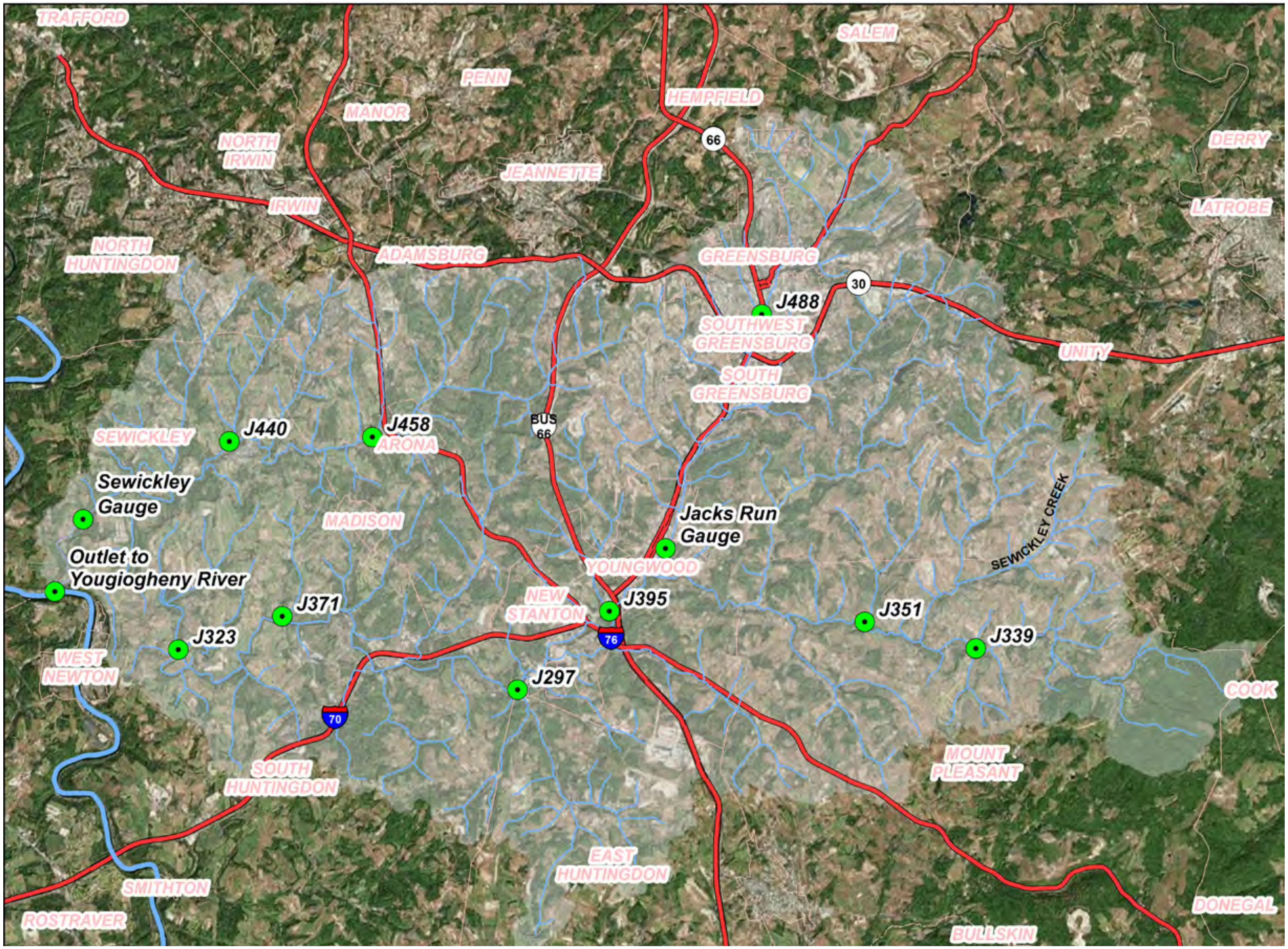
The Basin Storage Ratio in the Sewickley Creek Watershed indicates the proportion of each sub-watershed that can store water in a storm, instead of directly increasing stream discharge. Storage areas include lakes, ponds and floodplains. Storage ratios range from 0.0008 to 0.1999, therefore the storage amount available in each sub-watershed varies from 0.08-20% of the sub-watershed area.



Source - Ethos Collaborative

MODEL CALIBRATION IN THE SEWICKLEY CREEK WATERSHED

The Westmoreland Conservation District installed two water level gauges in this watershed, shown below, along Sewickley Creek and Jacks Run. These gauges provided important calibration data for this watershed, to compare modeled results to real-world discharge data. In addition, 10 sites were chosen and model results were compared to StreamStats for the same sites. This approach allowed for the fine calibration of hydrological models, in the absence of multiple stream gage locations in the watershed. Calibration sites were placed at important stream junctions throughout the watershed. Individual sites are designated with "J" below. For the methodology used for calibration, validating statistics and comparisons refer to the methodology in the appendix.



Source - Ethos Collaborative

RECOMMENDED RELEASE RATE MAP FOR THE SEWICKLEY CREEK WATERSHED AREA OF INTEREST

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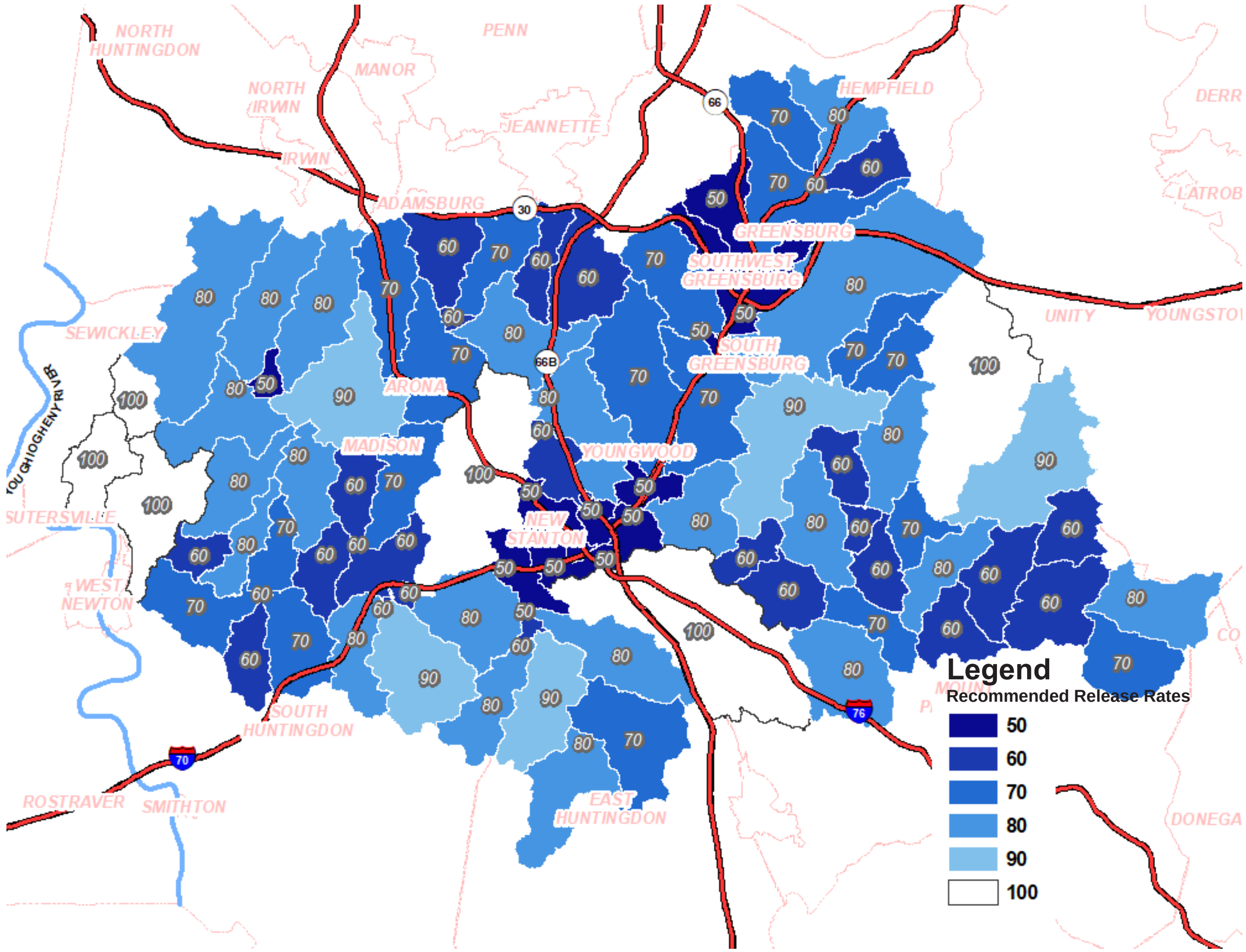
Release rates were calculated based on a hydrologic model of the area of interest using HEC-HMS, the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System, in conjunction with GEO-HMS (a GIS extension that allows for the manipulation of spatial data).

Final calculated release rates show a range in value from 50-100%. Darker colors and lower release rates indicate regions where future development must reduce runoff rates.

It should be noted that the methodology to calculate release rates focuses on the basin-wide contribution of upstream land on downstream flooding. In order to control more localized flooding, individual municipalities may enact stricter stormwater runoff controls.



Source - Ethos Collaborative

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TOTAL SUSPENDED SOLIDS (TSS)

Sediment, or Suspended Solids, encompasses any number of particulate pollutants or natural particles, from a myriad number of sources. Shown to the right is the estimated sub-watershed export of sediment, in pounds per year. It should be noted that this analysis does not include the sediment resulting from point source discharges, such as abandoned mine drainage, or in-stream sedimentation.

- The high percent of impervious surfaces in the urbanized centers of Greensburg and New Stanton collect solids during dry weather and then during wet weather contribute to high TSS loads. These sub-watersheds have little in the way of riparian buffers or other landscape features that help to slow, infiltrate, and absorb water.
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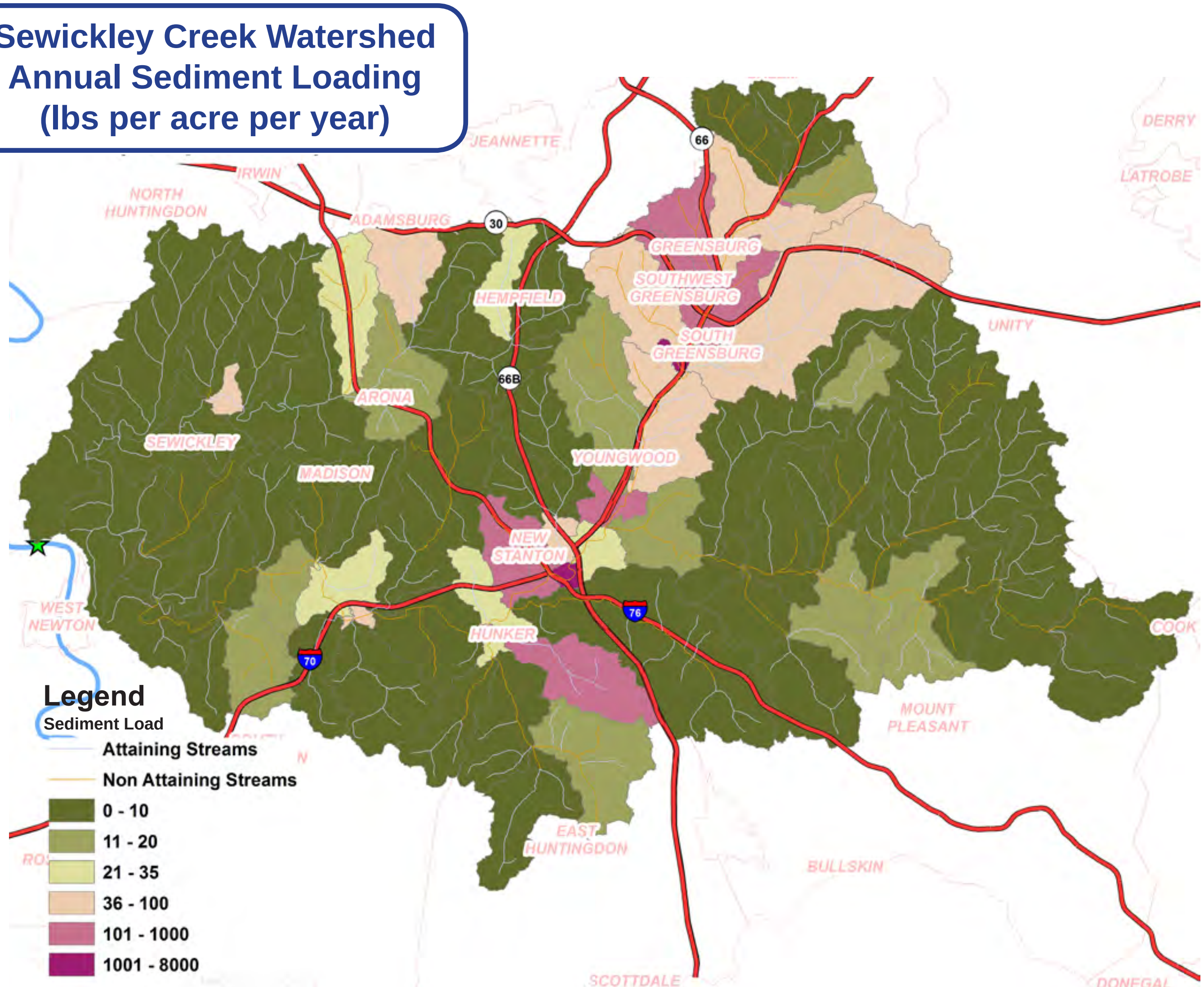

Source - Ethos Collaborative

NITRATE (TNO3-)

Nitrogen, here expressed as nitrate (NO_3^-), is a nutrient essential for plant and animal growth. Historically, biologically available nitrogen was a limiting factor in ecosystems, however industrial activities have increased biologically available nitrogen to the point where it is now considered a pollutant in many regions. Below, the sub-watershed export of nitrate is expressed in pounds per year.

- Agricultural activities and residential areas both contribute fertilizer-sourced nitrogen to the watershed. Fertilizer applied to croplands and residential lawns can be washed from the land surface into streams.
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- Fixed nitrogen is emitted to the atmosphere when fossil fuels are burned. This nitrogen is deposited as nitrogen oxides or NOx, on the landscape, with concentrations found in near-road areas.
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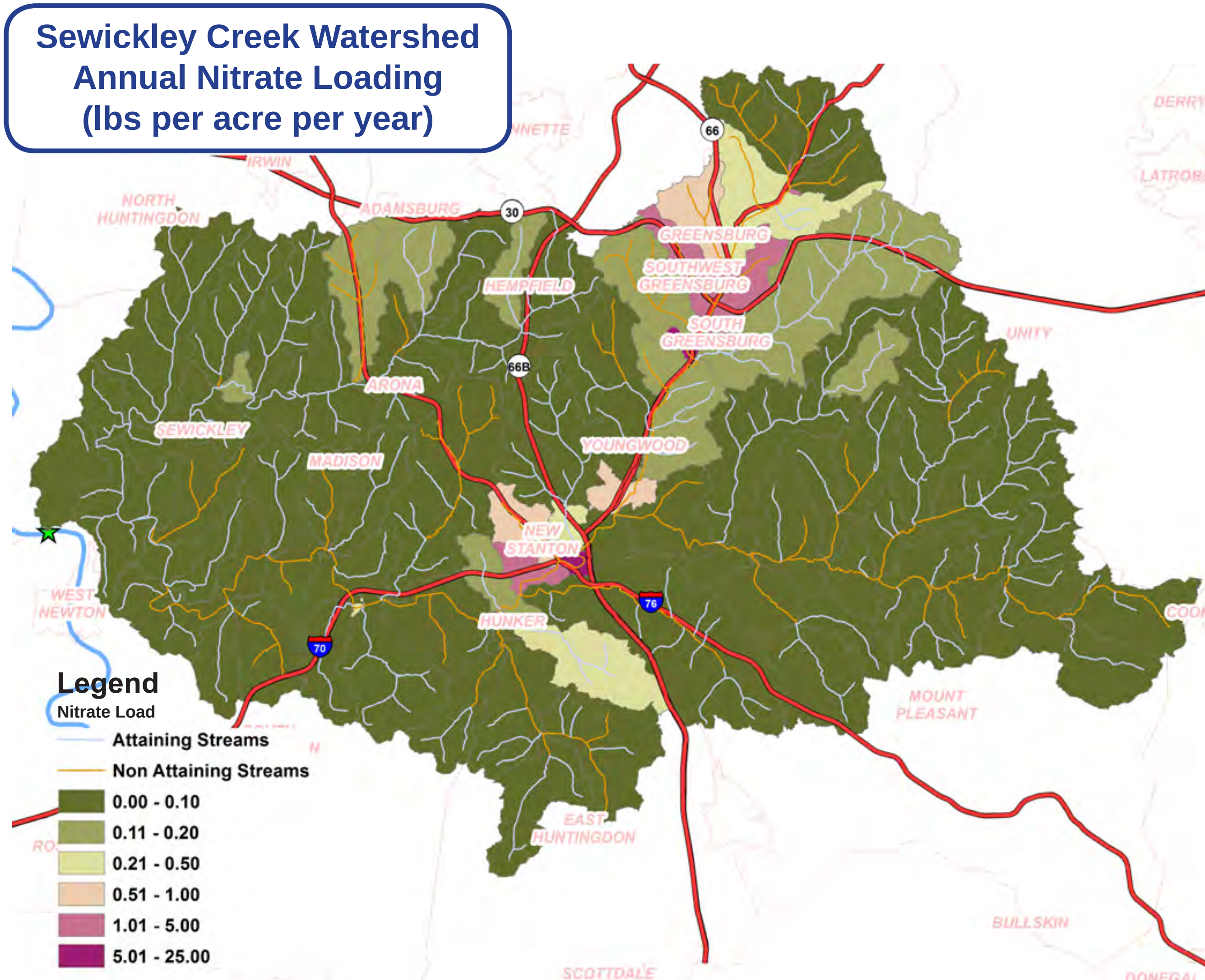

Source - Ethos Collaborative

TOTAL PHOSPHORUS (TP)

Phosphorus, here expressed as Total Phosphorus (TP) is a nutrient essential for life Phosphorus, like Nitrogen, used to be a limiting nutrient for ecosystems. Industrial activities and fertilizer both contribute excess phosphorus to ecosystems. This phosphorus contributes to algae blooms in water bodies, eutrophication, and overall habitat deterioration. Shown on the map to the right is the modeled sub-watershed export of TP in pounds per year.

- Higher amounts of phosphorus are exported from the urban sub-watersheds such as Greensburg and New Stanton. Phosphorus is sourced primarily from lawn fertilizer and roadway deposition. These sources produce both particulate and dissolved forms of phosphorus.
- Soil erosion is another contributor of phosphorus to streamwater. Erosion depletes the soil of valuable nutrients like phosphorus and transports the nutrient downstream, where it can contribute to water body eutrophication.
- Crops lands export Phosphorus to downstream environs, sourced from fertilizer applied to the fields. Fertilizer-sourced Phosphorus is likely in particulate forms, and therefore structural BMP's that filter and/or detain sediment and particles can help to mitigate downstream export.
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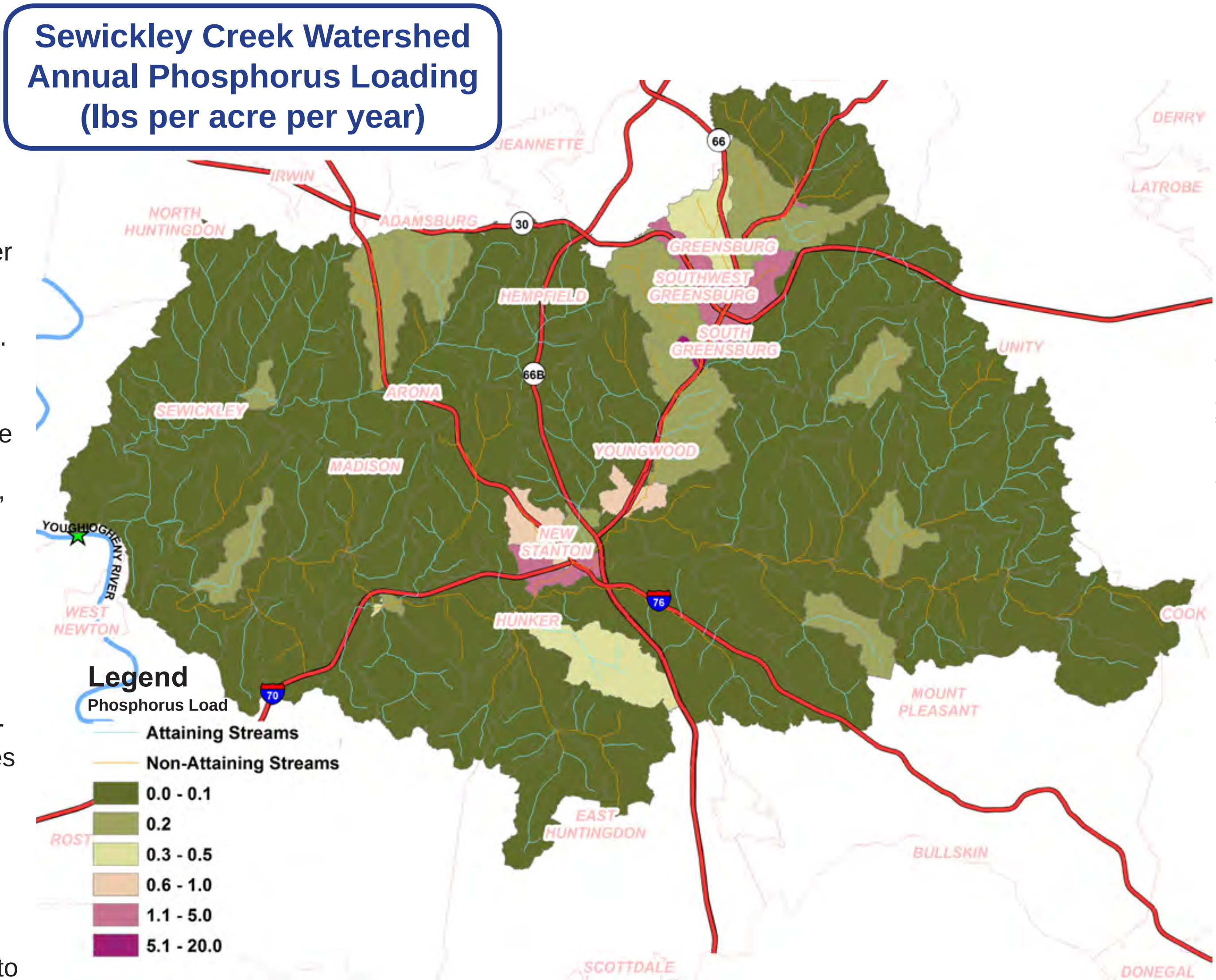


Source - Ethos Collaborative

OPPORTUNITIES FOR EFFECTIVE STORMWATER MANAGEMENT:

Based on Modeling Watershed Hydrology and Pollution Sources to Inform Smart Water Management

Effective water management protects valuable resources and built infrastructure.

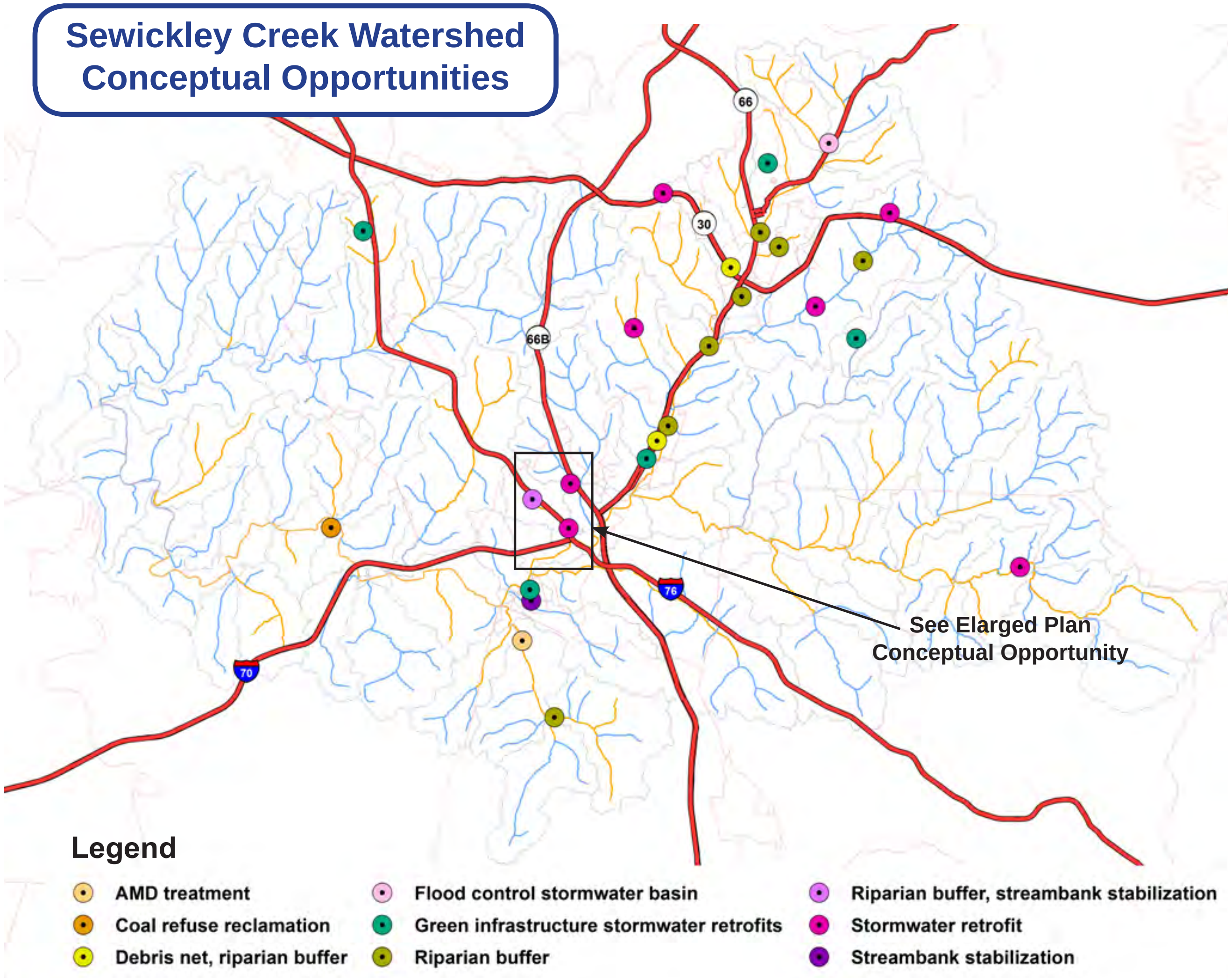
The drinking water and agricultural soils in this watershed are both valuable resources that must be conserved for future generations. Conservation efforts should consider ways to manage water runoff that decrease soil erosion, pollution transport, and in-stream erosion. The Sewickley Creek watershed is also affected by Abandoned Mine Drainage, which contributes to in-stream sedimentation, decreased habitat quality, and streamwater affected by acidic or alakaline mine drainage waters.

To increase water quality, we must decrease overland flow and water quantity.

Water detained by increasing infiltration to groundwater encourages nutrient retention, or the uptake and filtration of pollutants by biota and soil. Together, the processes of detention and retention increase water quality through decreasing erosion and downstream transport.

Conceptual ideas for BMP's/ Landscape Restoration: Highlighting the potential for water and pollutant capture and retention.

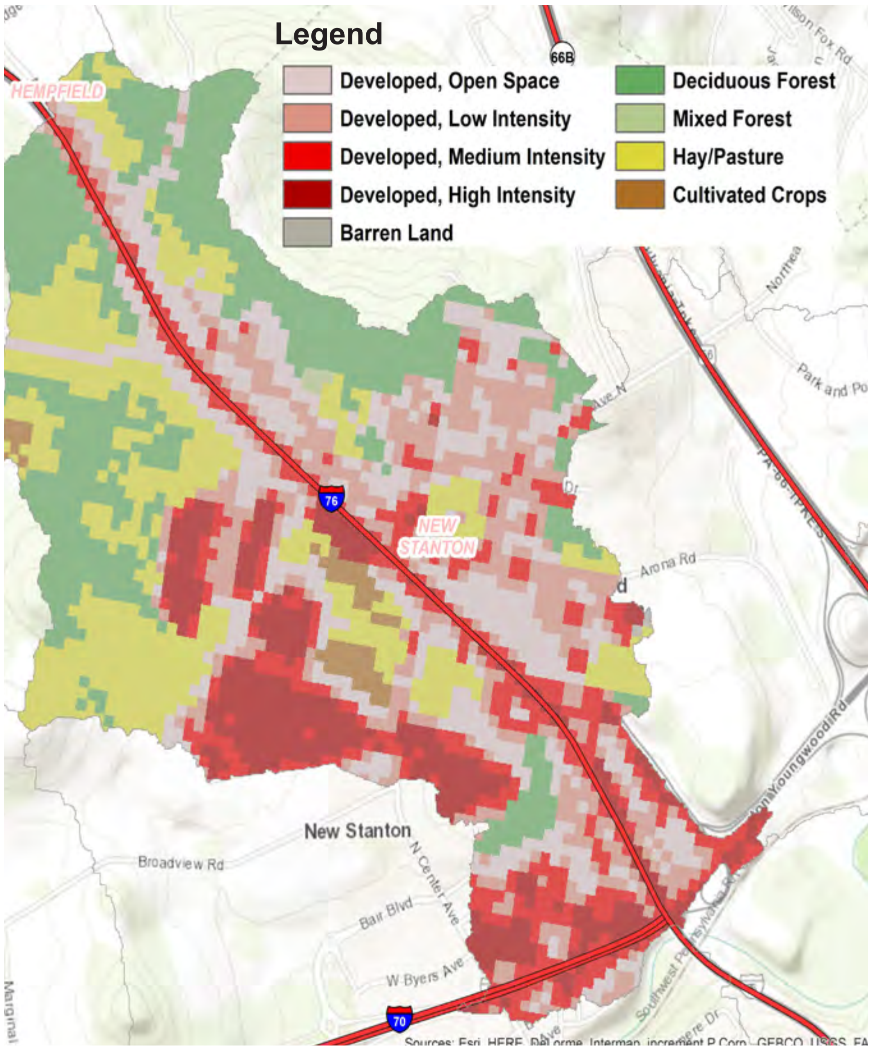
Identified issues include stormwater runoff and associated erosion, as well as the identification of sites appropriate for Green Infrastructure such as stormwater retrofits, riparian buffer restoration, and stream restoration. When coupled with the landscape-based nutrient accumulation and decay modeling, this list can help to identify and prioritize projects for future conservation efforts.



Source - Ethos Collaborative/WCD

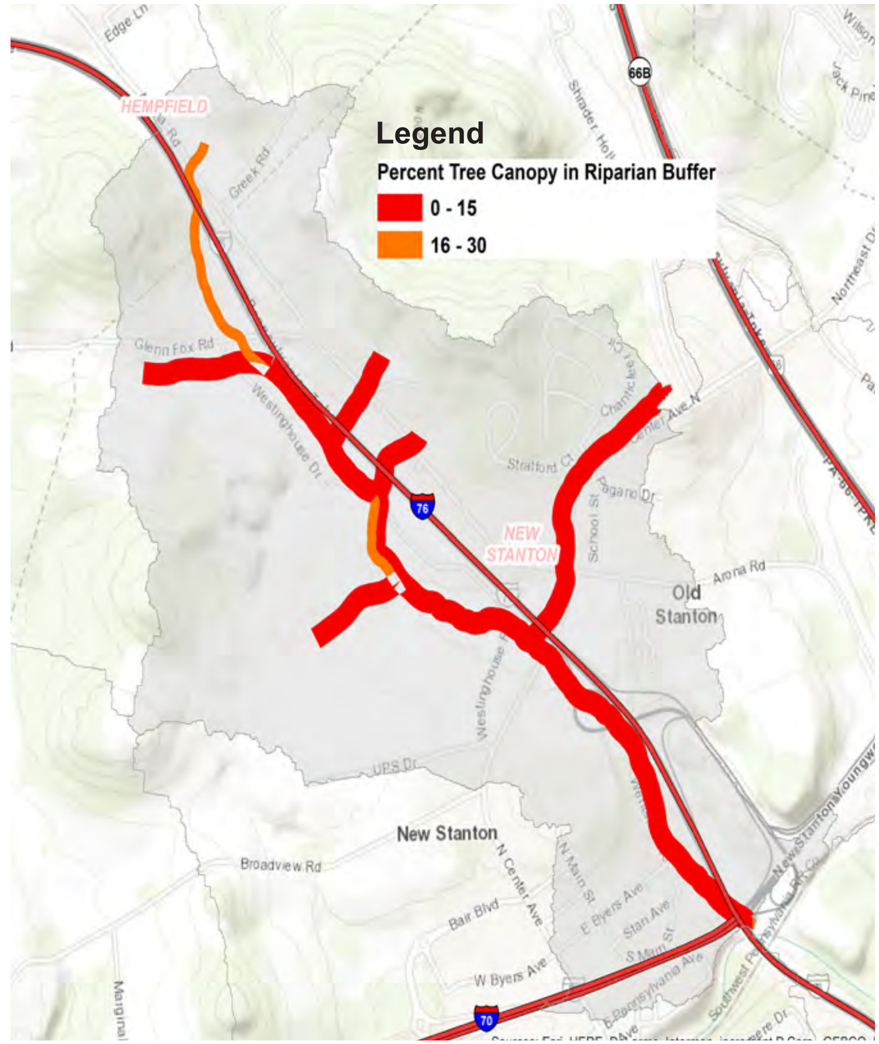
CONCEPTUAL OPPORTUNITY IN THE SEWICKLEY CREEK WATERSHED: WATERSHED IMPLEMENTATION PLAN

This small watershed (719 acres) is drained by ~2 miles of stream, yet estimates indicate it may contribute up to 241 pounds per acre every year of sediment to Sewickley Creek. The landuses are primarily developed (417 acres) and farmland (142 acres). During rain events, water flows across the farm fields and parking lots, contributing to increased downstream flooding, sediment, and nutrient loads. The watershed contains several large industrial complexes and associated parking lots. Significant watershed improvement could be gained by routing parking lot runoff through basins retrofitted to capture stormwater and settle sediment. Bioswales, bioretention, and enhanced riparian buffers would help infiltrate runoff and capture pollutants.



Source - Ethos Collaborative

Enlarged Plan: The lack of a healthy riparian buffer along the stream in New Stanton contributes to stream impairment but provides opportunities for establishing water quality BMPs.



Source - NLCO

Enlarged Plan: High stream flows and polluted runoff are the result of high density development in this New Stanton Watershed.

KISKIMINETAS WATERSHED AREA OF INTEREST

Source - Ethos Collaborative

WATERSHED SNAPSHOT

- ***Area: 19 square miles***
- ***Water Quality: Impaired for aquatic life***
- ***Characterization: This area of interest is largely forested, with pockets of developed land.***
- ***Highways provide relatively quick transportation from this rural region to the cities of Pittsburgh and Greensburg.***
- ***These qualities make the region an ideal location for future development.***

REGION OVERVIEW

The Kiskiminetas Area of Interest is approximately 19 mi^2/12,193 acres and contains 56 miles of streams that drain north into the Beaver Run Reservoir (outlet indicated by a star on the map, left). Landcover in this watershed is predominantly deciduous forest and hay/pasture, with a concentration of urbanized land and associated impervious surface around the town of Delmont and the State Highway 66/Old William Penn Highway (Rte 22) interchange. Twenty-one sub-watersheds were delineated ranging from 0.07 to 2.56 square miles in size. Most sub-watersheds were in the range of 1-2 square miles.

Why is this watershed of particular interest?

This watershed was identified in Phase I as a region with recurrent flooding problems. This small watershed has great potential for rapid development, which would only exacerabte flooding problems. The region is located East of the city of Pittsburgh and the developing Monroville/Murrysville suburban complex. The largely rural landscape leaves room for future expansion of residential or industrial areas. The lovely landscape and outdoor amenities draw visitors and residents alike. There is tremendous opportunity to carefully manage future development and stormwater planning in this area.

Assets in the Watershed

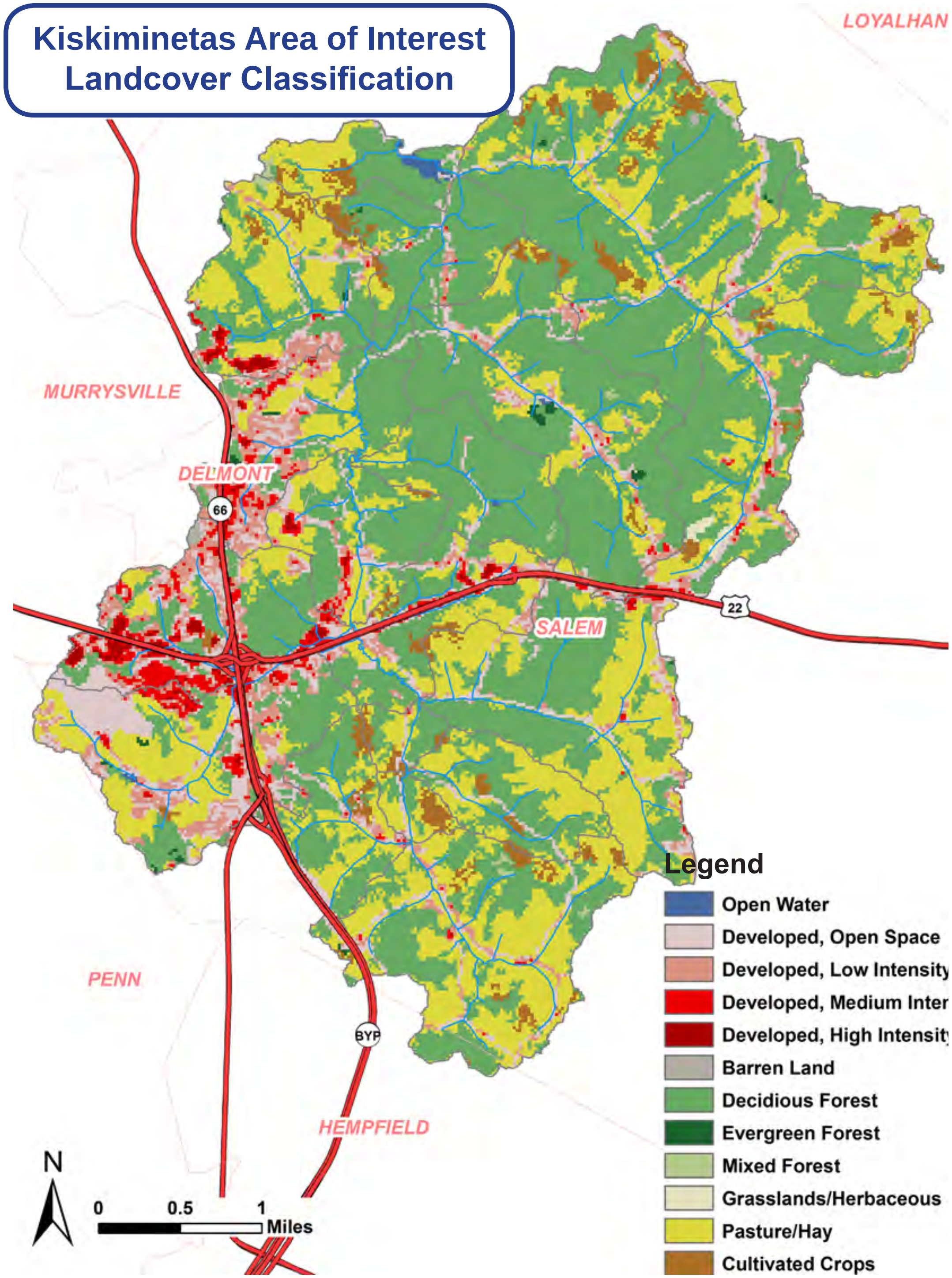
Water quality is of paramount importance in this watershed because the Beaver Run Reservoir serves as a drinking water supply to approximately 130,000 people. Ongoing collaborations between the Municipal Authority of Westmoreland County and researchers from Indiana University of Pennsylvania monitor the water and air quality at various locations in the Beaver Run Reservoir Watershed and around the reservoir. Sampling efforts are focused on areas with active Marcelles and Utica shale gas well pads, but are also examining the effects of other pollution, such as agricultural and urban runoff. Links to the project data and further information can be found at http://www.iup.edu/energy/research-initiatives/beaver-run-reservoir/.

Photo - pawatersheds.org

Kiskiminetas River

Landcover / Landuse Landcover in this watershed is predominantly deciduous forest and hay/pasture, with a concentration of urbanized land and associated impervious surface around the town of Delmont and the State Highway 66/William Penn Highway (Rte 22) interchange. Landcover data is based on the 2011 National Land Cover Dataset, created by the Multi-Resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.

Landcover Class	*Acres*	*Total Area (%)*
Open Water	22	0.2
Developed- Open Space	987	8
Developed- Low Intensity	821	7
Developed- Medium Intensity	369	3
Developed- High Intensity	114	1
Barren Land	11	0.1
Deciduous Forest	6105	50
Evergreen Forest	29	0.2
Mixed Forest	22	0.2
Herbaceous	17	0.1
Hay/Pasture	3300	27
Cultivated Crops	393	3

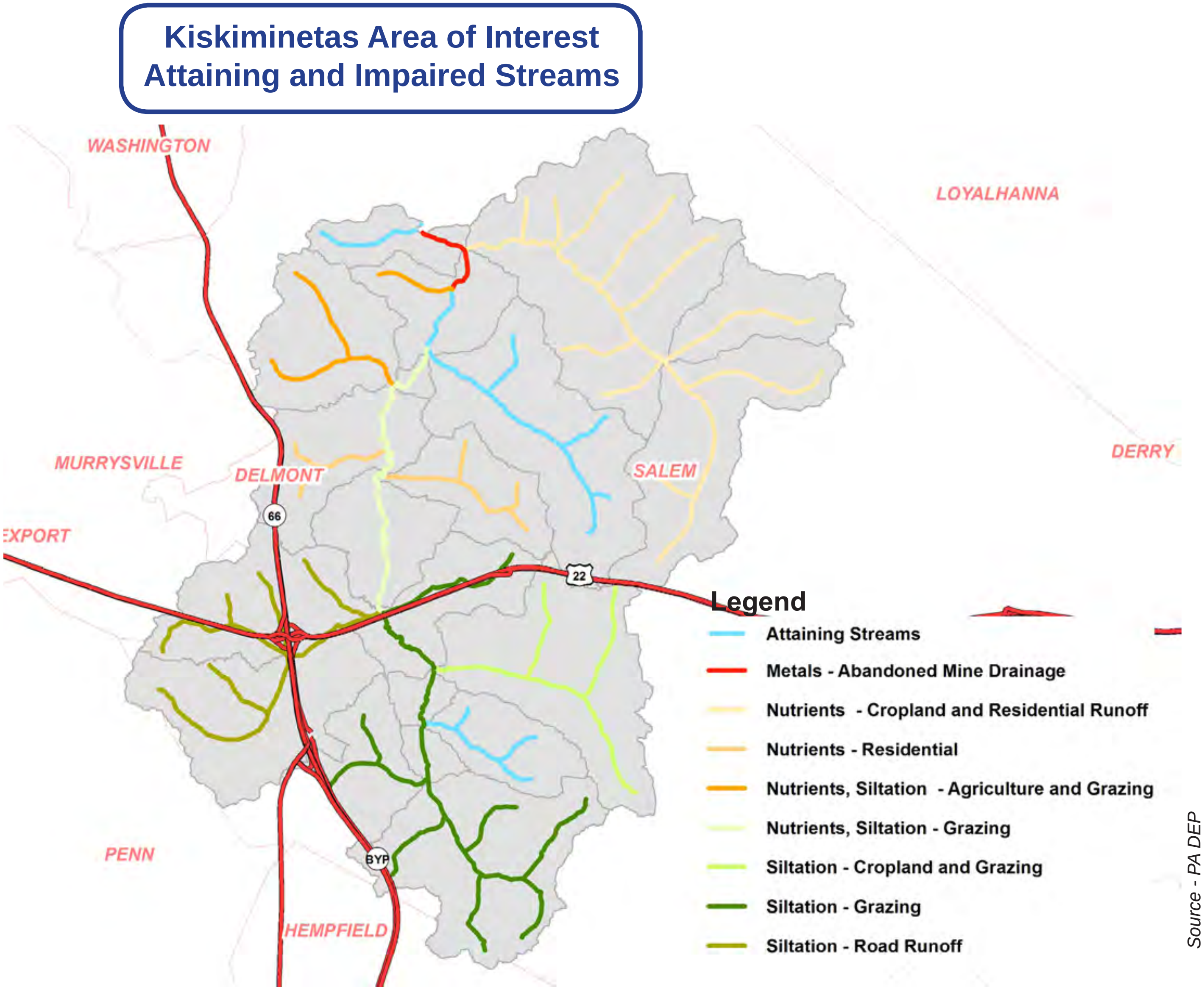


Source - NLCD (2011)

CURRENT WATER QUALITY IN THE KISKIMINETAS WATERSHED AREA OF INTEREST

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection identified 7.55 stream miles as "attaining" their designated uses of providing a potable water supply and supporting aquatic life, 38.9 stream miles as "non-attaining" for those specific designated uses, and the remaining are unclassified. The majority of streams that drain this watershed are considered "impaired" for aquatic life. Identified impairments include nutrients and siltation from agricultural land, as well as runoff and nutrients from residential/urban areas within the watershed. These are considered non-point sources, originating not from one identifiable point but instead from diffuse sources across the landscape.



TMDL status of the streams in this area of interest

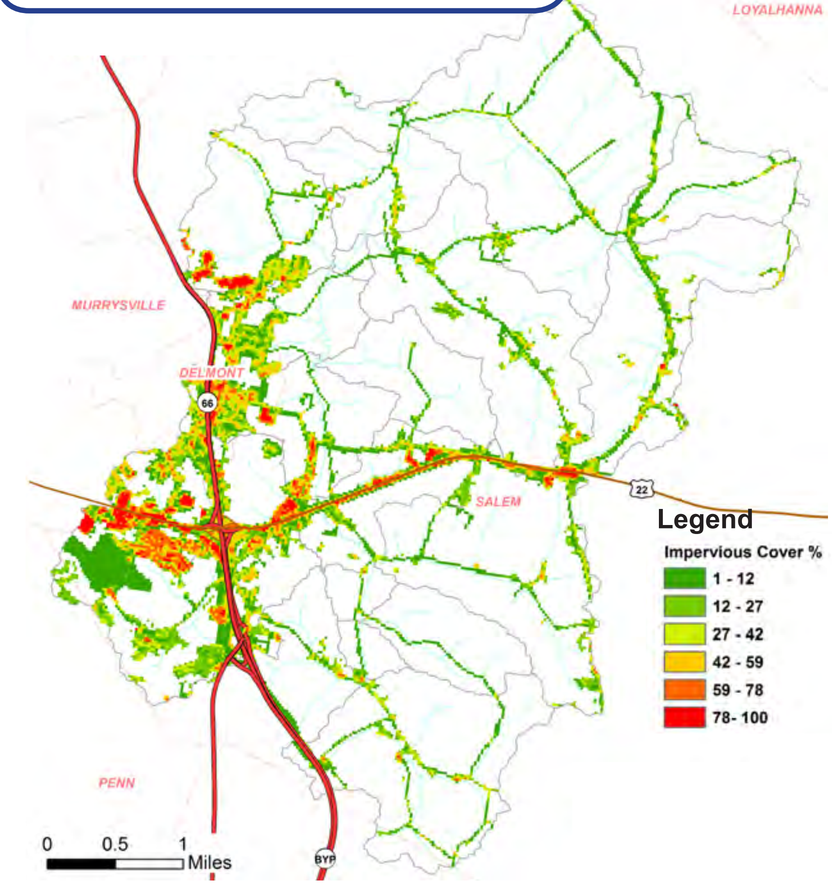
All of the streams in the Kiskiminetas Area of Interest are under a TMDL, (Total Maximum Daily Load) agreement, The "*Kiskiminetas-Conemaugh River Watersheds TMDL.*" This TMDL is a seeks to reduce non-point sources of pollution from Metals/ high pH (from Abandoned Mine Drainage) as well as Siltation and Suspended Solids. The other impairment sources are not addressed by TMDL agreements.

Abandoned Mine sites include regions of subsidence, abandoned structures and entries, and abandoned mine drainages. In particular, the drainages contribute to poor habitat and water quality.

WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE KISKIMINETAS WATERSHED AREA OF INTEREST

As water accumulates and moves overland on impervious surfaces, it picks up pollutants from the surface of the landscape and delivers it to receiving waters. Development, particularly that which increases impervious surfaces on the landscape, increases the overland flow of water during storms and decreases infiltration to groundwater. Increased stormwater also increases the erosive force of overland flow, increasing sediment load and delivering it to downstream receiving waters. Below, a watershed map shows the concentration of impervious surface in the area of Delmont and the highway.

Kiskiminetas Area of Interest Impervious Cover (%)



Source - NLCD

Source - Westmoreland County

Beaver Run - Sediment Bar

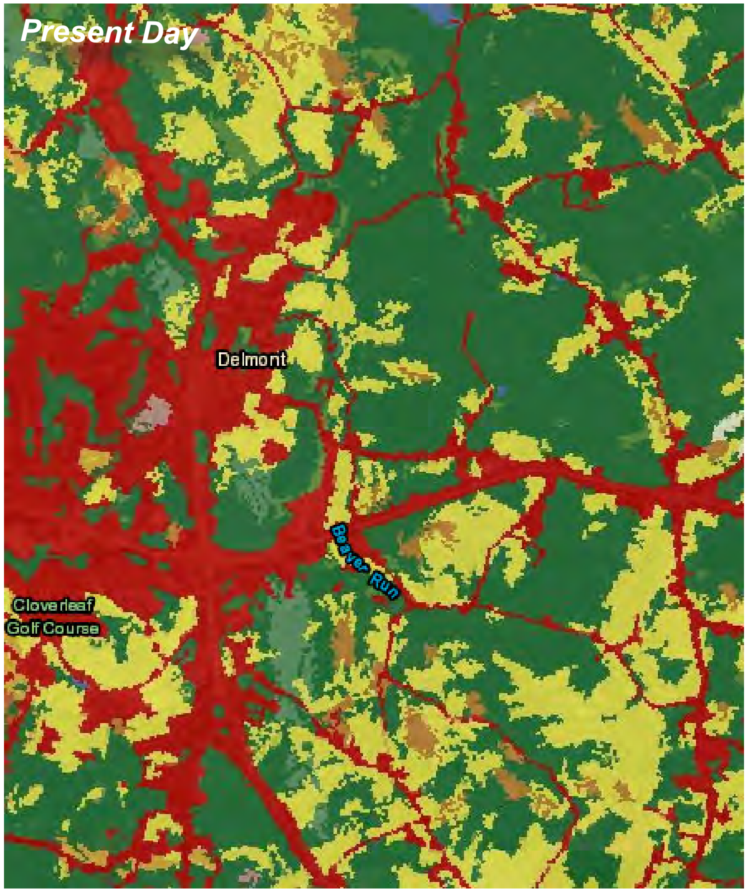
As stormwater runoff increases, so does the water's capacity to carry sediment and nutrients such as Nitrogen and Phosphorus. Stormwater may drop sediment and pollutants when the flow/energy of the water decreases. Above, we can observe this process where Beaver Run empties into Beaver Run Reservoir. The aerial image of the site clearly shows a sand/sediment bar at the mouth of Beaver Run. The swiftly moving stream water slows as it enters the reservoir and the water deposits sediment and associated pollution.

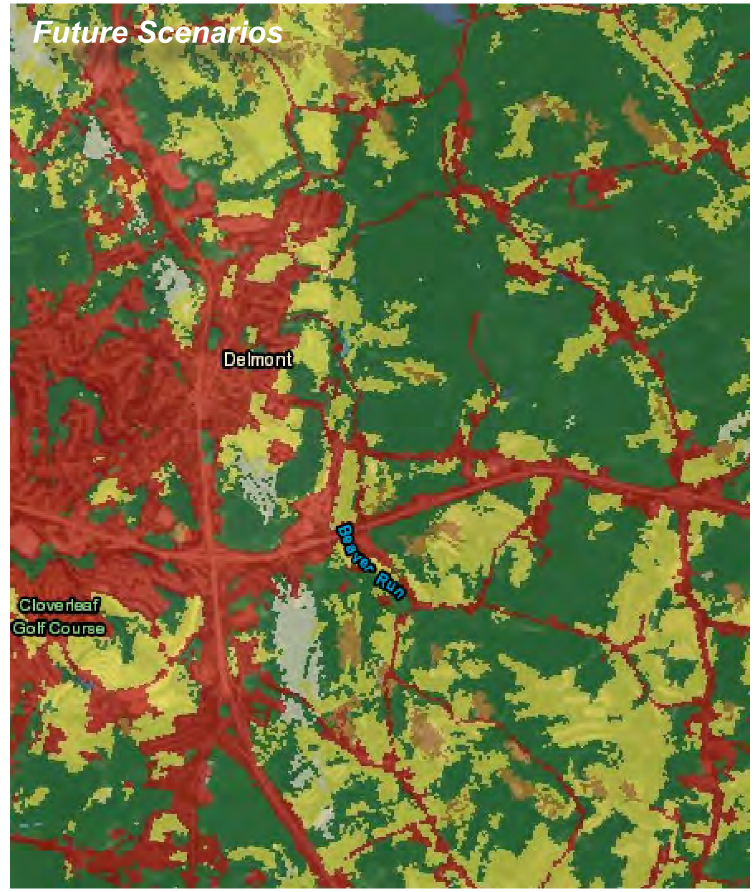
Both the sediment and the pollution are a threat to water. Accumulated nutrients can lead to harmful algae blooms, which may affect wildlife and water quality in the reservoir. The sediment accumulation represents the erosion, and loss, of valuable soil from upstream landscapes. The sediment is also a threat in the future as it continues to accumulate and reduces the available water holding capacity of the reservoir.

FUTURE TRENDS IN THE KISKIMINETAS WATERSHED AREA OF INTEREST

This watershed will likely see increasing development and a reduction in forested and agricultural land. These land-use trends will likely add to stormwater runoff and non-point pollution loadings.

There is tremendous opportunity to carefully plan now in order to mitigate the potential increase in flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source - ESRI

Legend

National Land Cover Database

- Open Water
- Perennial Ice/Snow
- Developed
- Barren Land (Rock/Sand/Clay)
- Forests
- Scrub/Shrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Herbaceous and Woody Wetlands

Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted increase in impervious surfaces. This analysis of land use change in the Kiskiminetas Area of Interest specifically estimates

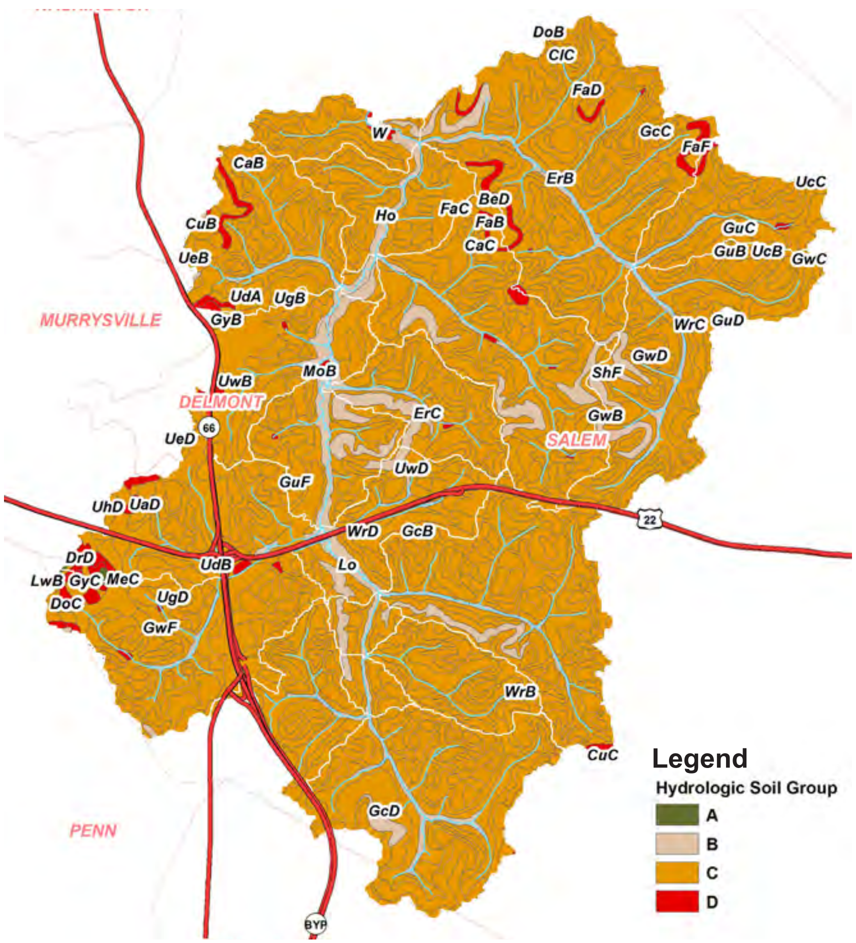
- A 22% *INCREASE* in developed land,
- A 8% *DECREASE* in forest cover
- A 14% *DECREASE* in agricultural cropland

HYDROLOGIC WATERSHED MODELING:

INPUT PARAMETERS, MODEL CALIBRATION & FINAL RELEASE RATES FOR THE KISKIMINETAS WATERSHED AREA OF INTEREST

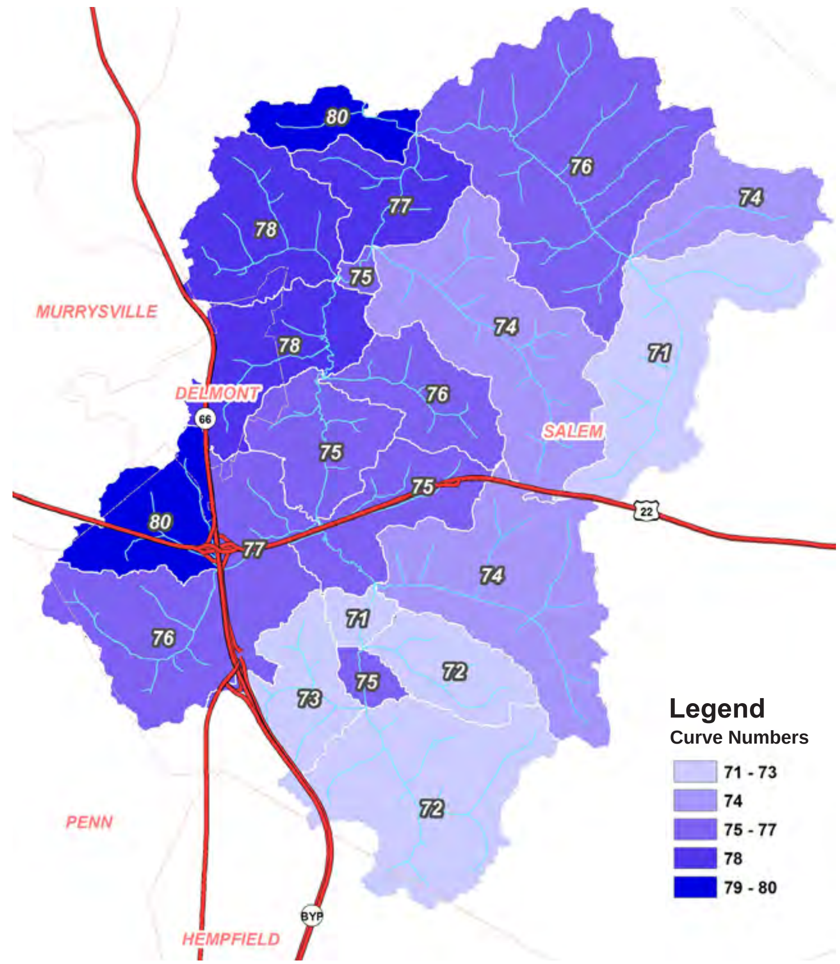
Controlling water now and in the future requires an understanding of current conditions and pollution sources. The ***Parameters*** below and on the following pages were used in hydrological models to help us understand the contribution of different sub-watersheds to the flow of the whole, and possible future changes.

Hydrologic Soil Groups in the Kiskiminetas Watershed Area of Interest The map below is color-coded by the Hydrologic Soil Group, which indicates a soil's water holding capacity. Group A soils have low runoff potential and high infiltration rates, while Group D soils show the highest runoff potential with very low infiltration rates. Also shown are the specific soil names, please see appendix for a list and descriptions of individual soil types.



Source - PASADA

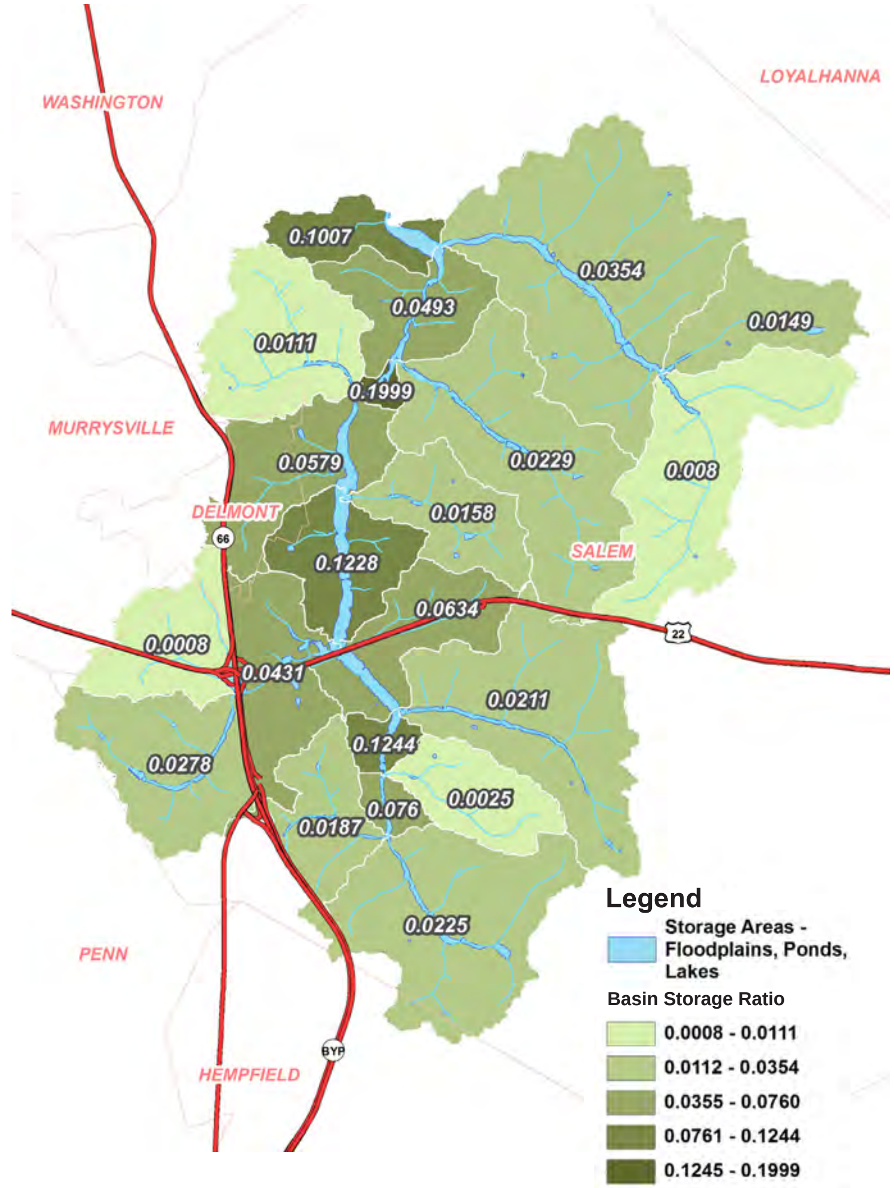
Basin Curve Numbers ("CN's") in the Kiskiminetas Watershed Area of Interest are an empirical parameter that help predict direct runoff/infiltration from a parcel of land during a rain event. In the Kiskiminetas are of interest, these range from 65 to 78. Watersheds with a higher curve number indicate higher runoff potential, leading to greater flooding and pollution delivery to streams.



Source - Ethos Collaborative

Average Basin Slope (%) in the Kiskiminetas Watershed Area of Interest Generally most regions in this watershed show a moderate slope, with a range of values from 16.37% to 32.29%. Steeper slopes are found in the stream valleys and shallower slopes on the upland regions. Slope steepness contributes to overall runoff calculations, as steeper regions generally experience greater runoff during rain events.

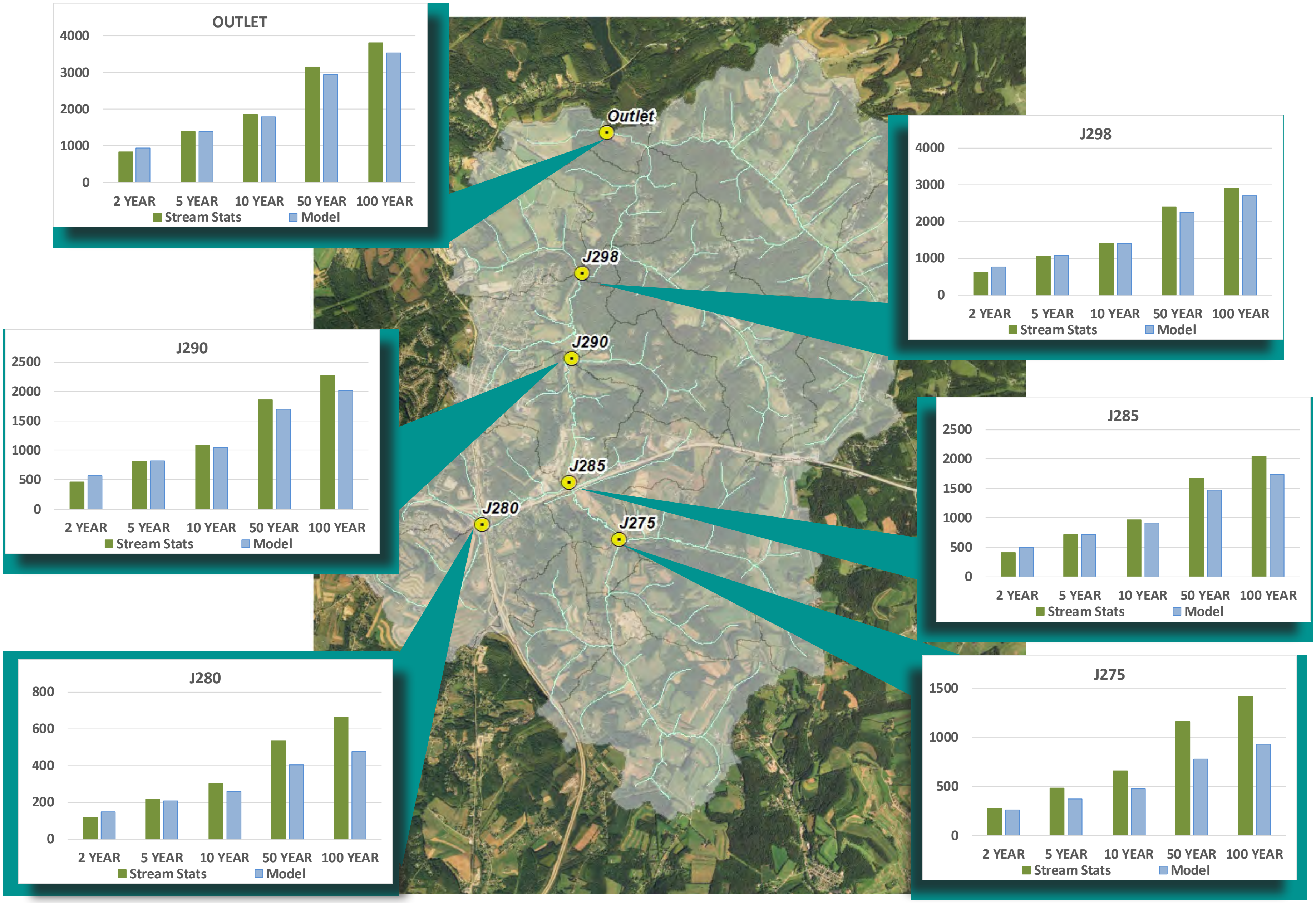
The Basin Storage Ratio in the Kisikminetas Area of Interest indicates the proportion of each sub-watershed that can store water in a storm, instead of directly increasing stream discharge. Storage areas include lakes, ponds and floodplains. Storage ratios range from 0.0008 to 0.1999, therefore the storage amount available in each sub-watershed varies from 0.08-20% of the sub-watershed area.



Source - Ethos Collaborative

MODEL CALIBRATION IN THE KISKIMINETAS WATERSHED AREA OF INTEREST

Six sites were chosen as “areas of interest” and model results at these sites were compared to Stream Stats data for the same site. This approach allowed the calibration of hydrological models, in the absence of multiple stream gage locations in the watershed. The graphs below show how each point of interest compares for the 2, 5, 10, 50, and 100 year storms. There is a good correlation between model results and Streams Stats data. For the methodology used for calibration, validating statistics and comparisons refer to the methodology in the appendix.



Source - Ethos Collaborative

RECOMMENDED RELEASE RATE MAP FOR THE KISKIMINETAS WATERSHED AREA OF INTEREST

Release rates are a tool that help determine the timing of when water can be released from a watershed. A release rate of 50% for a sub-watershed indicates that the rate at which stormwater moves out of the watershed and downstream must be reduced by half in any future development. In contrast, a release rate of 100% indicates that, with future development, stormwater can move off of the sub-watershed at the same rate that is does in the present. In other words, lower release rates require an increased control of runoff.

Release rates were calculated based on a hydrologic model of the area of interest using HEC-HMS, the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System, in conjunction with GEO-HMS (a GIS extension that allows for the manipulation of spatial data).

Final calculated release rates show a range in value from 50-100%. Darker colors and lower release rates indicate regions where future development must reduce runoff rates.

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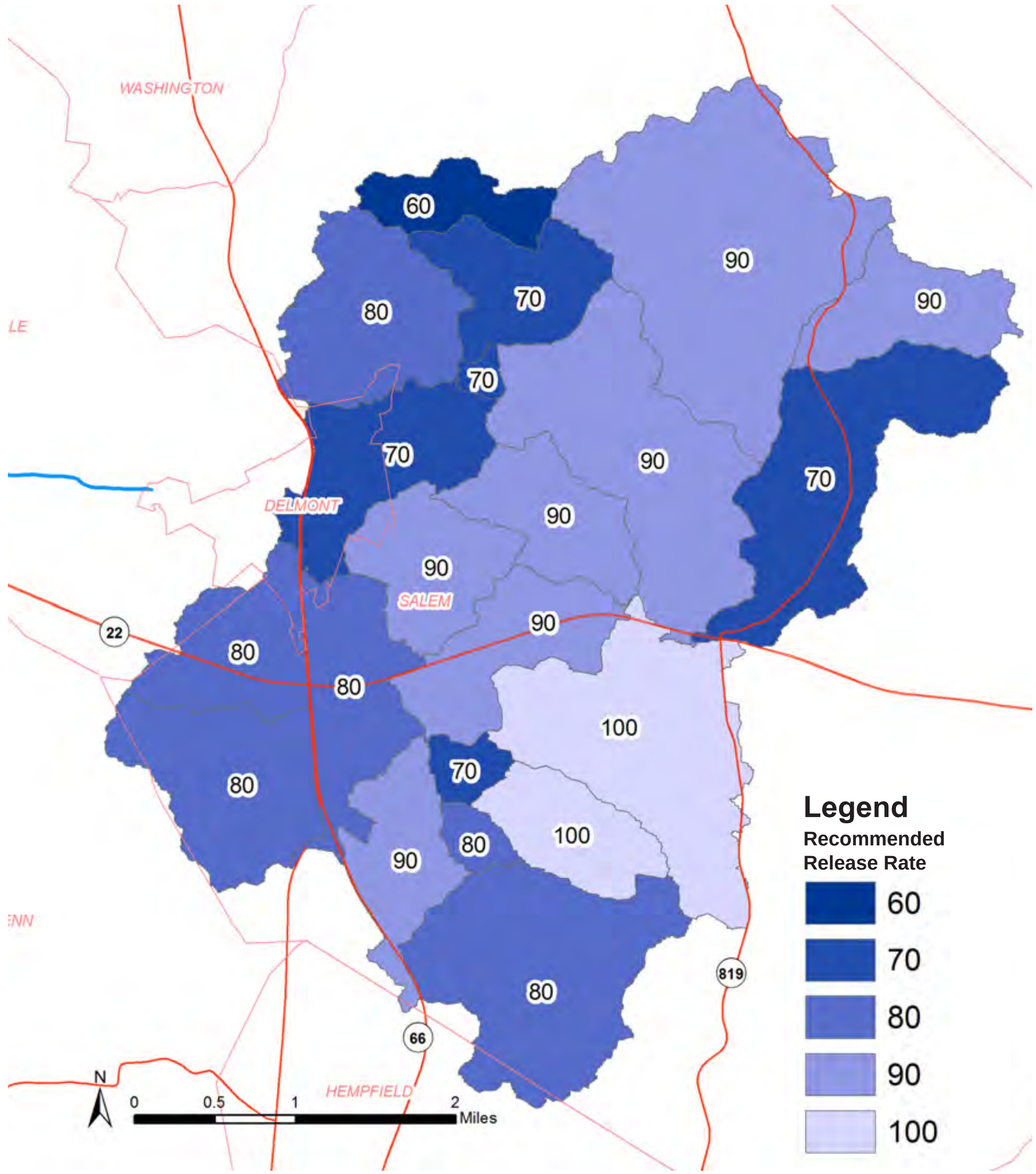

Source - Ethos Collaborative/WCD

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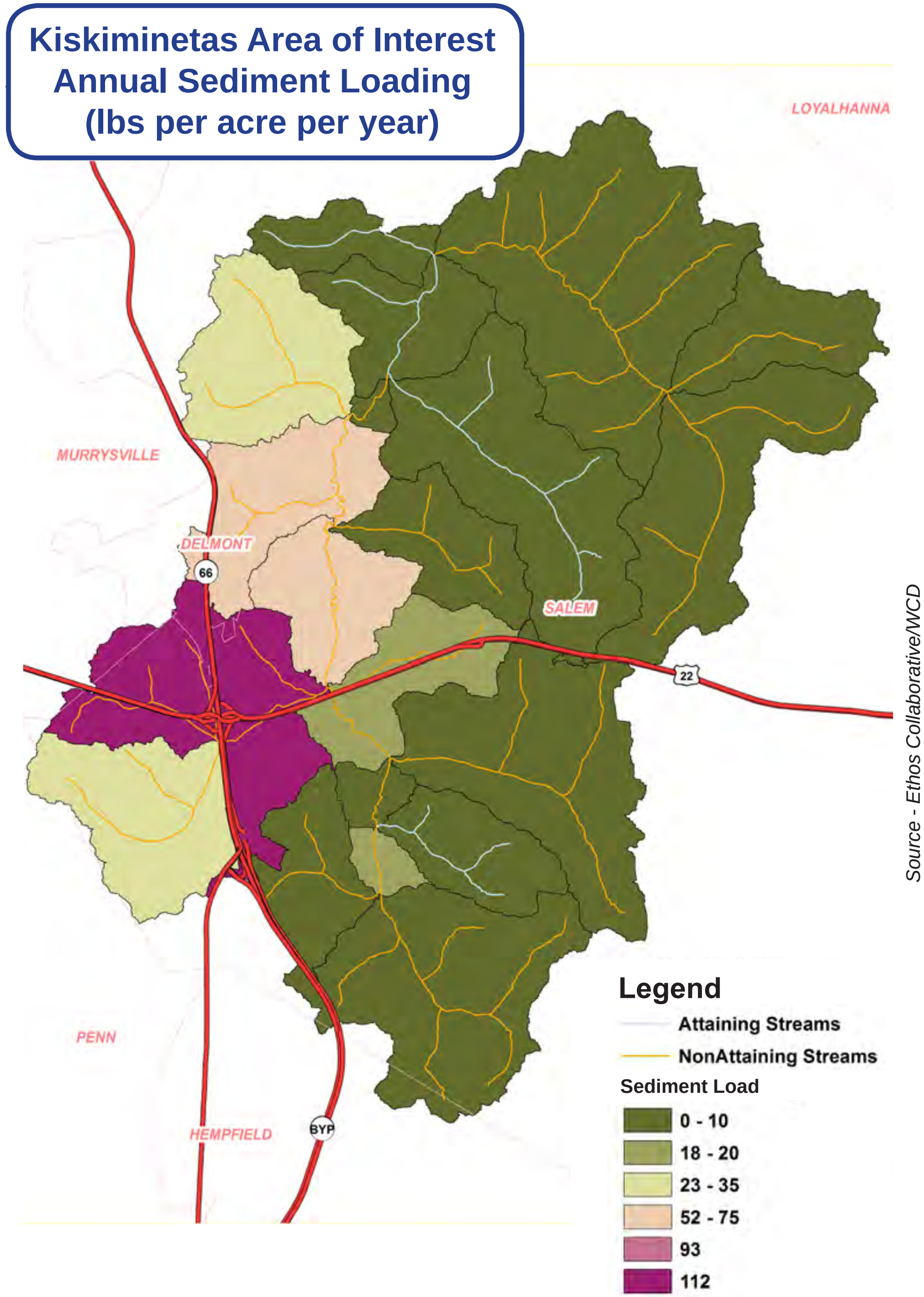
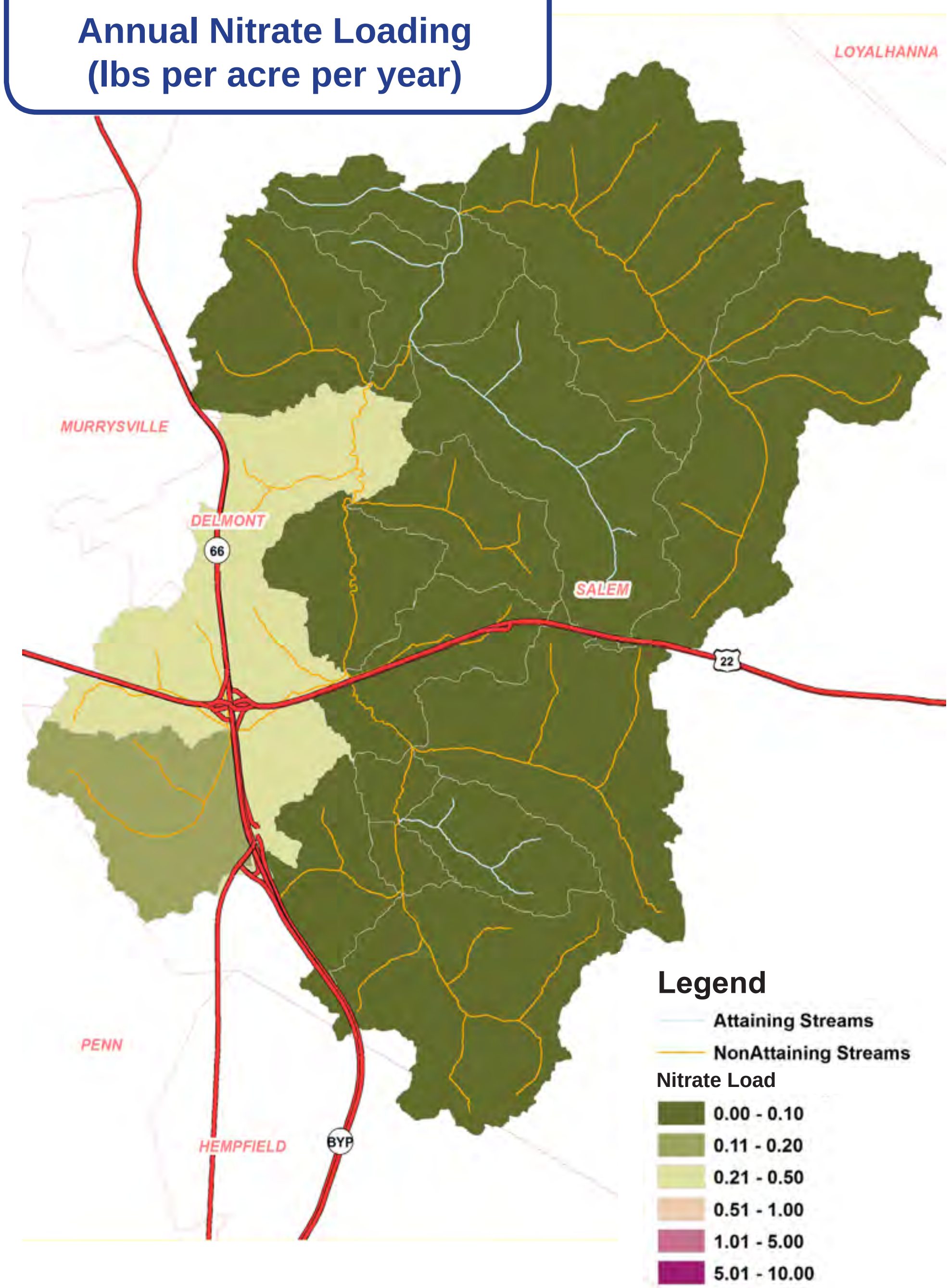


Kiskiminetas Area of Interest Annual Nitrate Loading (lbs per acre per year)



Source - Ethos Collaborative

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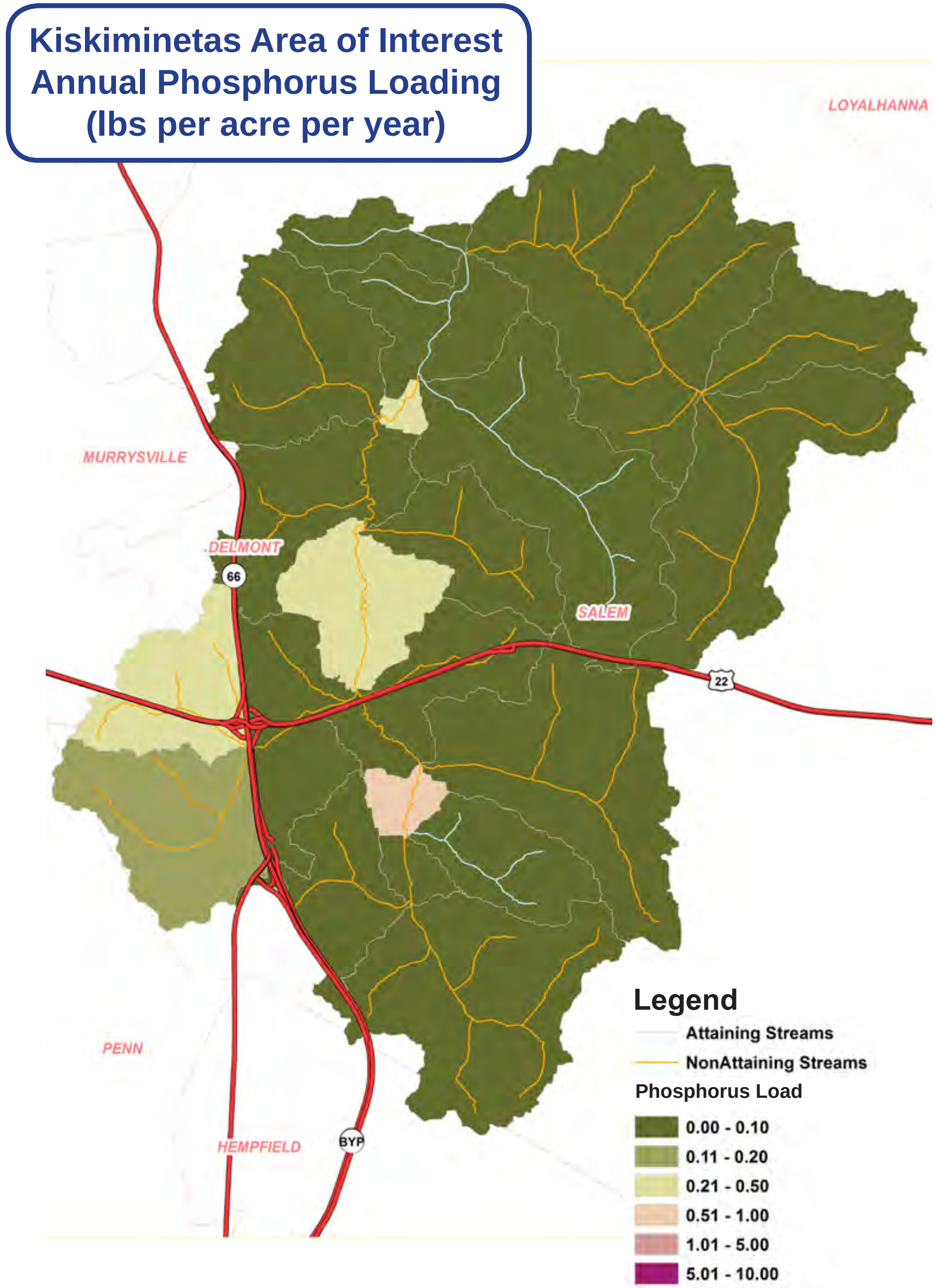

Source - Ethos Collaborative

OPPORTUNITIES FOR EFFECTIVE STORMWATER MANAGEMENT

Based on modeling watershed hydrology and pollution sources to inform smart water management.

Effective water management protects valuable resources and built infrastructure.

The drinking water sourced from Beaver Run Reservoir and the soil used in agricultural lands in this watershed are both valuable resources that must be conserved for future generations. Conservation efforts should consider ways to manage water runoff that decrease soil erosion, pollution transport, and sedimentation in the reservoir.

To increase water quality, we must decrease overland water quantity.

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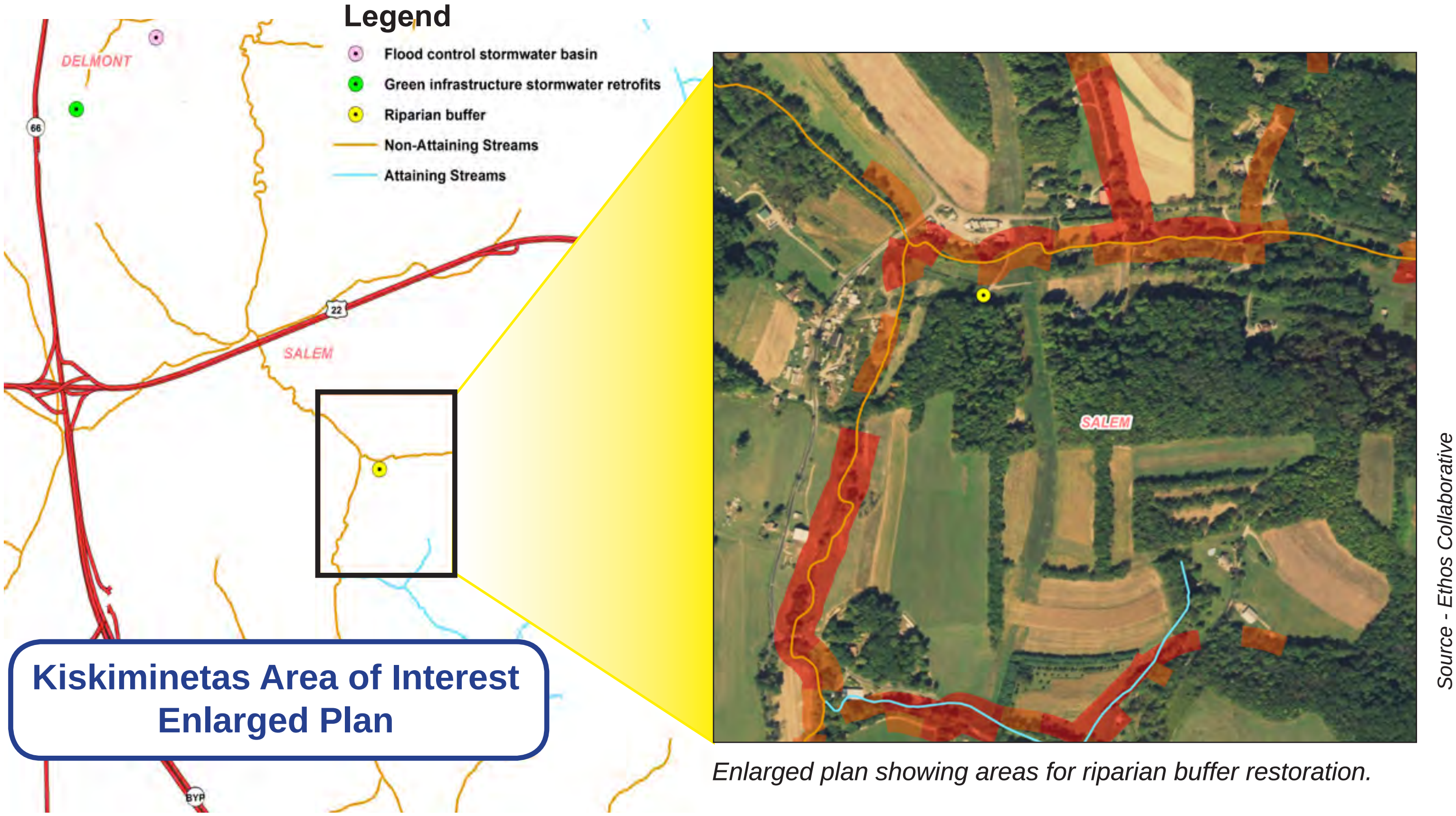
Conceptual Ideas for BMP's/Landscape Restoration: Highlighting the potential for water and pollutant capture and retention.

Identified issues include stormwater runoff and associated erosion, as well as the identification of sites appropriate for Green Infrastructure such as stormwater retrofits, riparian buffer restoration, and stream restoration. When coupled with the landscape-based nutrient accumulation and decay modeling, this list can help to identify and prioritize projects for future conservation efforts.

Opportunities for Effective Stormwater management

Three sites in the Kiskiminetas Area of Interest with known stormwater or water quality issues are identified below. This list was compiled based on reports made by local property owners to the Westmoreland Conservation District and should by no means be considered an exhaustive list of problem sites in the watershed.

Source - Ethos Collaborative/WCD



Enlarged plan showing areas for riparian buffer restoration.

CONCEPTUAL OPPORTUNITY IN THE KISKIMINETAS AREA OF INTEREST: RIPARIAN BUFFER RESTORATION

This area is located in Salem Township, near the Route 22/Route 66 highway interchange. Two tributaries come together to form the main stem of Beaver Run. The stream reach moving through this area drains a region of open land and farm fields.

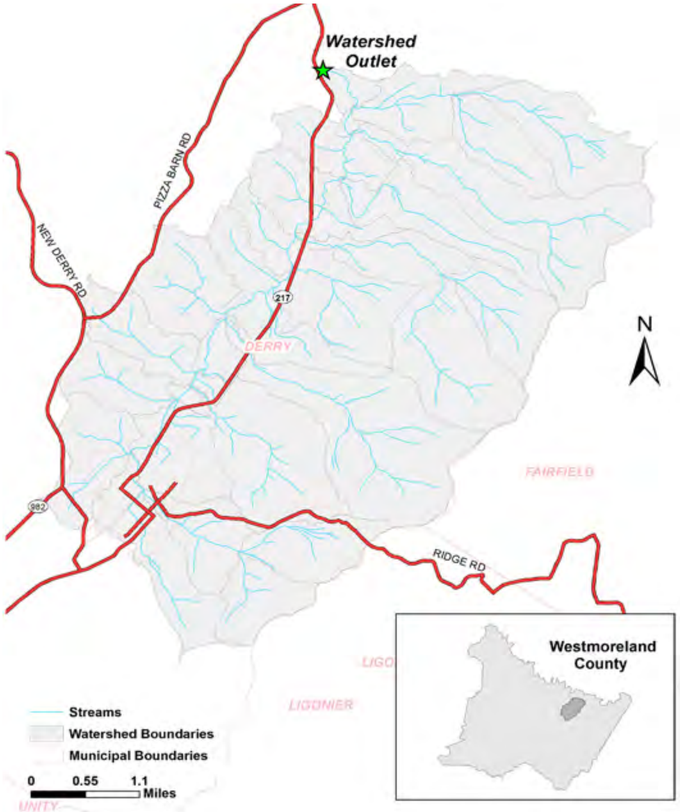
Water Quality Goals:
During rain events, water flows across the farm fields and pastures into the stream network. This water can increase downstream flooding, as well as deliver sediment and fertilizer-sourced pollution including dissolved and particulate Suspended Solids (TSS), Phosphorus (TP), and Nitrate (TNO_3^-).

Stormwater Management Potential:
Identified needs include increasing the riparian buffer along the stream to mitigate the overland flow of water and sediment.

Landscape Elements to Consider:
The map above shows the area of interest, close-up. As indicated by the red and orange buffers on either side of the stream, there is little tree canopy in the riparian buffer.

Water Quality Impacts of Stormwater Management:
Augmenting the riparian buffer in these areas would help improve water quality. Increased tree canopy would slow overland flow, encouraging water and particle infiltration/settling and increasing biological processing interactions. This would help to decrease stream loads of TSS, TP and $TNO3^-$ that are contributed from the landscape. Restoring/augmenting the riparian buffer on both sides of the above-ground stream would help to mitigate the influx of nutrients and sediment.

CONEMAUGH RIVER WATERSHED AREA OF INTEREST



Source - Ethos Collaborative

WATERSHED SNAPSHOT

- ***Area:** 22 mi²/14,080 acres*
- ***Water Quality:** Impaired for aquatic life due to abandoned mine drainage, siltation, nutrients.*
- ***Characterization:** This area of interest is largely forested, with pockets of developed land in the Southwest corner of the watershed.*
- ***Derry Borough, the most densely populated region of this watershed, is currently working to reduce pollution as part of an MS4 Pollution Reduction Plan.***

REGION OVERVIEW

The Conemaugh Area of Interest is approximately 22 mi^2/14,080 acres and contains 67.9 miles of streams that drain north, eventually joining the Conemaugh River near Blairsville. The Area of Interest drains to a point on McGee Run, indicated by a star on the map to the left. Landcover in this watershed is predominantly deciduous forest and hay/pasture, with a concentration of urbanized land and associated impervious surface around the town of Derry. Thirty-one sub-watersheds were delineated ranging from 0.07 to 7.12 square miles in size. Most sub-watersheds were in the range of 0.5-1.5 square miles.

Why is this watershed of particular interest?

This region was identified during Phase I as having recurrent flooding problems, particularly upland tributaries in Derry Township/Derry Borough. This problem will be exacerbated in the future, as further development and build-out continues. This small watershed has great potential for rapid development. The largely rural landscape leaves room for future expansion of residential or industrial areas. The lovely landscape and outdoor amenities draw visitors and residents alike. There is tremendous opportunity to carefully manage future development and stormwater planning in this area.

Assets in the Watershed

The town of Derry is the primary urbanized area in this watershed. Derry Borough released a Pollution Reduction Plan in July of 2017, detailing the pollution reduction goals for three specific sub-watersheds. Current efforts are underway to reduce the pollutants from entering surface waters through Derry's municipal separate sanitary sewer system, or MS4. Proposed efforts include several sections of streambank stabilization in the urbanized center of Derry, conversion of existing swales to bioswales, and additional detention basins. Restoration efforts in this watershed should coordinate with Derry planners.

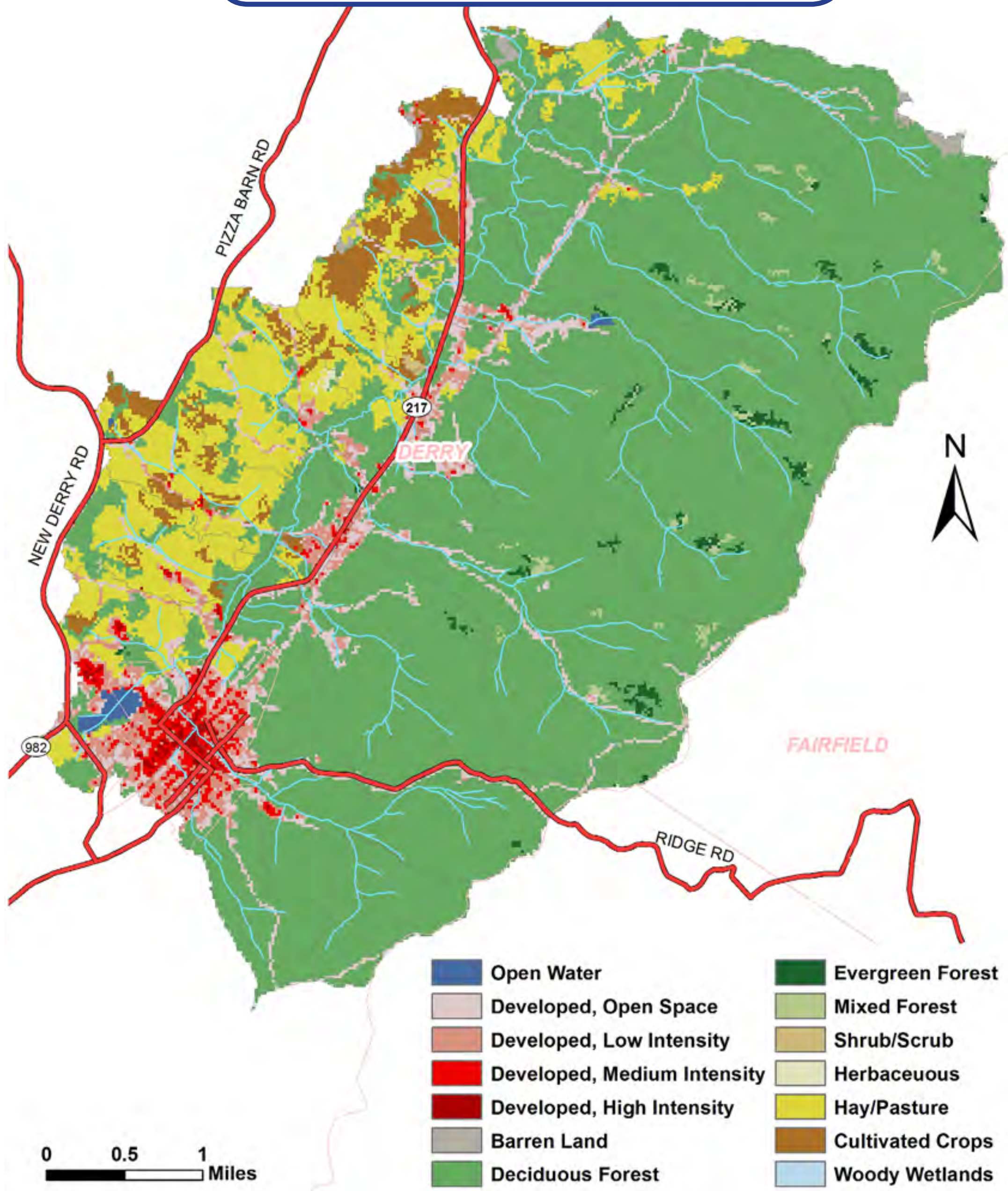
Landcover / Landuse

Landcover in this watershed is predominantly deciduous forest and hay/pasture, with a concentration of urbanized land and associated impervious surface around the town of Derry. Overall, the watershed has a low percent impervious surfaces (ranging from 0.2% to 32%).

Landcover data is based on the 2011 National Land Cover Dataset, created by the Multi-Resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.

Landcover Class	*Acres*	*Total Area (%)*
Open Water	42	0.3
Developed- Open Space	741	5
Developed- Low Intensity	527	4
Developed- Medium Intensity	217	2
Developed- High Intensity	36	0.3
Barren Land	56	0.4
Deciduous Forest	10302	73
Evergreen Forest	70	0.5
Mixed Forest	7	0.05
Herbaceous	9	0.1
Hay/Pasture	1595	11
Cultivated Crops	437	3
woody wetlands	1	0.01

Conemaugh River Area of Interest Land Classification

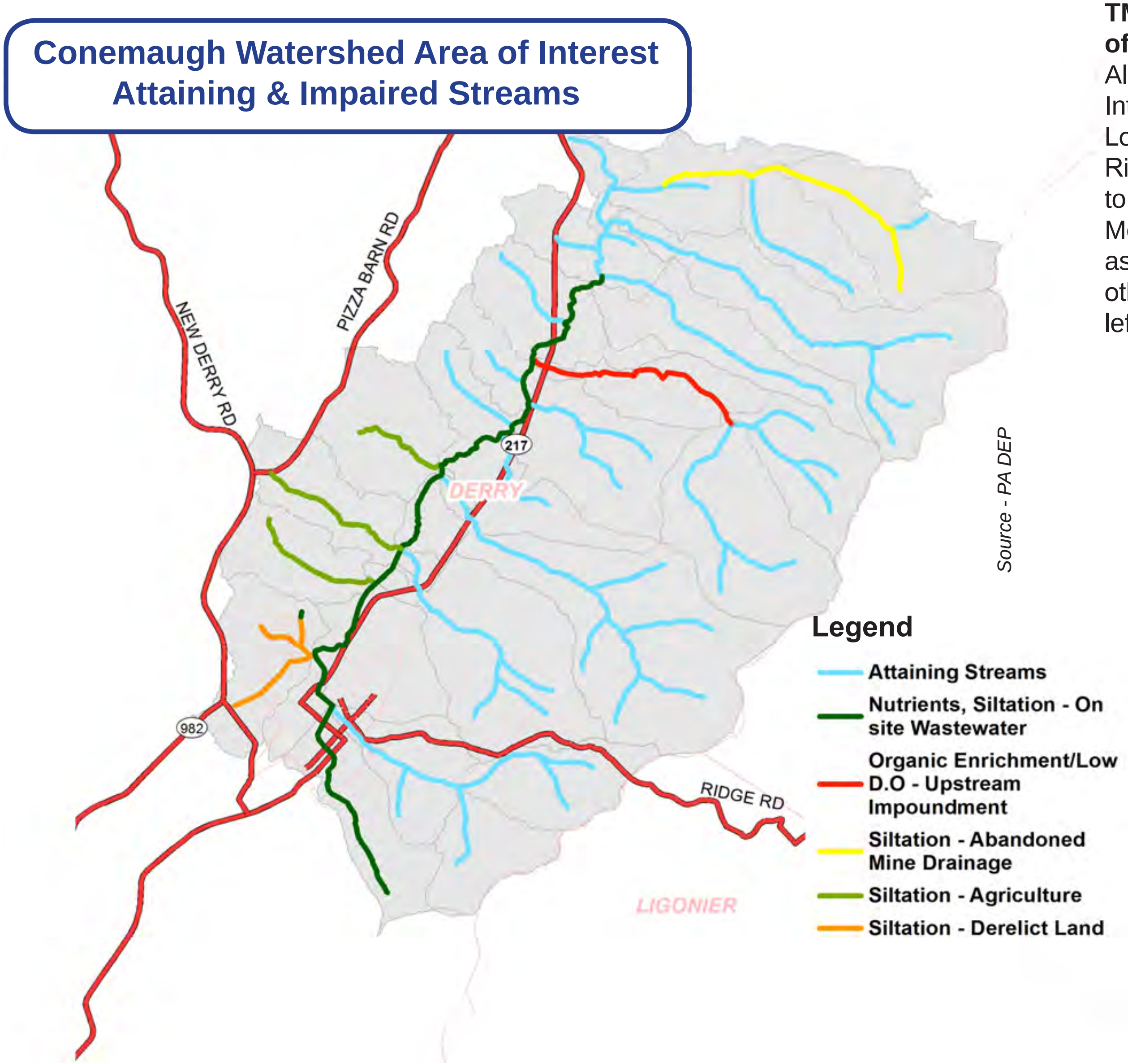


Source - NLCD (2011)

CURRENT WATER QUALITY IN THE CONEMAUGH RIVER WATERSHED AREA OF INTEREST

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection identified 42.8 stream miles as “attaining” their designated use of supporting aquatic life, 15.5 stream miles as “non-attaining” for that designated use, and the remaining are unclassified.   Identified impairments include nutrients from on-site wastewater treatment, siltation from agricultural land, as well as runoff and nutrients from derelict lands within the watershed. These are considered non-point sources, originating not from one identifiable point but instead from diffuse sources across the landscape.



TMDL status of the streams in this area of interest

All of the streams in the Conemaugh Area of Interest are under a TMDL, (Total Maximum Daily Load) agreement, The “Kiskiminetas-Conemaugh River Watersheds TMDL.” This TMDL is a seeks to reduce non-point sources of pollution from Metals/ high pH (from Abandoned Mine Drainage) as well as Siltation and Suspended Solids. The other identified impairment sources (listed to the left) are not addressed by TMDL agreements.

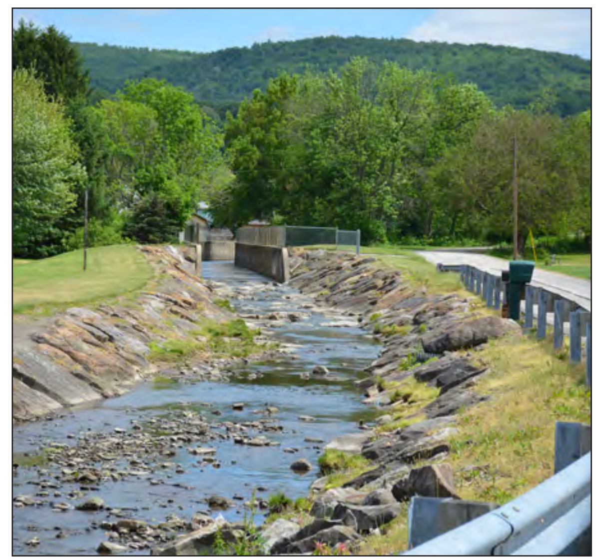


Photo by Mark Jackson

McGee Run

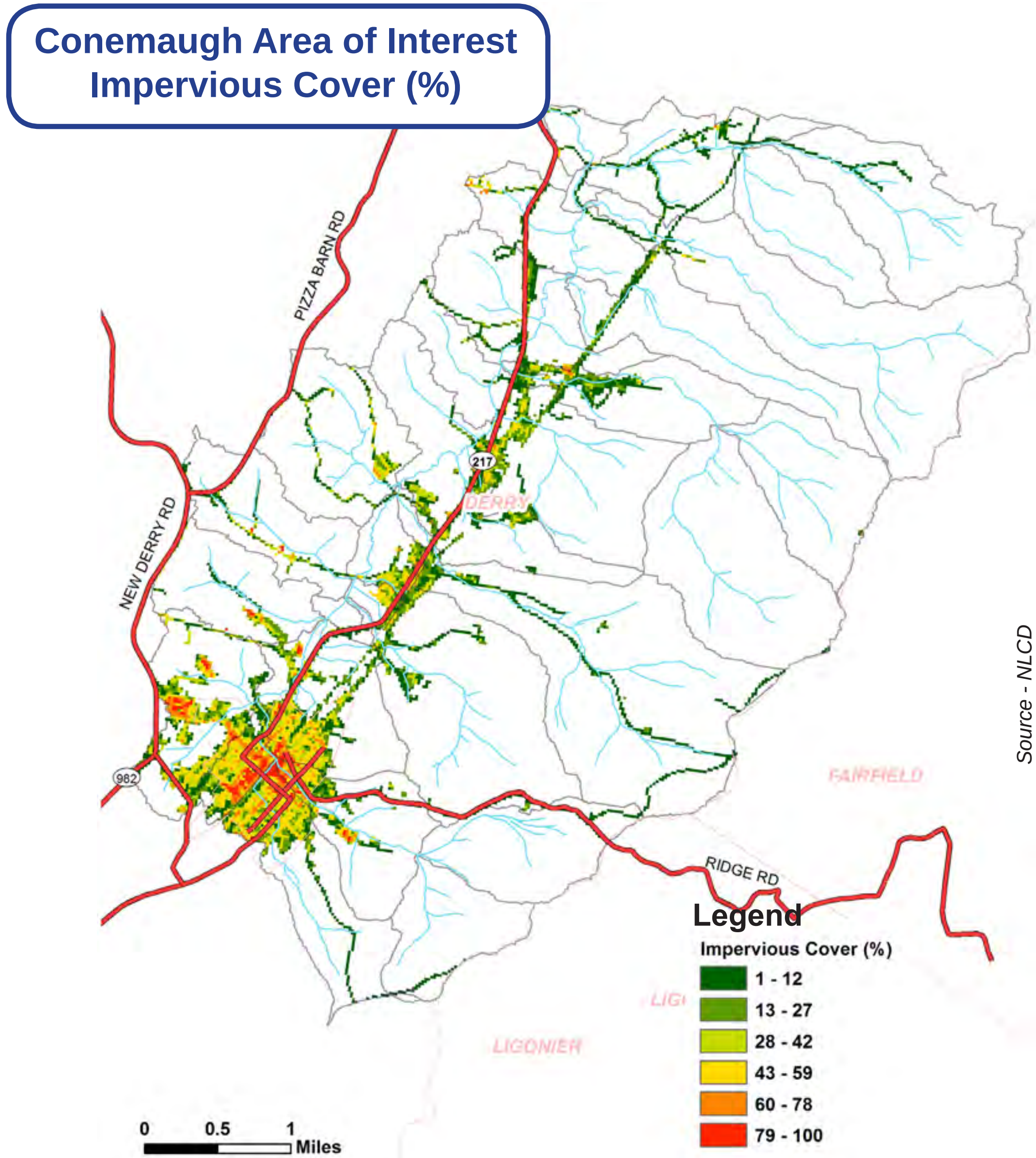
WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE CONEMAUGH WATERSHED AREA OF INTEREST

As water accumulates and moves overland on impervious surfaces, it picks up pollutants from the surface of the landscape and delivers it to receiving waters. Development, particularly that which increases impervious surfaces on the landscape, increases the overland flow of water during storms and decreases infiltration to groundwater. Increased stormwater also increases the erosive force of overland flow, increasing sediment load and delivering it to downstream receiving waters. Here, a watershed map shows the concentration of impervious surface in the area of Derry and around roads.

As stormwater runoff increases, so does the water's capacity to carry sediment and nutrients such as Nitrogen and Phosphorus. Stormwater may drop sediment and pollutants when the flow/energy of the water decreases. Both the sediment and the pollution are a threat to water. Accumulated nutrients can lead to harmful algae blooms, which may affect wildlife and water quality in the reservoir. The sediment accumulation represents the erosion, and loss, of valuable soil from upstream landscapes.

Photo - Derry Township

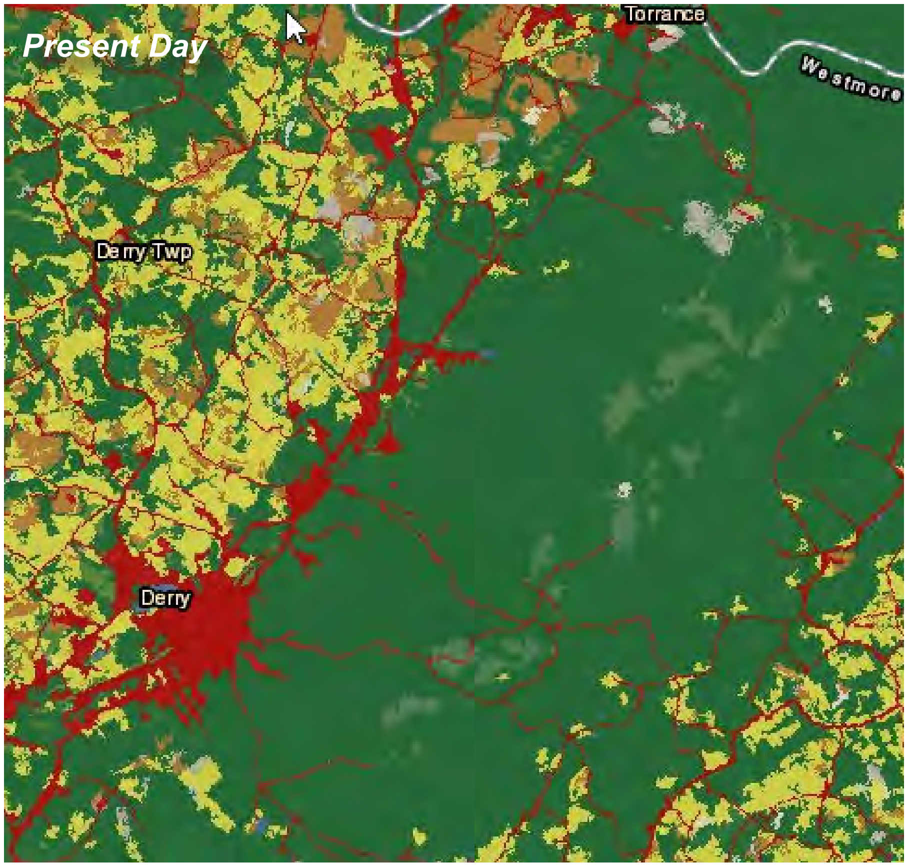
Ethel Springs Lake

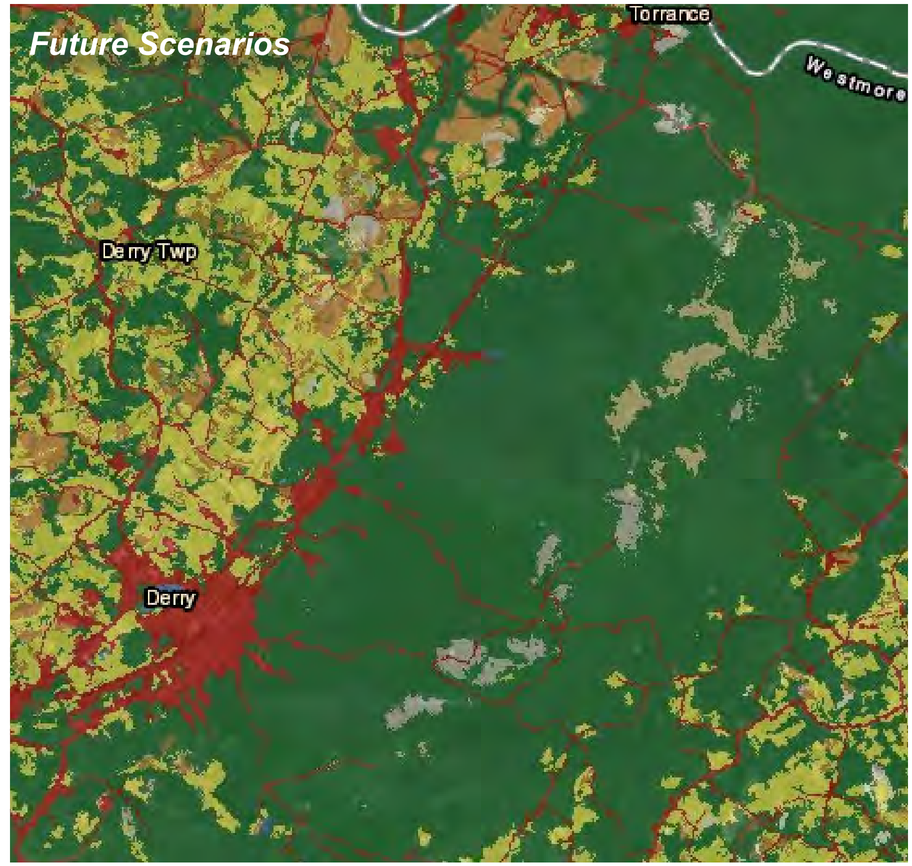


Source - NLCD

FUTURE TRENDS IN THE CONEMAUGH WATERSHED

This watershed will likely see slight increases in development and accompanying slight reductions in forested and agricultural land. These land-use trends will likely add to stormwater runoff and non-point pollution loadings. Carefully planning now to mitigate the effects of these changes will help to decrease flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source - ESRI

Legend

National Land Cover Database

- Open Water
- Perennial Ice/Snow
- Developed
- Barren Land (Rock/Sand/Clay)
- Forests
- Scrub/Shrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Herbaceous and Woody Wetlands

Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted changes in landcover types. Predictions indicate only a slight increase in impervious surfaces. This analysis of land use change in the Conemaugh Area of Interest specifically estimates

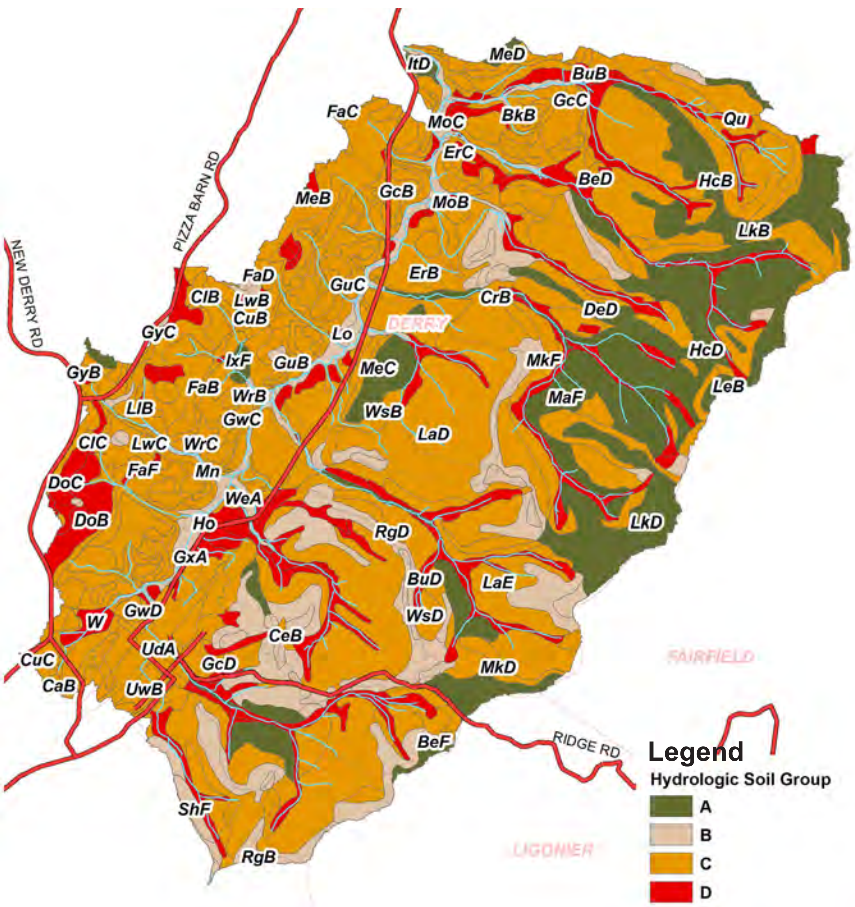
- A 3% *INCREASE* in developed land,
- A 3% *DECREASE* in forest cover
- A slight 0.6% *INCREASE* in agricultural cropland

HYDROLOGIC WATERSHED MODELING:

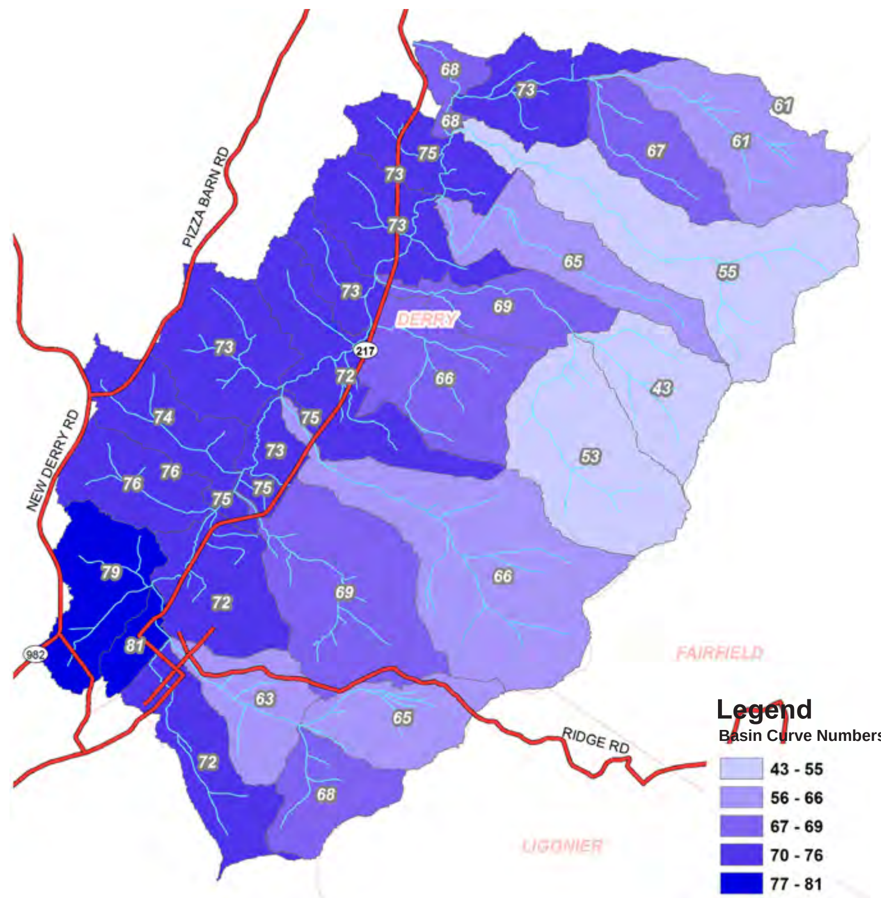
INPUT PARAMETERS, MODEL CALIBRATION & FINAL RELEASE RATES FOR THE CONEMAUGH WATERSHED AREA OF INTEREST

Controlling water now and in the future requires an understanding of current conditions and pollution sources. ***Parameters*** below and on the following pages were used in hydrological models to help us understand the contribution of different sub-watersheds to the flow of the whole, and possible future changes.

Hydrologic Soil Groups in the Conemaugh Watershed Area of Interest The map below is color-coded by the Hydrologic Soil Group, which indicates a soil's water holding capacity. Group A soils have low runoff potential and high infiltration rates, while Group D soils show the highest runoff potential with very low infiltration rates. Also shown are the specific soil names, please see appendix for a list and descriptions of individual soil types.



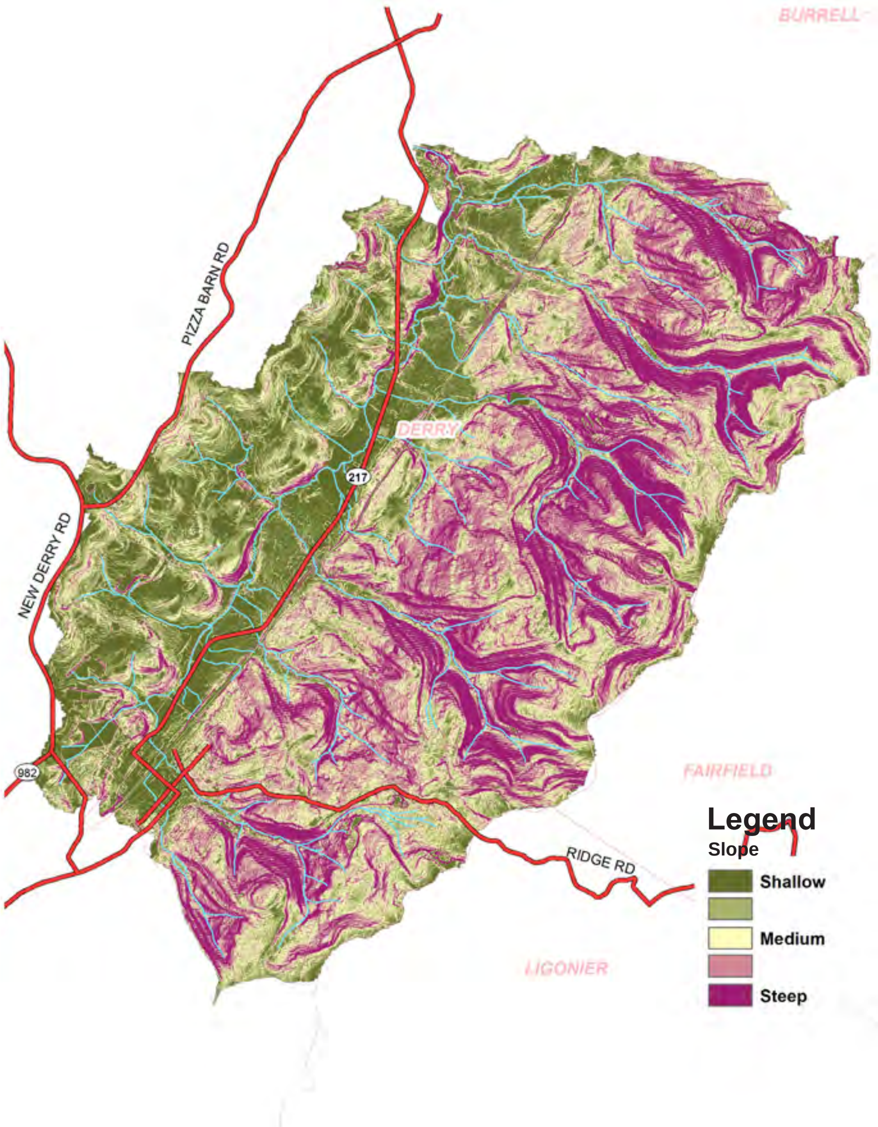
Basin Curve Numbers ("CN's") in the Conemaugh Watershed Area of Interest are an empirical parameter that help predict direct runoff/infiltration from a parcel of land during a rain event. In the Conemaugh area of interest, these range from 43-81. Watersheds with a higher curve number indicate higher runoff potential, leading to greater flooding and pollution delivery to streams.

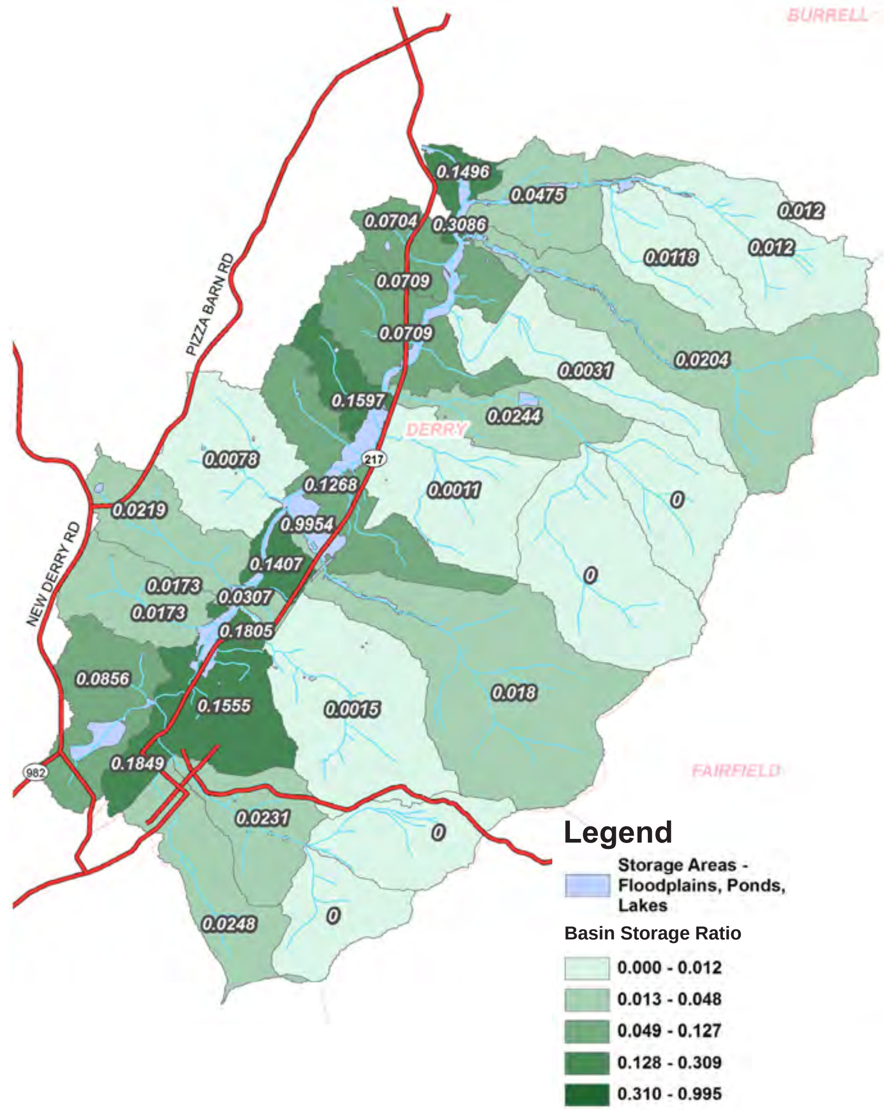


Source - Ethos Collaborative

Average Basin Slope (%) in the Conemaugh Watershed Area of Interest Slope steepness contributes to overall runoff calculations, as steeper regions generally experience greater runoff during rain events. The ridge line that runs along the Eastern boundary of the watershed has high slopes with shallower slopes in the stream valley below. Average sub-watershed slope values range from 5.31% to 26.06%.

The Basin Storage Ratio in the Conemaugh Watershed Area of Interest indicates the proportion of each sub-watershed that can absorb/store water in a storm instead of directly increasing stream discharge. Storage areas include lakes, ponds and floodplains. Storage ratios range from 0 to 0.9954, therefore the storage amount available in each sub-watershed varies from 0 to 99% of the sub-watershed area.

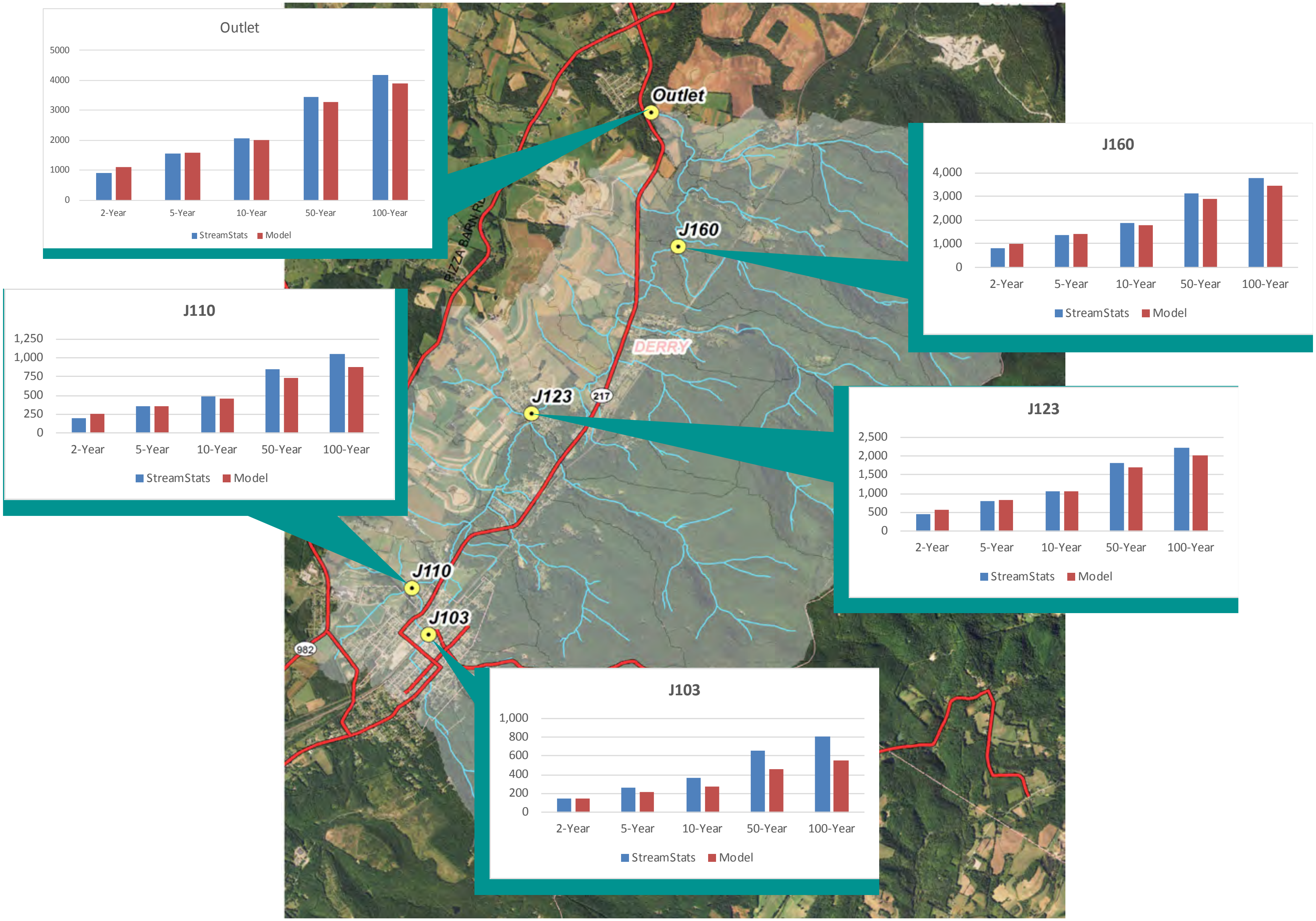




Source - Ethos Collaborative

MODEL CALIBRATION IN THE CONEMAUGH WATERSHED AREA OF INTEREST

Five sites were chosen as "areas of interest" and model results were compared to Stream Stats data for the same site. This approach allowed us to calibrate hydrological models in the absence of multiple stream gage locations in the watershed. The graphs below show how each point of interest compares for the 2, 5, 10, 50, and 100 year storms. There is a good correlation between model results and Streams Stats data. For the methodology used for calibration, validating statistics and comparisons refer to the methodology in the appendix.



Source - Ethos Collaborative

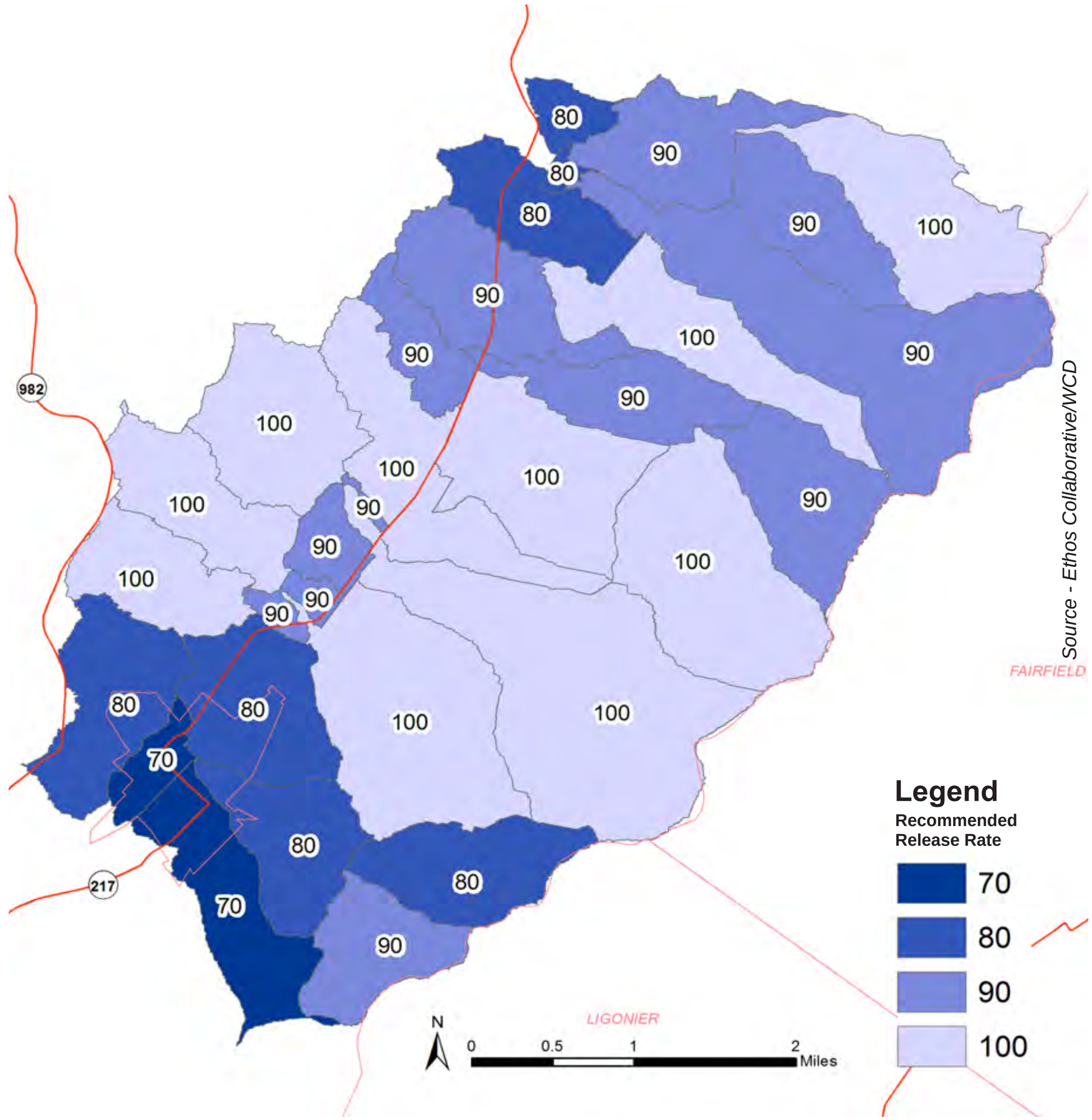
RECOMMENDED RELEASE RATE MAP FOR THE CONEMAUGH WATERSHED AREA OF INTEREST

Release rates are a tool that help determine the timing of when water can be released from a watershed. A release rate of 50% for a sub-watershed indicates that the rate at which stormwater moves out of the watershed and downstream must be reduced by half in any future development. In contrast, a release rate of 100% indicates that, with future development, stormwater can move off of the sub-watershed at the same rate that is does in the present. In other words, lower release rates require an increased control of runoff.

Release rates were calculated based on a hydrologic model of the area of interest using HEC-HMS, the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System, in conjunction with GEO-HMS (a GIS extension that allows for the manipulation of spatial data).

Final calculated release rates show a range in value from 50-100%. Darker colors and lower release rates indicate regions where future development must reduce runoff rates.

It should be noted that the methodology to calculate release rates focuses on the basin-wide contribution of upstream land on downstream flooding. In order to control more localized flooding, individual municipalities may enact stricter stormwater runoff controls.



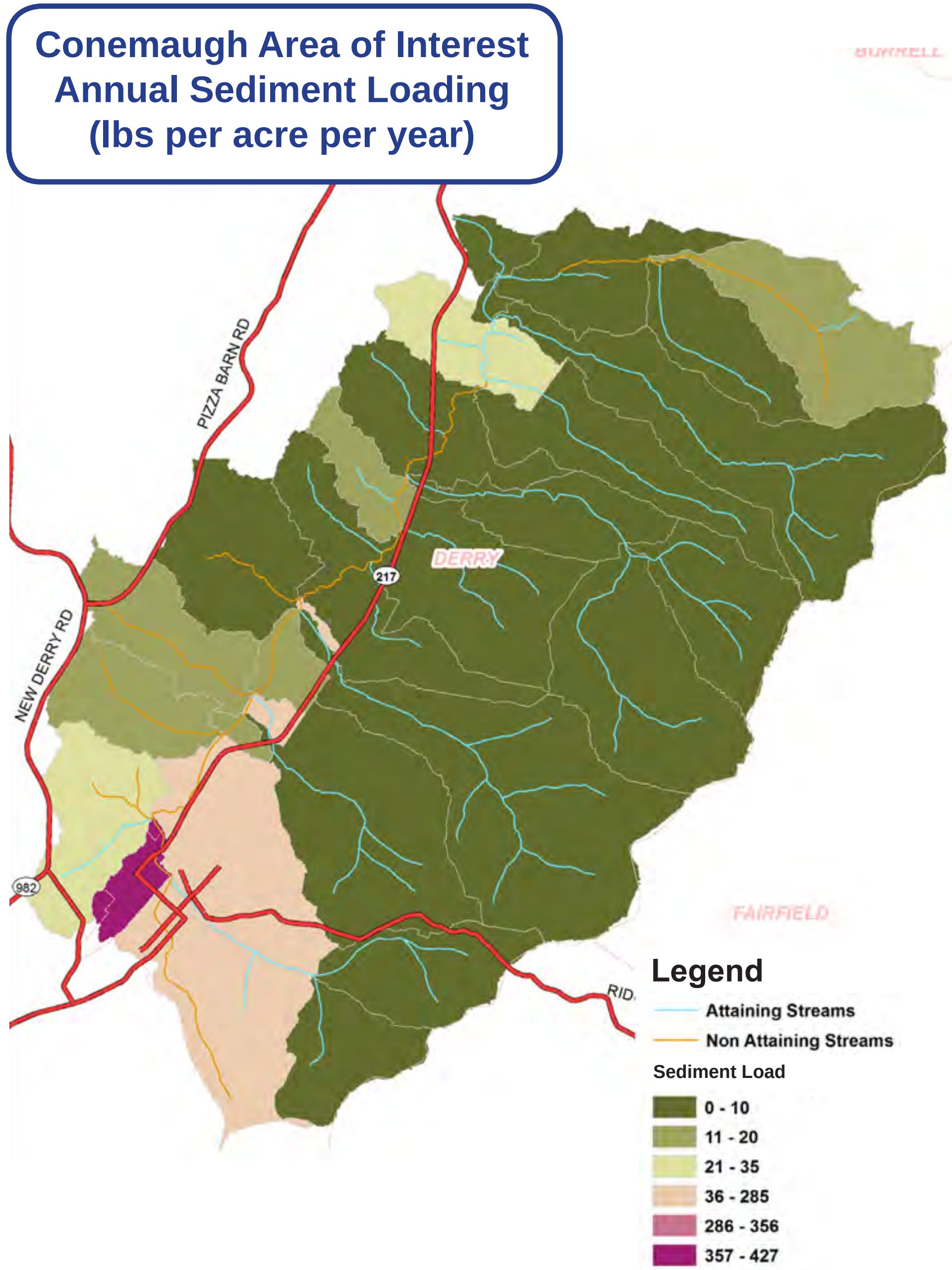
LANDSCAPE POLLUTION ACCUMULATION MODELING

To understand where and how pollution-bearing runoff moves across the landscape, we modeled accumulation using ArcGIS in conjunction with a specialized terrain analysis toolset, (TAUDEM). This analysis allowed us to understand both pollution contributions and pollution reductions due to the underlying landscape. Please see the Methodology Appendix for further details about this process.

TOTAL SUSPENDED SOLIDS (TSS)

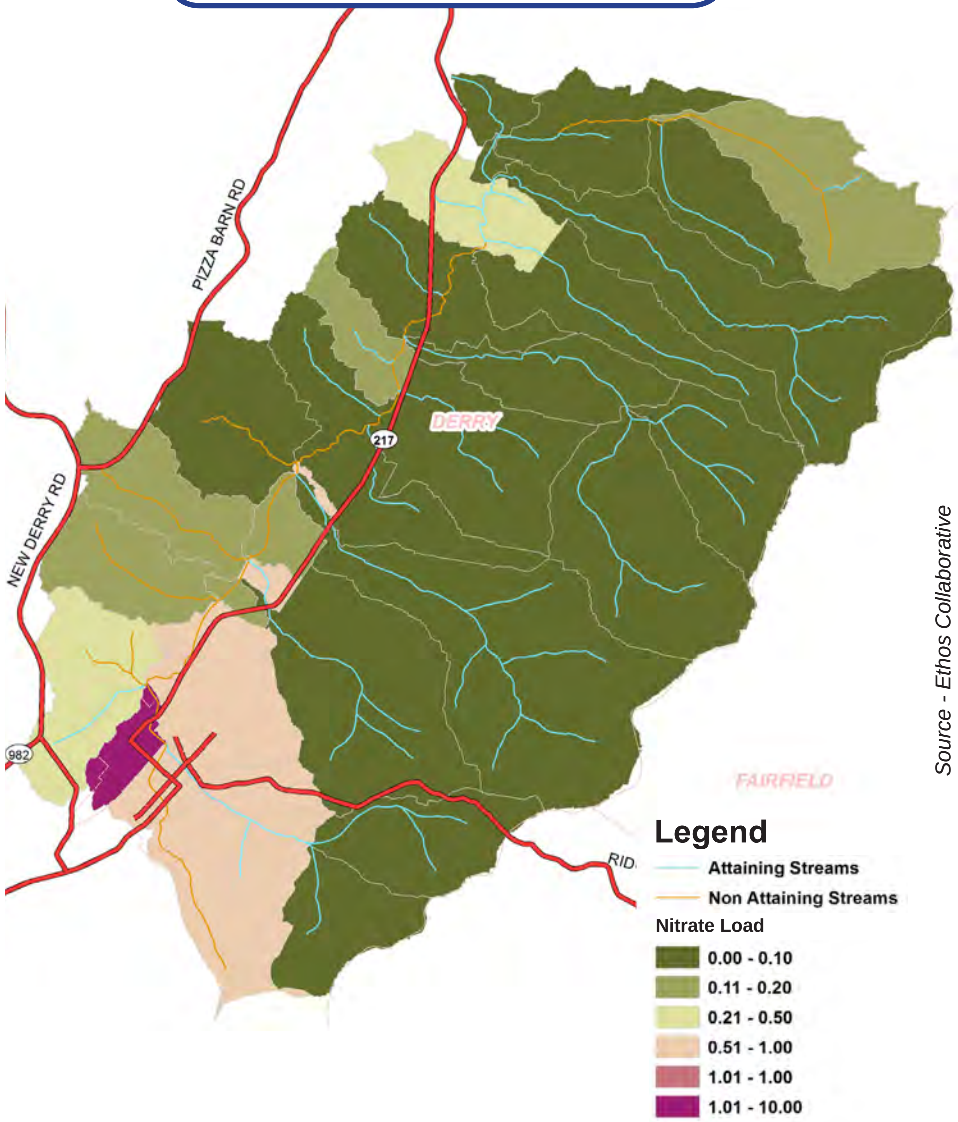
Sediment, or Suspended Solids, encompasses any number of particulate pollutants or natural particles, from a myriad number of sources. Shown to the right is the estimated sub-watershed export of sediment, in pounds per year.

- Impervious surfaces in the town of Derry collect solids during dry weather and then during wet weather contribute to high TSS loads draining from these watersheds. These sub-watersheds have little in the way of riparian buffers or other landscape features that help to slow, infiltrate, and absorb water, preventing it and associated pollutant loads from moving into the stream, and subsequently downstream.
- Significant contributions of TSS are also found in sub-watersheds where agricultural activities such as grazing and plowing take place. These regions in particular would benefit from increased riparian buffers as a way to detain water and associated pollutants - and encourage infiltration - before runoff reaches the stream.



Source - Ethos Collaborative/WCD

Conemaugh Area of Interest Annual Nitrate Loading (lbs per acre per year)



NITRATE ($TNO3^-$)

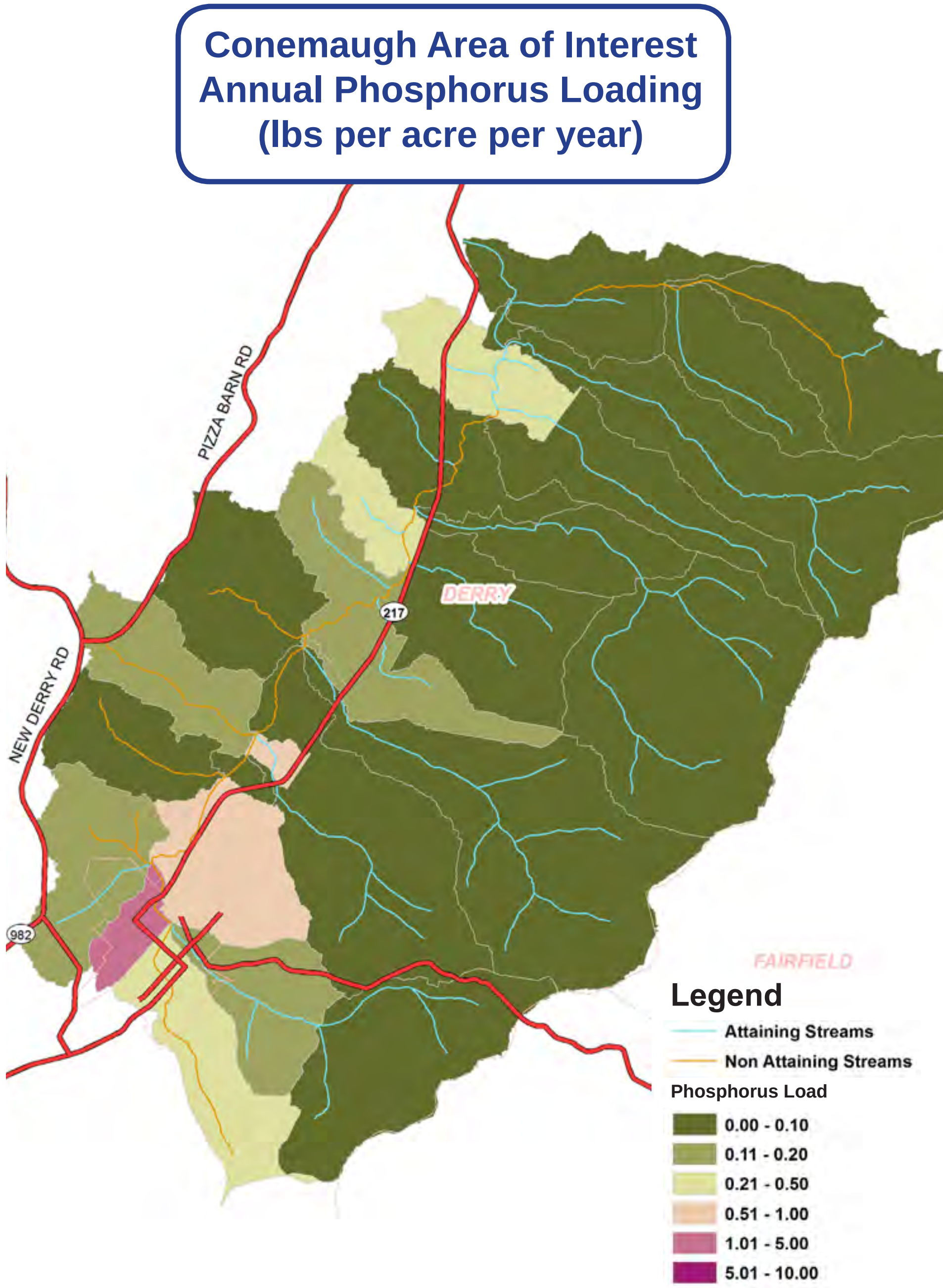
Nitrogen, here expressed as nitrate (NO_3^-), is a nutrient essential for plant and animal growth. Historically, biologically available nitrogen was a limiting factor in ecosystems, however industrial activities have increased biologically available nitrogen to the point where it is now considered a pollutant in many regions. Shown on the map to the left is the modeled sub-watershed export of nitrate, in pounds per year.

- Agricultural activities and residential areas both contribute fertilizer-sourced nitrogen to the watershed. Fertilizer applied to croplands and residential lawns can be washed from the land surface into streams.
- Nitrogen can be found in urine excreted from grazing animals. Urine-sourced nitrogen is biologically transformed to nitrate, which can then be transported downstream.
- Fixed nitrogen is emitted to the atmosphere when fossil fuels are burned. This nitrogen is deposited as nitrogen oxides or NOx, on the landscape, with concentrations found in near-road areas.
- Wastewater contains biologically available nitrogen. Wastewater treatment plants may not remove all of the nitrogen before treated water is discharged to streams. On-lot septic systems may contribute biologically available nitrogen to groundwater.

TOTAL PHOSPHORUS (TP)

Phosphorus, here expressed as Total Phosphorus (TP) is a nutrient essential for life Phosphorus, like Nitrogen, used to be a limiting nutrient for ecosystems. Industrial activities and fertilizer both contribute excess phosphorus to ecosystems. This phosphorus contributes to algae blooms in water bodies, eutrophication, and overall habitat deterioration. Shown on the map to the right is the modeled sub-watershed export of TP in pounds per year.

- Higher amounts of phosphorus are exported from the urban sub-watersheds in the Conemaugh AOI. Phosphorus is sourced primarily from lawn fertilizer and roadway deposition. These sources produce both particulate and dissolved forms of phosphorus.
- Soil erosion is another contributor of phosphorus to streamwater. Erosion depletes the soil of valuable nutrients like phosphorus and transports the nutrient downstream,.
- Crops lands export Phosphorus to downstream environs, sourced from fertilizer applied to the fields. Fertilizer-sourced Phosphorus is likely in particulate forms, and therefore structural BMP's that filter and/or detain sediment and particles can help to mitigate downstream export.
- Wastewater contains phosphorus from human waste and detergents. Wastewater treatment plants may not remove all of the phosphorus before treated water is discharged to streams.



Source - Ethos Collaborative

OPPORTUNITIES FOR EFFECTIVE STORMWATER MANAGEMENTS

Based on modeling watershed hydrology and pollution sources to inform smart water management

Effective water management protects valuable resources and built infrastructure.

Water and the soil used in agricultural lands in this watershed are both valuable resources that must be conserved for future generations. Conservation efforts should consider ways to manage water runoff that decrease soil erosion, pollution transport, and sedimentation in the reservoir.

To increase water quality, we must decrease overland water quantity.

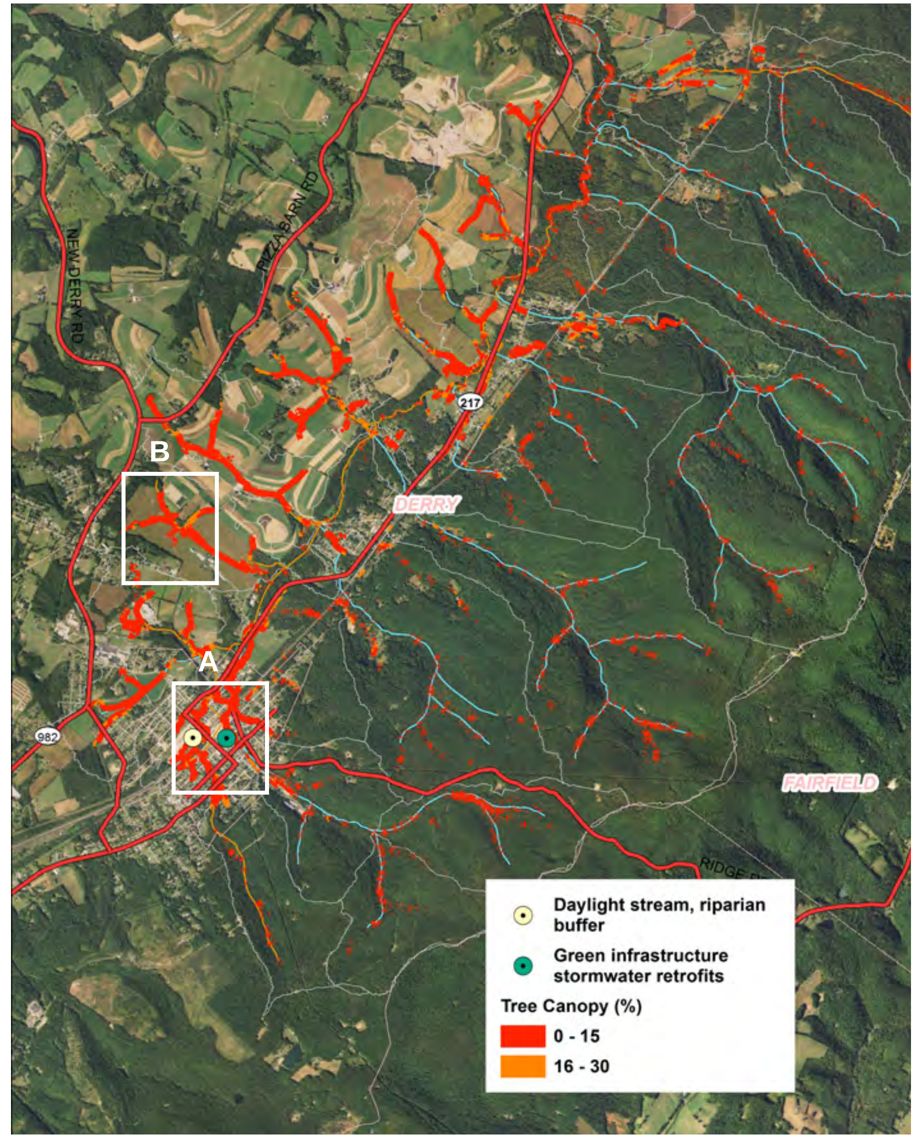
Water detained by increasing infiltration to groundwater encourages nutrient retention, or the uptake and filtration of pollutants by biota and soil. Together, the processes of detention and retention increase water quality through decreasing erosion and downstream transport.

Conceptual Ideas for BMP's/Landscape Restoration: Highlighting the potential for water and pollutant capture and retention.

Specific identified issues in this area of interest include a lack of sufficient riparian buffer along the stream in agricultural sub-watersheds and through the town of Derry. The lack of riparian buffer along the stream adds to stormwater runoff and associated erosion. Landscape-based nutrient accumulation and decay modeling and other spatial analysis can help to identify and prioritize project sites appropriate for Green Infrastructure such as stormwater retrofits, riparian buffer restoration, and stream restoration.

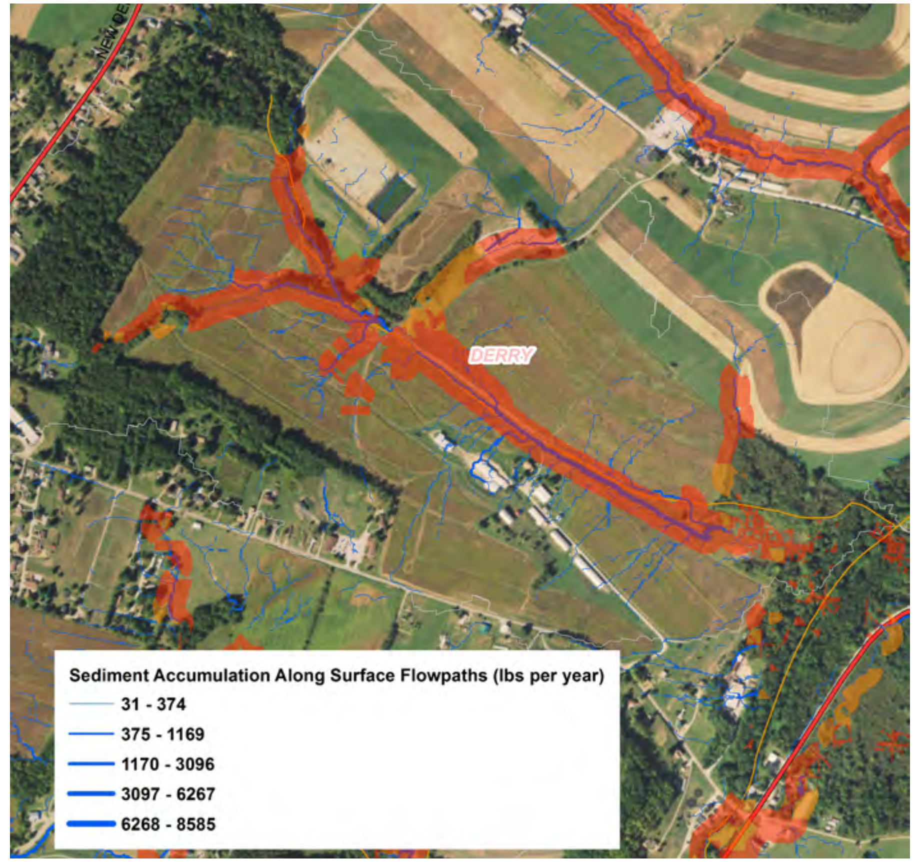
Opportunities for Effective Stormwater management

On this map, stream-side regions with little or no riparian buffers are highlighted. Focusing on restoring tree canopy in these areas would help to mitigate stream nutrient and sediment loading. Additionally, two regions in the town of Derry with known stormwater or water quality issues are identified.



See enlarged images.

A: Enlargement of urban area in Derry Borough, Conemaugh Area of Interest, showing opportunities



B: Enlargement of rural area in Derry Township, Conemaugh Area of Interest, showing opportunities

Opportunity: Retrofits and restoration in Derry

Above, a close up map shows the *approximate* region of identified problem areas, as well as the *approximate* stream location. The stream through Derry is largely routed through underground storm sewer networks. Also shown are the surface flow paths that indicate increasing sediment accumulation across the land surfaces.

Stormwater Management Potential:

Restoring the stream banks and retrofitting infrastructure in this area to include Green Infrastructure would help to decrease flooding and pollution inputs delivered to the stream in storm runoff.

Landscape Elements to Consider:

The map above shows a close-up view of a watershed in the Northeast of the Conemaugh Watershed. As indicated by the red and orange buffers on either side of the stream, there is little tree canopy in the riparian buffer.

Water Quality Impacts of Stormwater Management:

Augmenting the riparian buffer in these areas would help improve water quality. Increased tree canopy would slow overland flow from agricultural land, encouraging water and particle infiltration/settling and increasing biological processing interactions. This would help to decrease stream loads of TSS, TP and TNO3- that are contributed from the landscape.

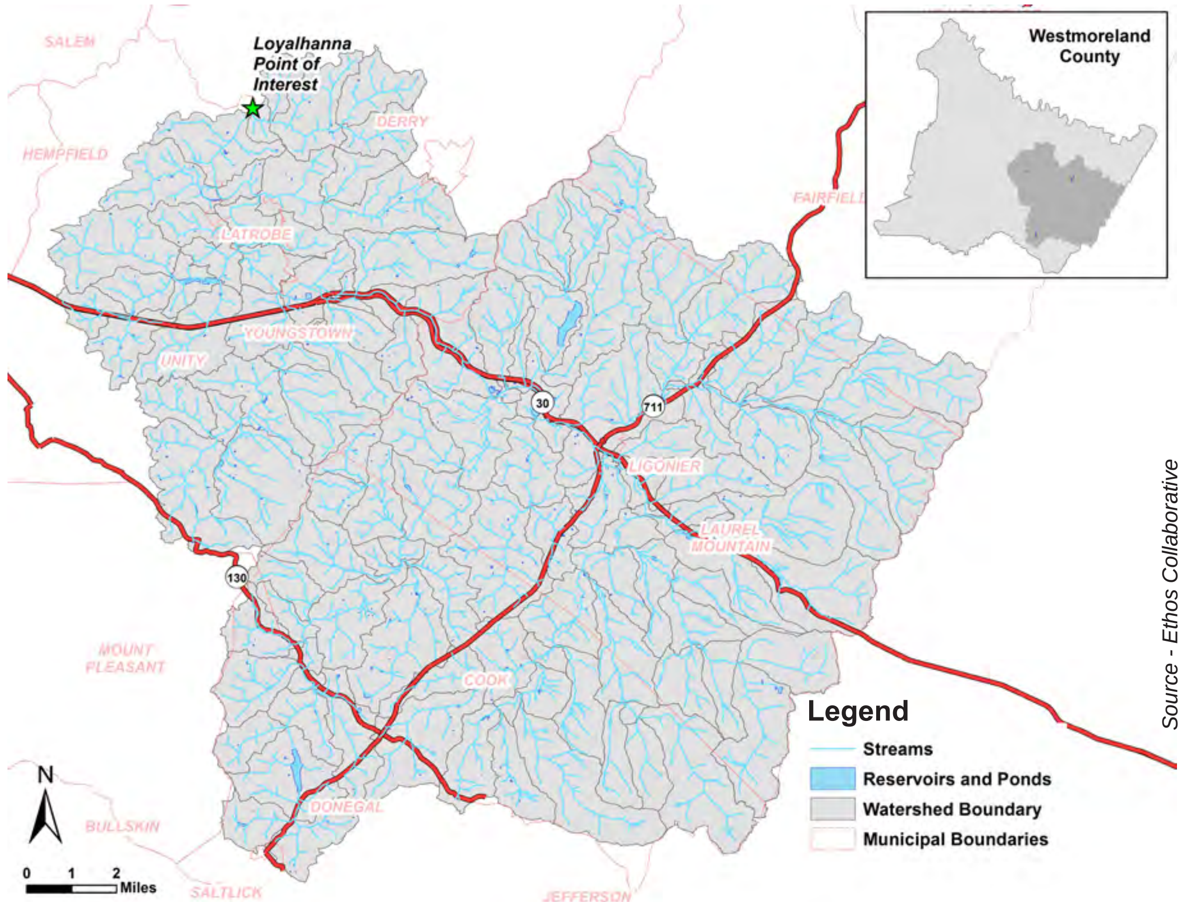
LOYALHANNA CREEK WATERSHED AREA OF INTEREST

REGION OVERVIEW

The Loyalhanna Creek Area of Interest is approximately 230 mi2/147,200 acres and contains ~750 miles of streams. The headwaters of the Loyalhanna Creek start on the Laurel Ridge. From here, the stream drops down and flows through a steeply sloping ravine that bisects Chestnut Ridge. The Loyalhanna Creek drains north into the Kiski river just outside of Saltsburg, PA. This is the largest Area of Interest examined as part of the IWRP process. In this area, one hundred and thirty four sub-watersheds were delineated ranging from a few acres to 6 square miles in size. Most sub-watersheds were in the range of 1-2 square miles.

Why is this watershed of particular interest?
This watershed was identified in Phase I as an area of interest because of re-occurring flood problems, inadequate infrastructure, and the potential for growth. The largely rural landscape leaves room for future expansion of residential or industrial areas. There is tremendous opportunity to carefully manage future development and stormwater planning in this area, to conserve and preserve the current water quality.

Assets in the Watershed
The lovely landscape and outdoor amenities draw visitors and residents alike. The streams in this area are largely considered "attaining" for recreational, potable water supply, and aquatic life uses. Trout fishing in the Loyalhanna creek is a popular pastime. There is an active Loyalhanna Watershed Association dedicated to increasing water quality, conserving and preserving land, and offering educational programs and nature-based experiences to school groups and families. www.loyalhannawatershed.org



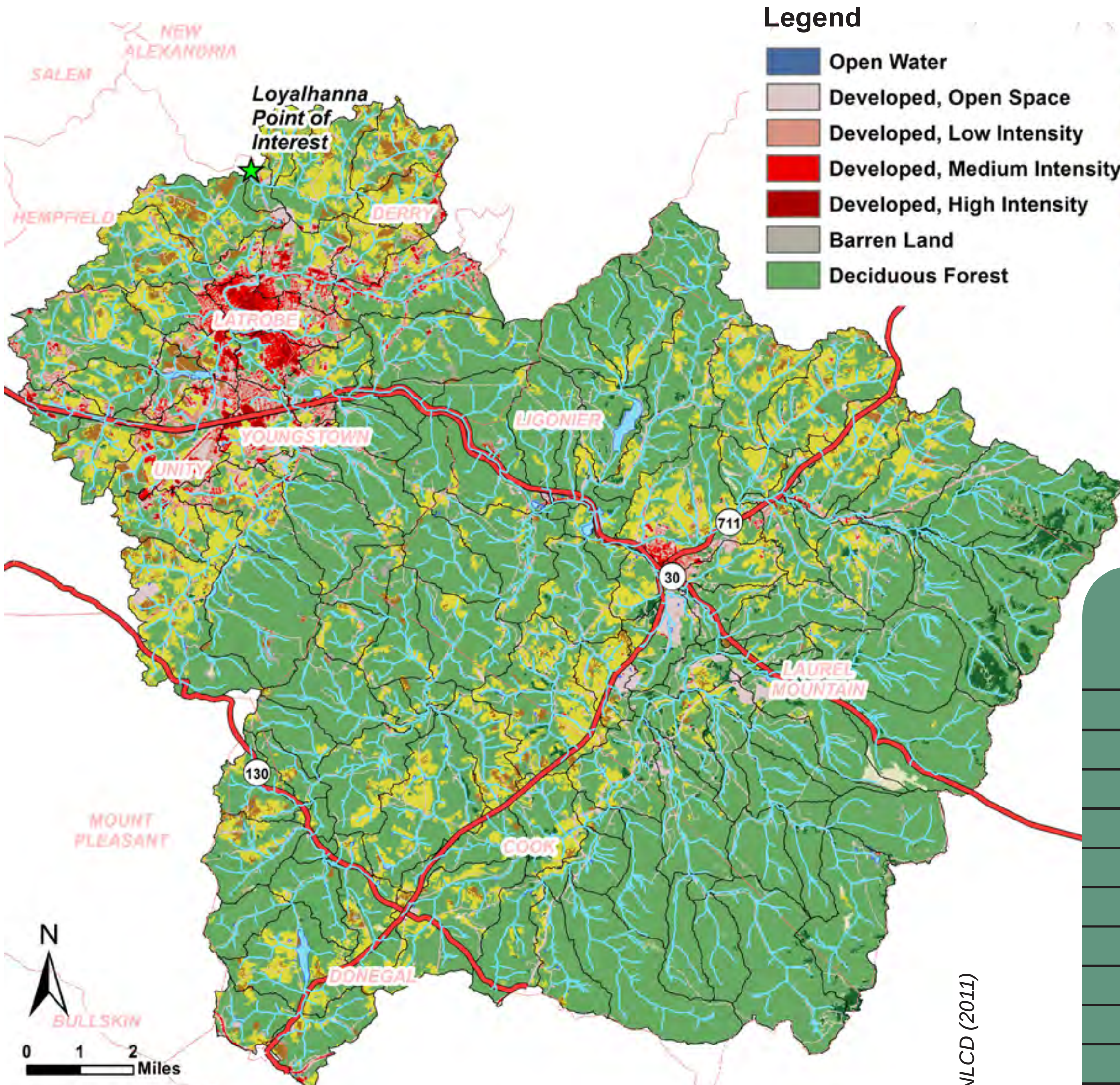
Source - Ethos Collaborative

WATERSHED SNAPSHOT

- ***Area:** 230 square miles*
- ***Water Quality:** Some areas are impaired for aquatic life.*
- ***Characterization:** This area of interest is largely forested, with pockets of developed land.*
- ***Highways provide relatively quick transportation from this rural region to the cities of Pittsburgh and Greensburg. These qualities make the region an ideal location for future development.***

Landcover / Landuse

Landcover in this watershed is dominated by deciduous forest and hay/pasture, with a concentration of urbanized land and associated impervious surface around the town of Latrobe, and along State Route 30 / the historic Lincoln Highway. Landcover data is based on the 2011 National Land Cover Dataset, created by the Multi-resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.



Loyalhanna Creek Area of Interest Landcover Classification

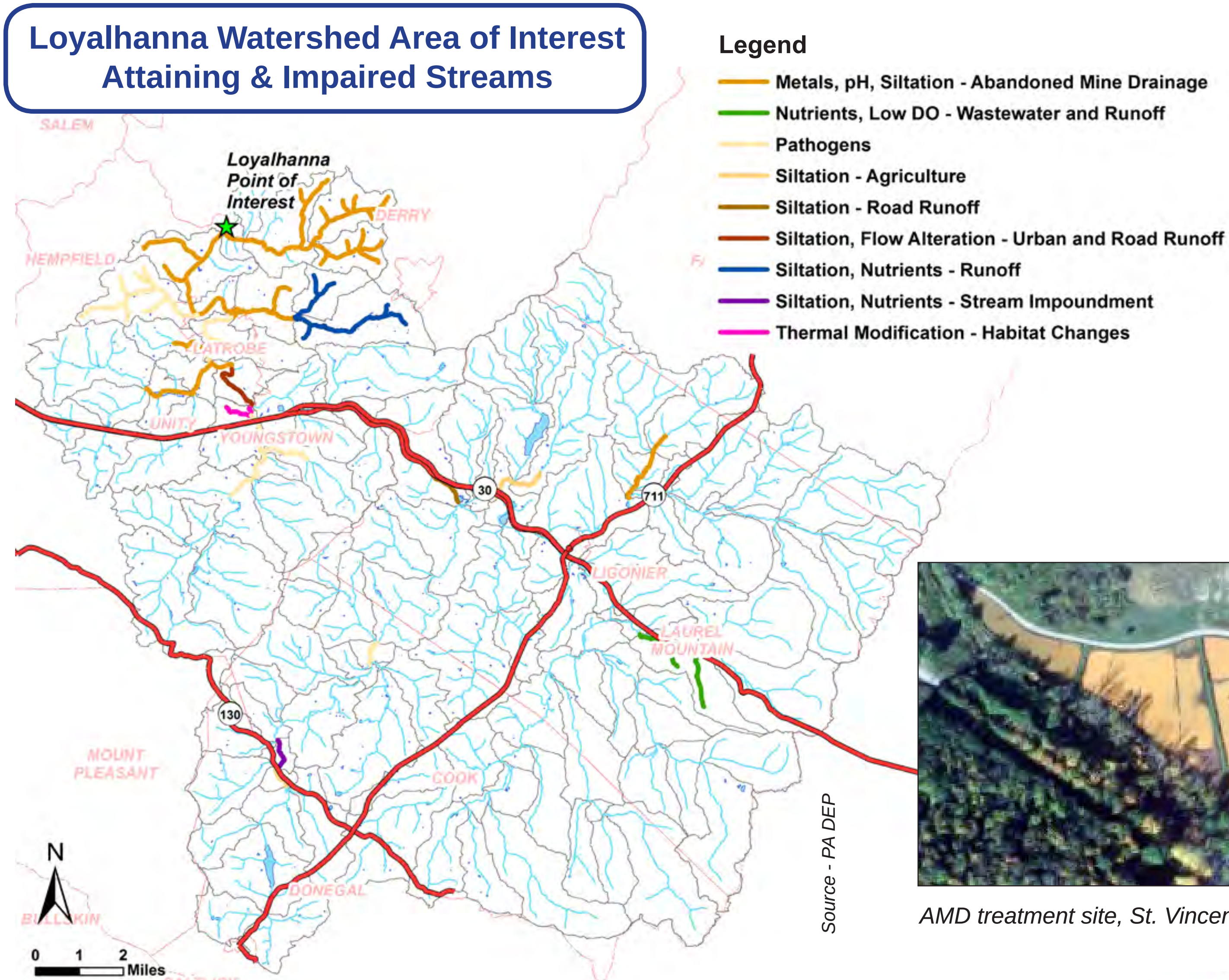
Source - NLCD (2011)

Landcover Class	*Acres*	*Total Area (%)*
Open Water	355	0.24
Developed- Open Space	11044	7.5
Developed- Low Intensity	4673	3
Developed- Medium Intensity	2241	1.5
Developed- High Intensity	704	0.5
Barren Land	472	0.3
Deciduous Forest	100451	68
Evergreen Forest	2591	1.8
Mixed Forest	676	0.5
Herbaceous	371	0.3
Hay/Pasture	20932	14
Cultivated Crops	2904	2
Woody wetlands	1.3	0.0009

CURRENT WATER QUALITY IN THE LOYALHANNA CREEK WATERSHED AREA OF INTEREST

Non-point source pollution

In the Loyalhanna Watershed AOI, the Pennsylvania Department of Environmental Protection identified 675 stream miles as “attaining” their designated uses of providing a potable water supply, supporting aquatic life, and recreation. Only 60.5 miles are considered “non-attaining” for those specific designated uses, and the remaining are unclassified. Identified impairments include siltation from abandoned mine drainage, nutrients from agricultural land, as well as runoff and nutrients from residential/urban areas within the watershed. These are considered non-point sources, originating not from one identifiable point but instead from diffuse sources across the landscape.



Source - PA DEP

TMDL status of the streams in this area of interest

Despite the “attaining” status of so many stream miles in the Area of Interest, 531 miles are under one of 4 TMDL (Total Maximum Daily Load) agreements. Each of these agreements seeks to reduce the affect of Abandoned Mine Drainage, including metals, pH, and siltation, on the water. The other impairment sources are not addressed by TMDL agreements.

Image from Google Maps

AMD treatment site, St. Vincent’s Archabbey, Latrobe, PA

WATER QUALITY AND QUANTITY ARE INEXTRICABLY LINKED IN THE LOYALHANNA WATERSHED AREA OF INTEREST

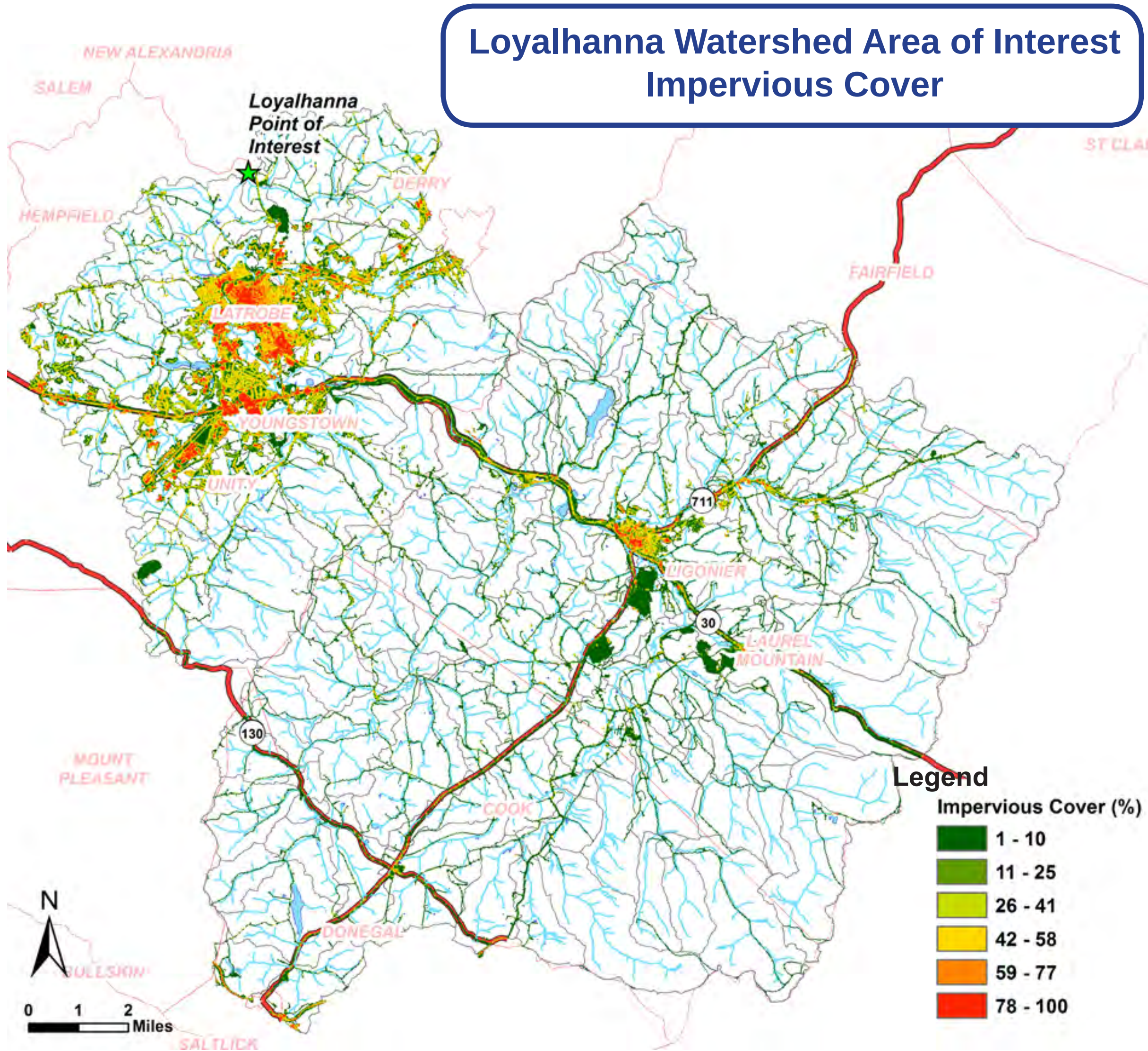
As water accumulates and moves overland on impervious surfaces, it picks up pollutants from the surface of the landscape and delivers it to receiving waters. Development, particularly that which increases impervious surfaces on the landscape, increases the overland flow of water during storms and decreases infiltration to groundwater. Increased stormwater also increases the erosive force of overland flow, increasing sediment load and delivering it to downstream receiving waters. Below, a watershed map shows the concentration of impervious surface in the towns of Latrobe, Youngstown, and Ligonier.

As stormwater runoff increases, so does the water's capacity to carry sediment and nutrients such as Nitrogen and Phosphorus. Stormwater may drop sediment and pollutants when the flow/energy of the water decreases.

Both the sediment and the pollution are a threat to water. Accumulated nutrients can lead to harmful algae blooms, which may affect wildlife and water quality, particularly for species of interest such as trout or salamanders. The sediment accumulation represents the erosion, and loss, of valuable soil from upstream farming landscapes.

Photo by Stephen Simpson

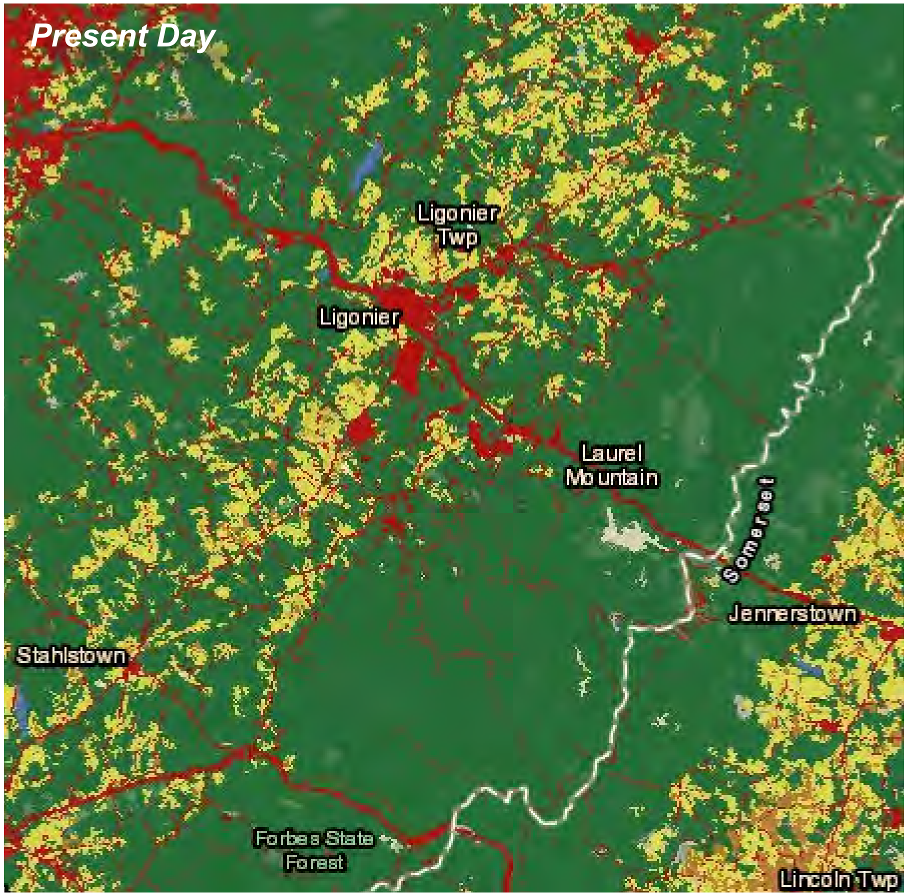
Loyalhanna Creek, summer

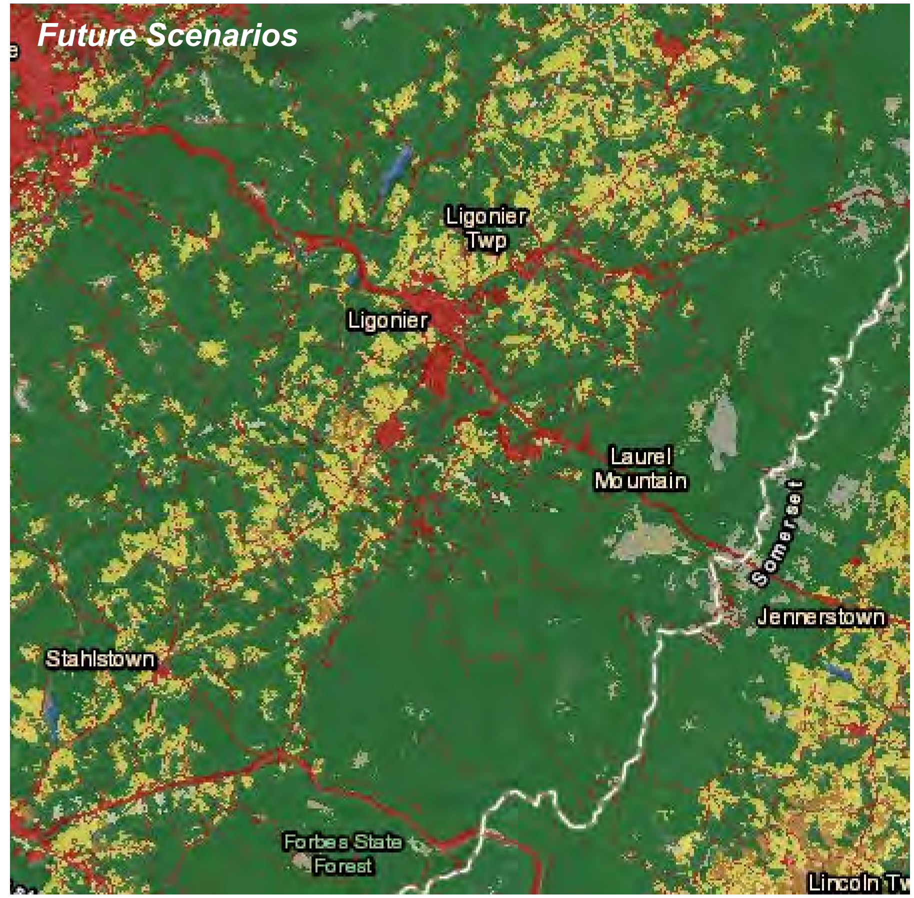


Source - NLCD

FUTURE TRENDS IN THE LOYALHANNA WATERSHED AREA OF INTEREST

There is tremendous opportunity to manage future growth in this watershed carefully. Future land-use predictions indicate there may be very limited increases in development and accompanying stormwater flow in the Loyalhanna Area of interest. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source - ESRI

Legend

National Land Cover Database

- Open Water
- Perennial Ice/Snow
- Developed
- Barren Land (Rock/Sand/Clay)
- Forests
- Scrub/Shrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Herbaceous and Woody Wetlands

Specific predictions of change in land-use

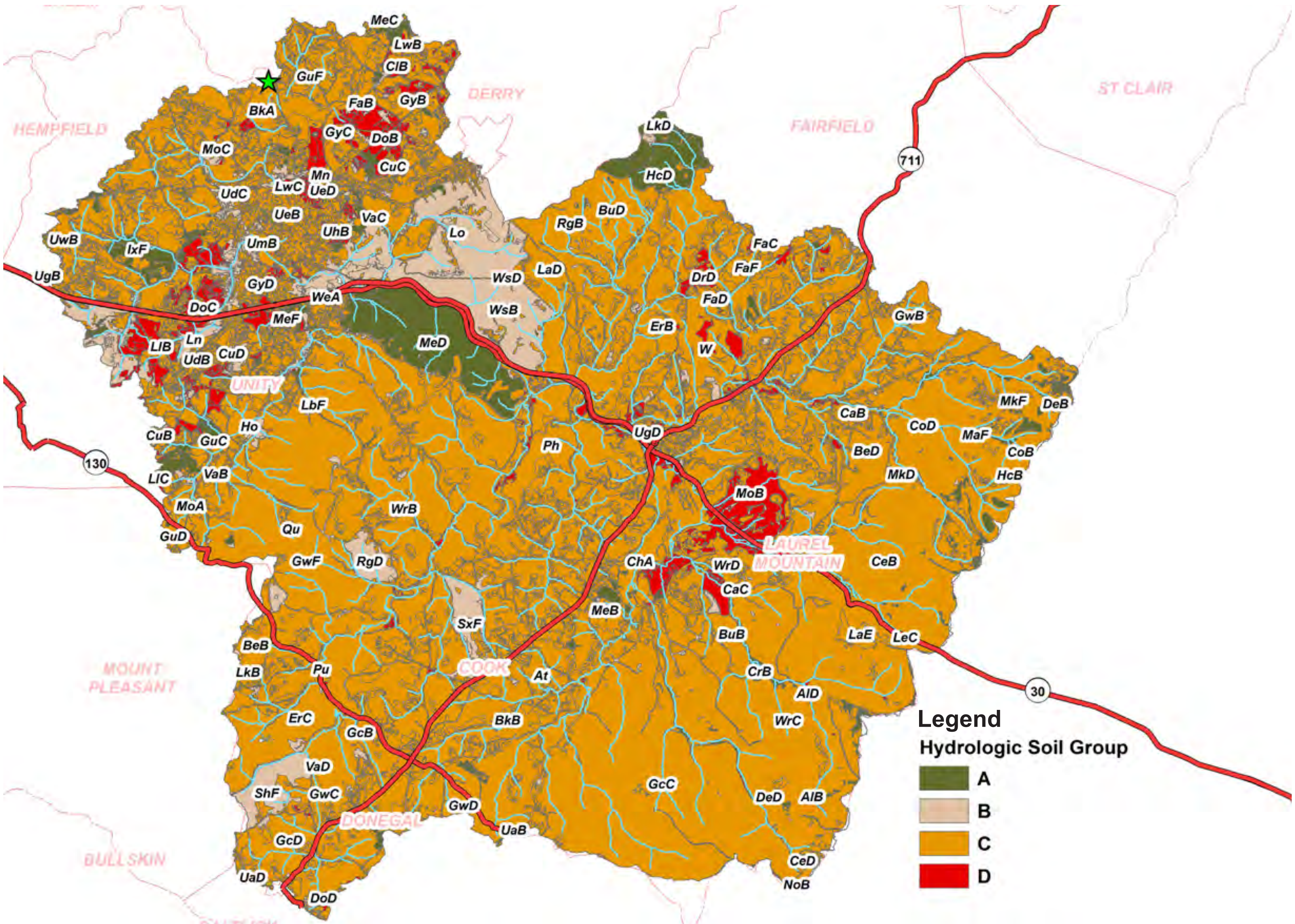
Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights that little development is predicted for this watershed. This analysis of land use change in the Loyalhanna Area of Interest specifically estimates

- A 3% *INCREASE* in developed land,
- A 3% *DECREASE* in forest cover
- A 0.8% *DECREASE* in agricultural cropland.

HYDROLOGIC WATERSHED MODELING

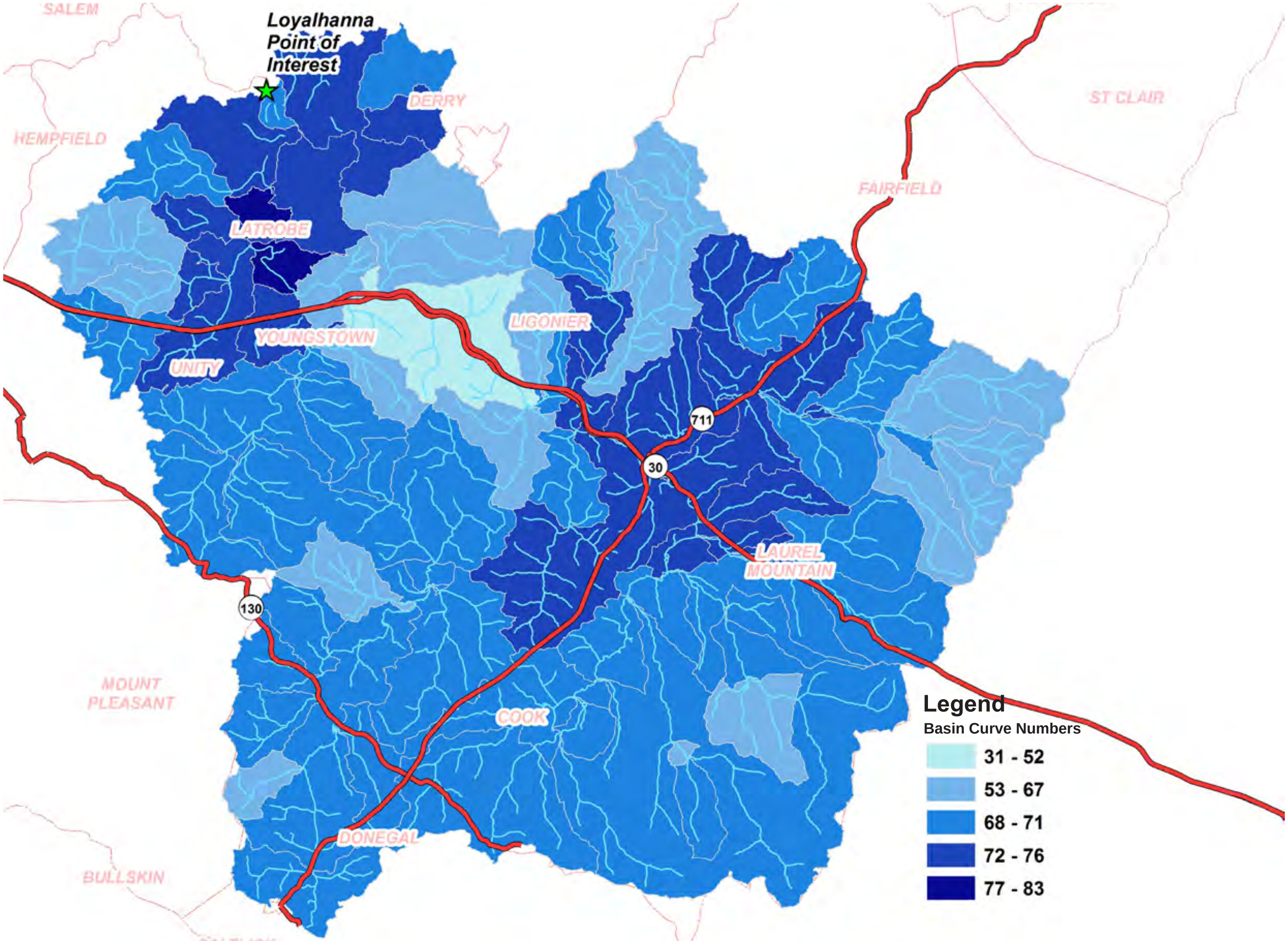
Controlling water now and in the future requires an understanding of current watershed conditions and pollution sources. The hydrologic watershed modeling has yet to be completed on this entire watershed. The ***Parameters*** below and on the following pages were will be used to help us understand the contribution of different sub-watersheds to the flow of the whole.

Hydrologic Soil Groups in the Loyalhanna Watershed Area of Interest. The map below is color-coded by the Hydrologic Soil Group, which indicates a soil's water holding capacity. Group A soils have low runoff potential and high infiltration rates, while Group D soils show the highest runoff potential with very low infiltration rates. Also shown are the specific soil names, please see appendix for a list and descriptions of individual soil types.



Source - PASDA

Basin Curve Numbers ("CN's") in the Loyalhanna Watershed Area of Interest are an empirical parameter that helps to predict direct runoff/ infiltration from a parcel of land during a rain event. In the Loyalhanna area of interest, CN's averaged across the watershed show a range from ~31-83. The low CN's are indicative of watersheds where there is little runoff during a rain event, for example a forested region with soils that exhibit high infiltration rates.



Source - Ethos Collaborative

Average Basin Slope (%) in the Loyalhanna Watershed Area of Interest Generally most regions in this watershed have shallow to moderate slopes. Steeper slopes are found as the stream valleys move from the Laurel and Chestnut Ridges, and plunge to the valleys below. Slope steepness contributes to overall runoff calculations, as steeper regions generally experience greater runoff during rain events.

Source - Ethos Collaborative

LANDSCAPE POLLUTION AND ACCUMULATION MODELING

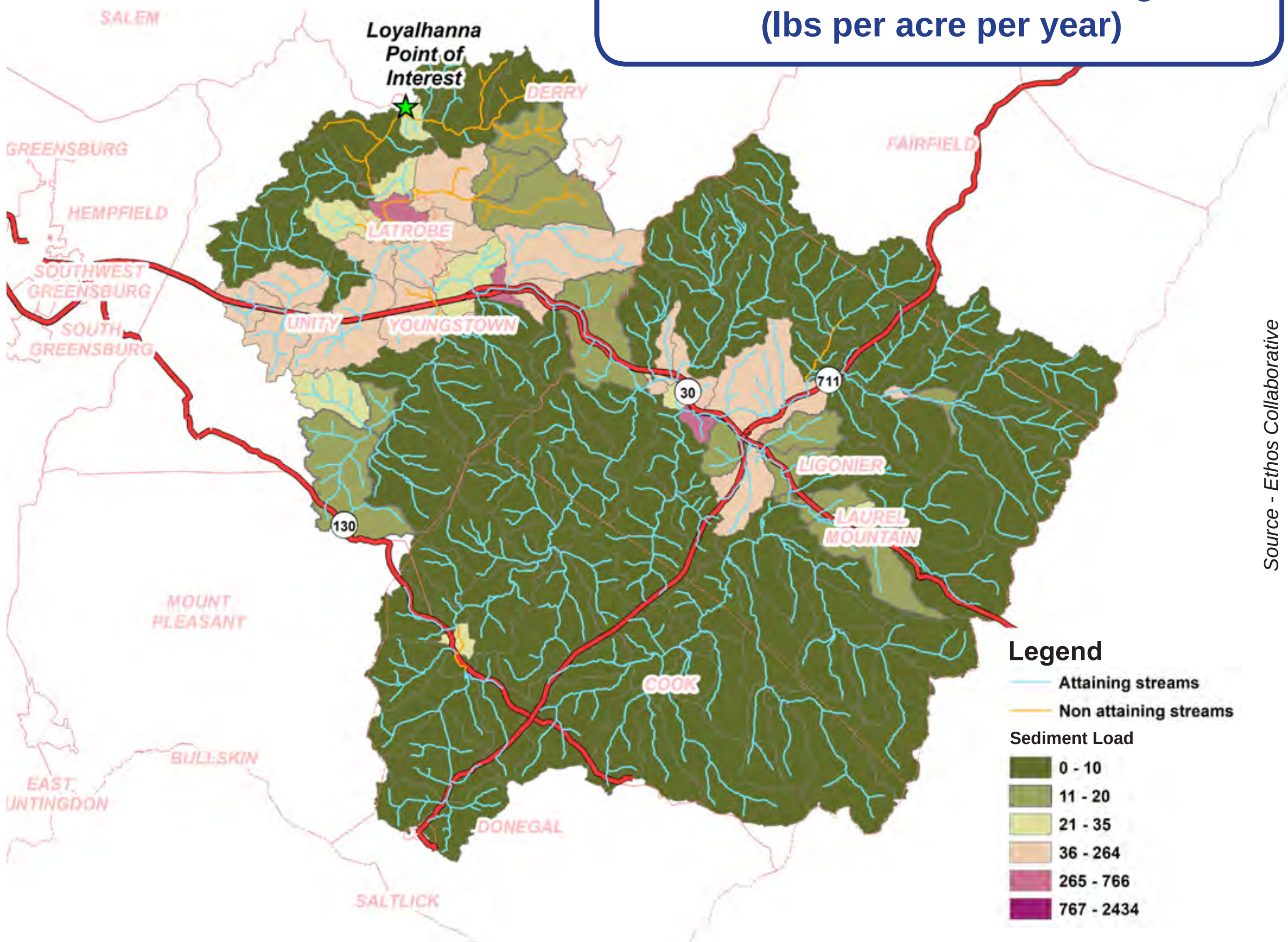
To understand where and how pollution-bearing runoff moves across the landscape, we modeled accumulation using ArcGIS in conjunction with a specialized terrain analysis toolset, (TAUDEM). This analysis allowed us to understand both pollution contributions and pollution reductions due to the underlying landscape. Please see the Methodology Appendix for further details about this process.

TOTAL SUSPENDED SOLIDS (TSS)

Sediment, or Suspended Solids, encompasses any number of particulate pollutants or natural particles, from a myriad number of sources. Shown is the estimated sub-watershed export of sediment, in pounds per year.

- The high percent of impervious surfaces associated with the highways and urban centers of Latrobe, Ligonier, and Youngstown, and Unity collect solids during dry weather and then during wet weather contribute to high TSS loads. Urbanized areas have little in the way of riparian buffers or other landscape features that help to slow, infiltrate, and absorb water, preventing it and associated pollutant loads from moving into the stream, and subsequently downstream.
- Significant contributions of TSS are also found in sub-watersheds where agricultural activities such as grazing and plowing take place. These regions in particular would benefit from the increase in riparian buffers as a way to capture water and associated pollutants before it reaches the stream.

Loyalhanna Watershed Area of Interest
Annual Sediment Loading
(lbs per acre per year)



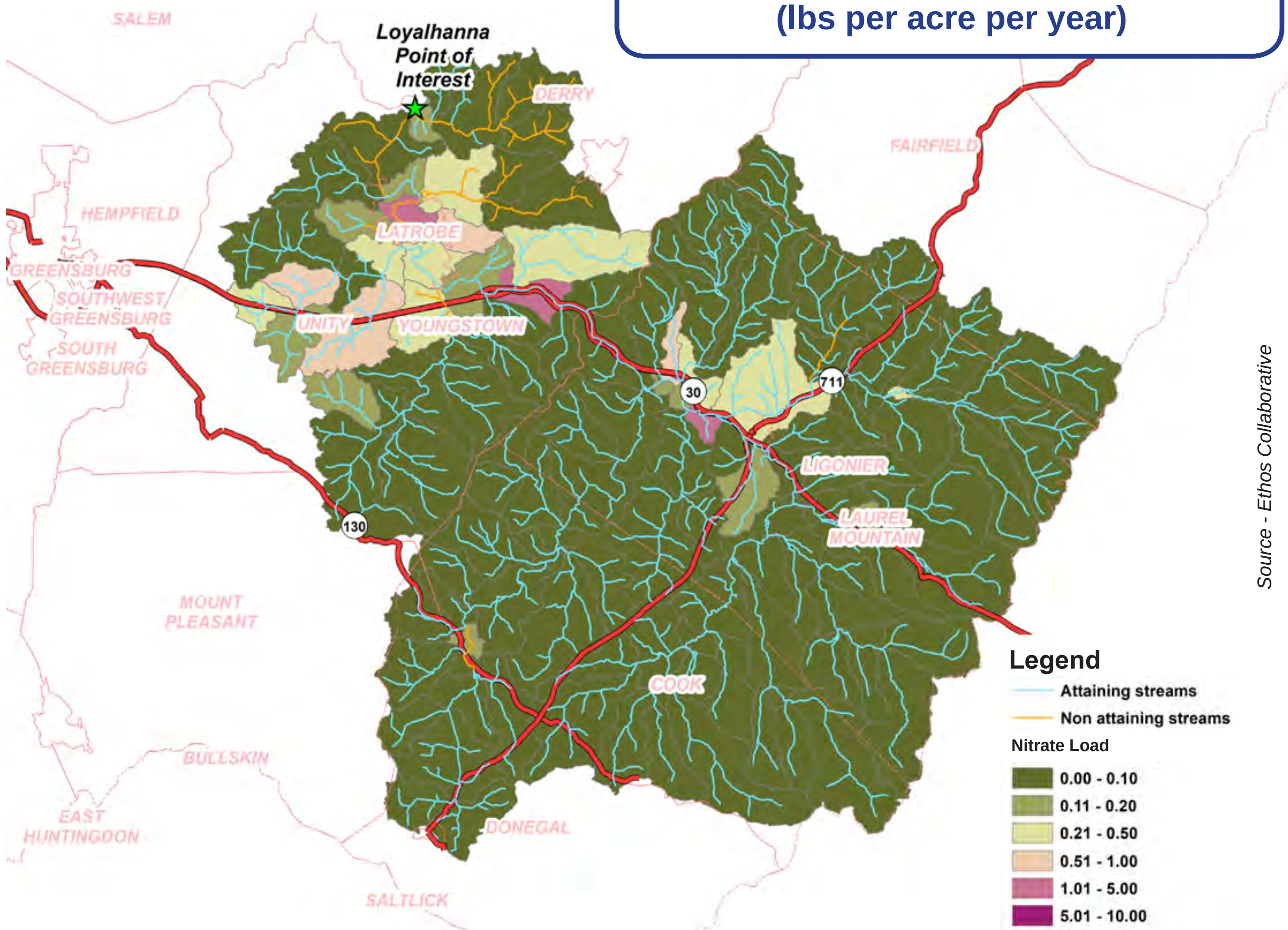
Source - Ethos Collaborative

NITRATE (TNO3$^-$)

Nitrogen, here expressed as nitrate (NO_3^-), is a nutrient essential for plant and animal growth. Historically, biologically available nitrogen was a limiting factor in ecosystems, however industrial activities have increased biologically available nitrogen to the point where it is now considered a pollutant in many regions. Shown on the map is the modeled sub-watershed export of nitrate, in pounds per year.

- Agricultural activities and residential areas both contribute fertilizer-sourced nitrogen to the watershed. Fertilizer applied to croplands and residential lawns can be washed from the land surface into streams.
- Nitrogen can be found in urine excreted from grazing animals. Urine-sourced nitrogen is biologically transformed to nitrate, which can then be transported downstream.
- Fixed nitrogen is emitted to the atmosphere when fossil fuels are burned. This nitrogen is deposited as nitrogen oxides or NOx, on the landscape, with concentrations found in near-road areas.
- Wastewater contains biologically available nitrogen. Wastewater treatment plants may not remove all of the nitrogen before treated water is discharged to streams. Septic systems may contribute biologically available nitrogen to groundwater.

Loyalhanna Watershed Area of Interest
Nitrate Loading
(lbs per acre per year)



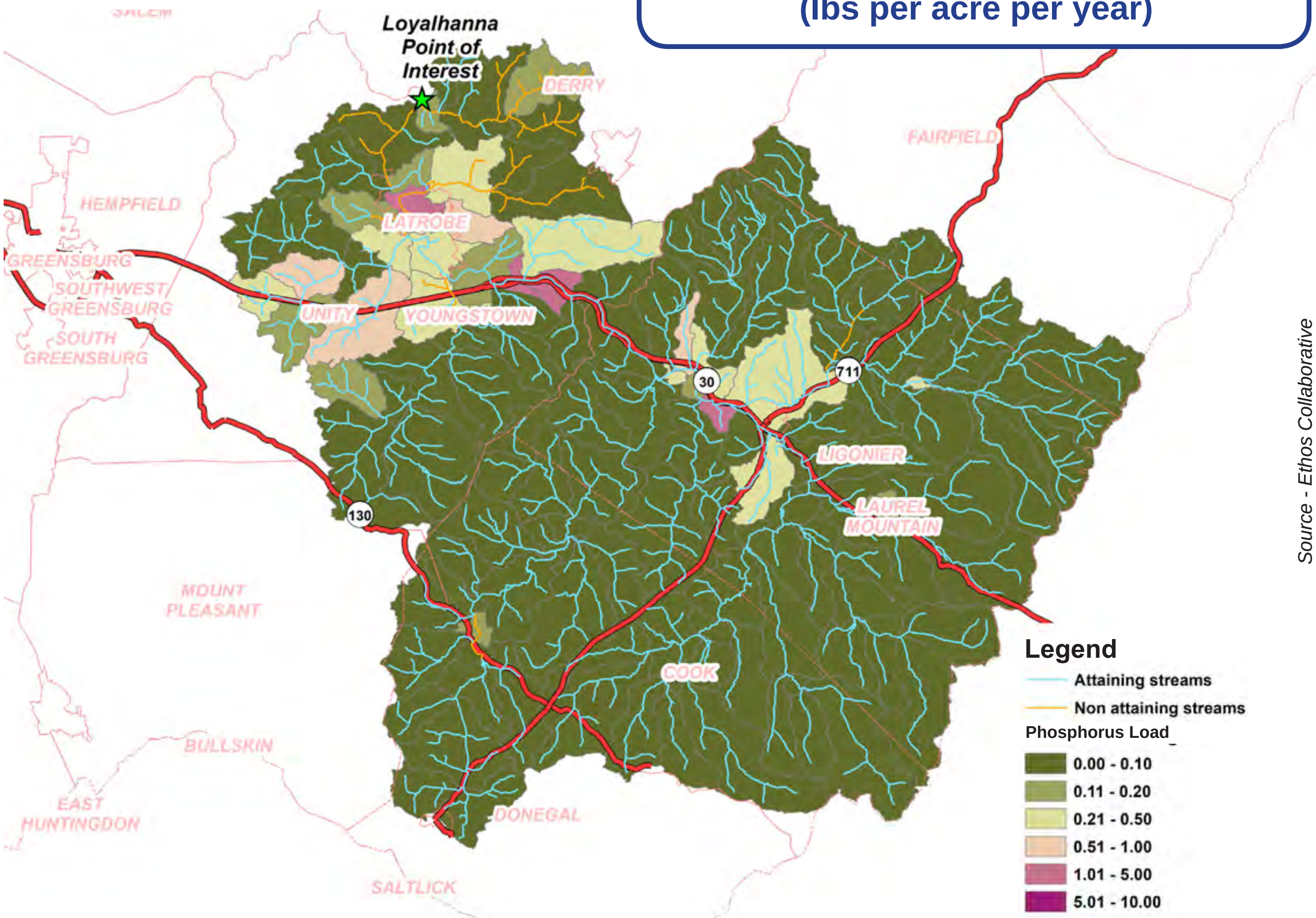
Source - Ethos Collaborative

TOTAL PHOSPHORUS (TP)

Phosphorus, here expressed as Total Phosphorus (TP) is a nutrient essential for life   Phosphorus, like Nitrogen, used to be a limiting nutrient for ecosystems. Industrial activities and fertilizer both contribute excess phosphorus to ecosystems. This phosphorus contributes to algae blooms in water bodies, eutrophication, and overall habitat deterioration. Shown on the map is the modeled sub-watershed export of TP in pounds per year.

- Higher amounts of phosphorus are exported from the urban sub-watersheds in the Loyalhanna AOI. Phosphorus is sourced primarily from lawn fertilizer and roadway deposition. These sources produce both particulate and dissolved forms of phosphorus.
- Soil erosion is another contributor of phosphorus to streamwater. Erosion depletes the soil of valuable nutrients like phosphorus and transports the nutrient downstream,.
- Crops lands exportPhosphorus to downstream environs, sourced from fertilizer applied to the fields. Fertilizer-sourced Phosphorus is likely in particulate forms, and therefore structural BMP's that filter and/or detain sediment and particles can help to mitigate downstream export.
- Wastewater contains phosphorus from human waste and detergents. Wastewater treatment plants may not remove all of the phosphorus before treated water is discharged to streams.

Loyalhanna Watershed Area of Interest
Annual Phosphorus Loading
(lbs per acre per year)



Source - Ethos Collaborative

OPPORTUNITIES FOR EFFECTIVE STORMWATER MANAGEMENT:

Based on Modeling Watershed Hydrology and Pollution Sources to Inform Smart Water Management:

To increase water quality, we must decrease overland water quantity.
The good water quality in this watershed is a valuable resource that should be conserved for future generations. Conservation efforts should consider ways to manage landscape-based runoff that decreases soil erosion, pollution transport, and sediment deposition in the healthy creeks and rivers. Water detained by increasing infiltration to groundwater encourages nutrient retention, or the uptake and filtration of pollutants by biota and soil. The processes of detention and retention increase water quality through decreasing erosion and downstream pollutant transport.

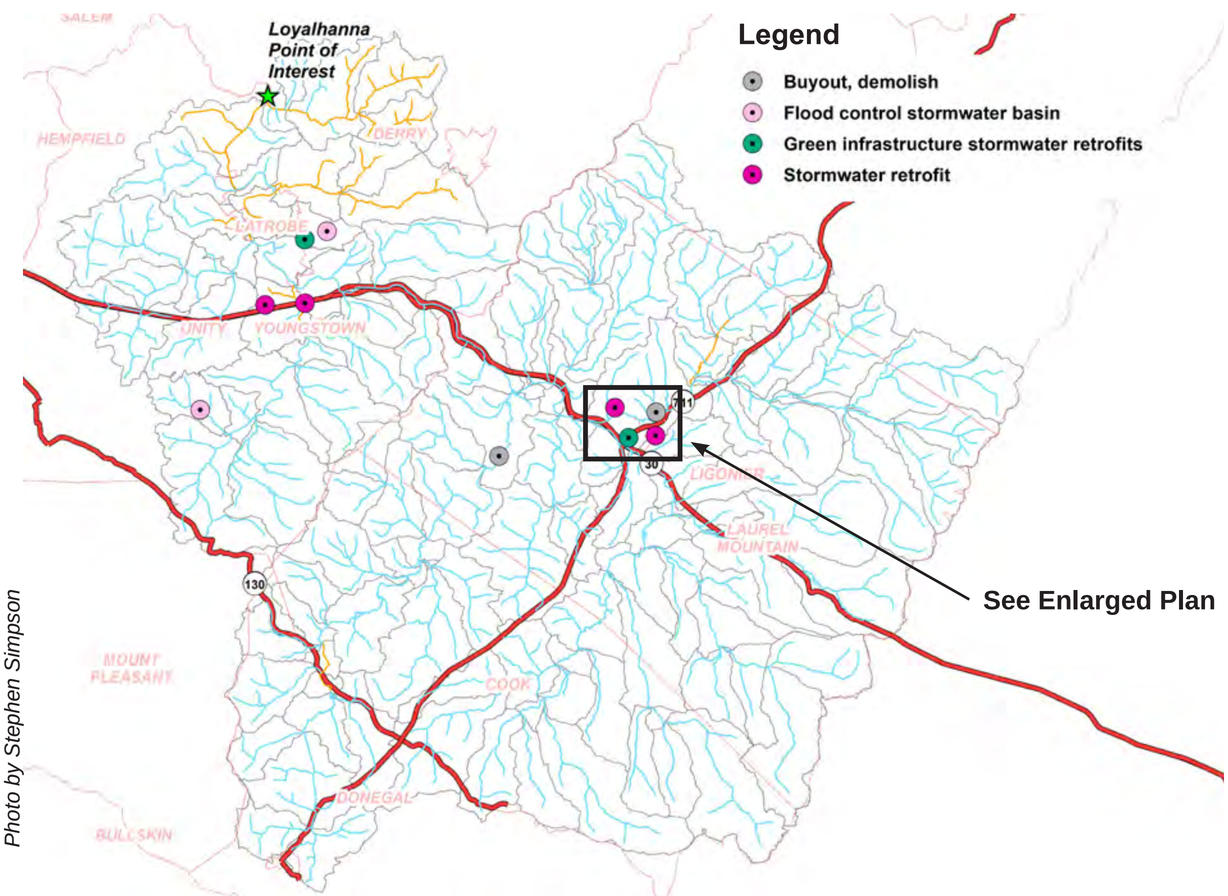
Effective water management protects valuable resources and built infrastructure.
Recreational uses, high quality streams and woodlands in this watershed are valuable resources. Many homes and built infrastructure are subject to flooding during severe rain events where streams have been impacted by developments. Conservation efforts should consider ways to manage water runoff that decrease soil erosion, pollution transport, sedimentation, and flooding.

Conceptual Ideas for BMP's/Landscape Restoration: Highlighting the potential for water and pollutant capture and retention.
Identified issues include stormwater runoff and associated erosion, as well as the identification of sites appropriate for Green Infrastructure such as stormwater retrofits, riparian buffer restoration, and stream restoration. When coupled with the landscape-based nutrient accumulation and decay modeling, this list can help to identify and prioritize projects for future conservation efforts. This list was compiled based on reports made by local property owners to the Westmoreland Conservation District and should by no means be considered an exhaustive list of problem sites in the watershed.

Photo by Stephen Simpson

Loyalhanna Creek, view from the causeway, autumn

Loyalhanna Watershed Area of Interest Conceptual Opportunities



Source - Ethos Collaborative/WCD

CONCEPTUAL OPPORTUNITY: URBAN GREEN INFRASTRUCTURE STORMWATER RETROFITS

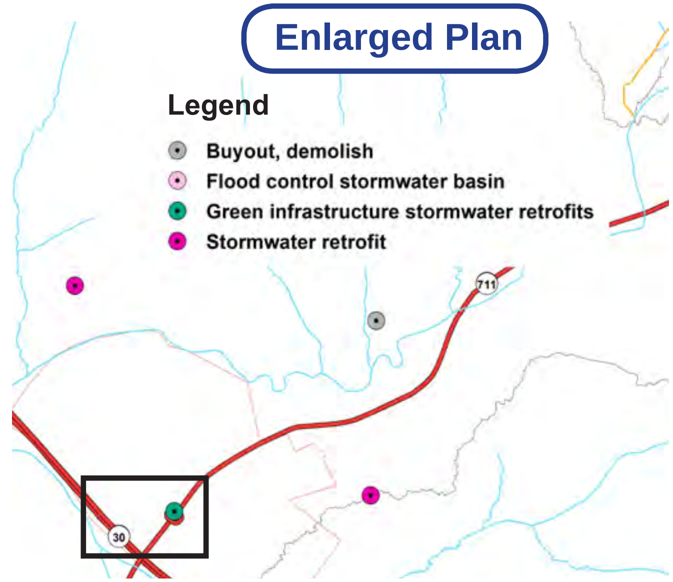
This area is located in Ligionier, a town located close to the Laurel Ridge. Here, we used GIS spatial method to determine the location of public parcels including parks and municipality-owned lots. These public parcels were chosen because it would be easier to enact Green Infrastructure on areas that were not privately owned. Parcels of interest are color-coded to indicate the modeled amount of sediment, in lbs per year, that may be exported from these properties. This example shows how the sediment/pollution modeling (1) pinpoints regions of concentrated pollution, and (2) helps to guide efforts to find accessible areas where stormwater and pollution mitigation efforts can be enacted.

Water Quality Goals:
During rain events, water collects and runs off of impervious surfaces, carrying with it pollution including Suspended Solids (TSS), Phosphorus (TP), and Nitrate (TNO_3^-). Best management practices that slow overland flow, encourage water and particle infiltration/settling and increasing biological processing interactions would help to mitigate the effect of stormwater flow. Stormwater management potential landscape elements to consider will affect impacts of stormwater management.

Stormwater Management Potential:
Protecting streambanks from erosion and retrofitting infrastructure in the urban areas to include green infrastructure would help decrease flooding and pollution inputs delivered to the streams in storm runoff.

Landscape Elements to Consider:
Shade in urban areas and along stream channels reduces thermal pollution and contributes to stormwater volume reduction through evapotranspiration.

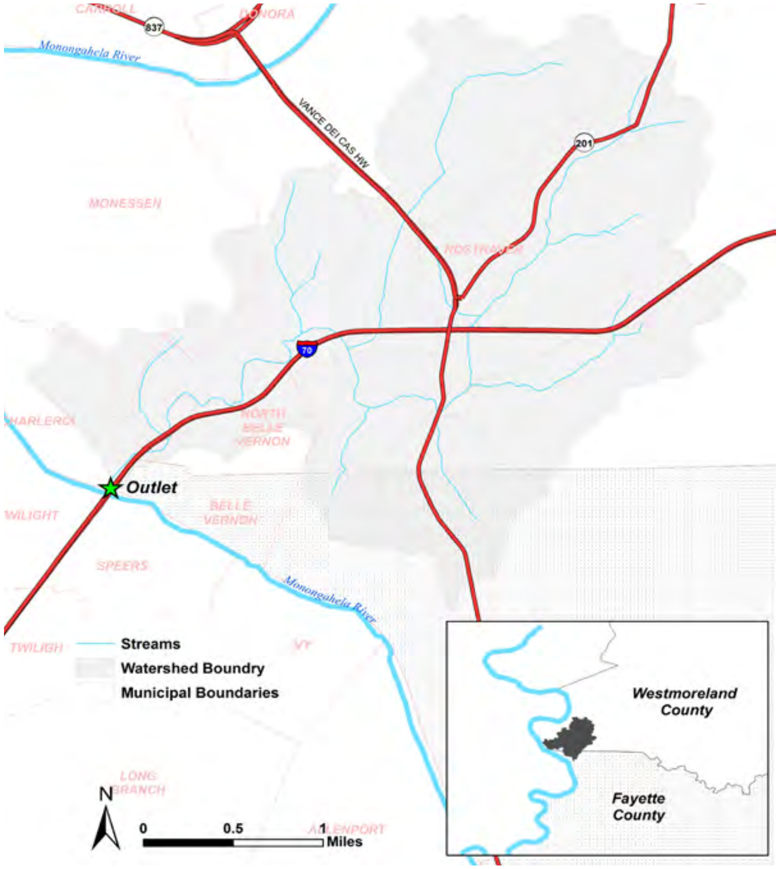
Water Quality Impacts of Stormwater Management:
The inclusion of green infrastructure in urban areas and augmenting riparian buffers will reduce stormwater runoff and allow pollutants to break down through natural processes rather than degrading streams.



Source - Ethos Collaborative

Enlarged plan of Ligonier, Loyalhanna Watershed Area of Interest indicating impacts and opportunities for BMPs

MONONGAHELA RIVER WATERSHED AREA OF INTEREST



Source - Ethos Collaborative

REGION OVERVIEW

The Monongahela Area of Interest is approximately 6.8 mi²/4,352 acres and contains 14 miles of streams that drain southwest to the Monongahela River in Belle Vernon (outlet indicated by a star on the map, left). The main stream draining this landscape is Speer's Run. Seven sub-watersheds were delineated ranging from 0.07 to 2.56 square miles in size. Most sub-watersheds were in the range of 1-2 square miles.

Why is this watershed of particular interest?

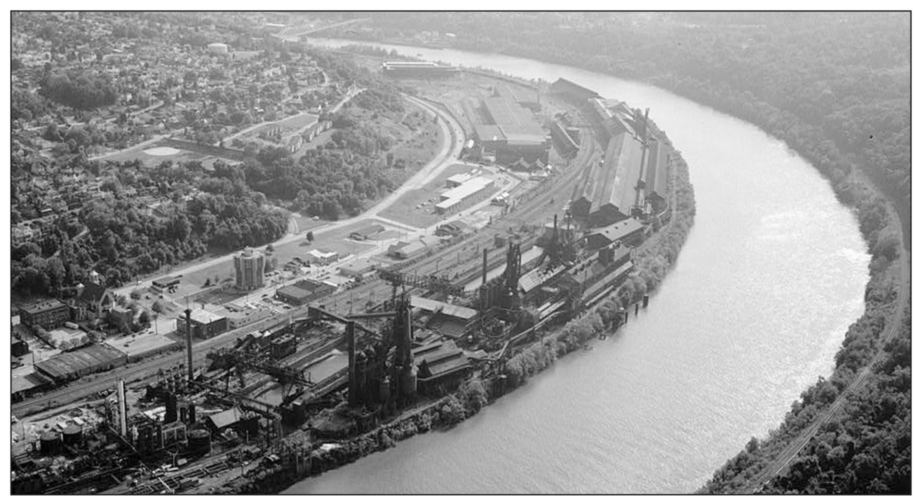
During the Phase I assessment, it was noted that this small watershed has great potential for rapid development. The I-70 corridor provides quick access to rapidly growing areas around Washington that service the oil and gas industry. The largely rural landscape leaves room for future expansion of residential or industrial areas. There is tremendous opportunity to carefully manage future development and stormwater planning in this area.

Challenges in the Watershed

The city of Monessen and Rostraver Township are required to develop and implement a Pollutant Reduction Plan (PRP) for discharges from the municipal separate sanitary sewer system to impaired streams, including an un-named tributary to Speers Run. Proposed solutions include storm sewer inserts to capture sediment and debris, and restoration of natural drainageways.

WATERSHED SNAPSHOT

- ***Area: 6.8 square miles***
- ***Water Quality: Impaired for aquatic life, due to inputs from suburban lands and abandoned mines.***
- ***Characterization: This area of interest is a mix of forested and developed land.***
- ***Highways provide relatively quick transportation from this rural region to the cities of Pittsburgh and Greensburg. These qualities make the region an ideal location for future development.***



Source - historic-structures.com

City of Monessen Waterfront - 1955

Landcover / Landuse

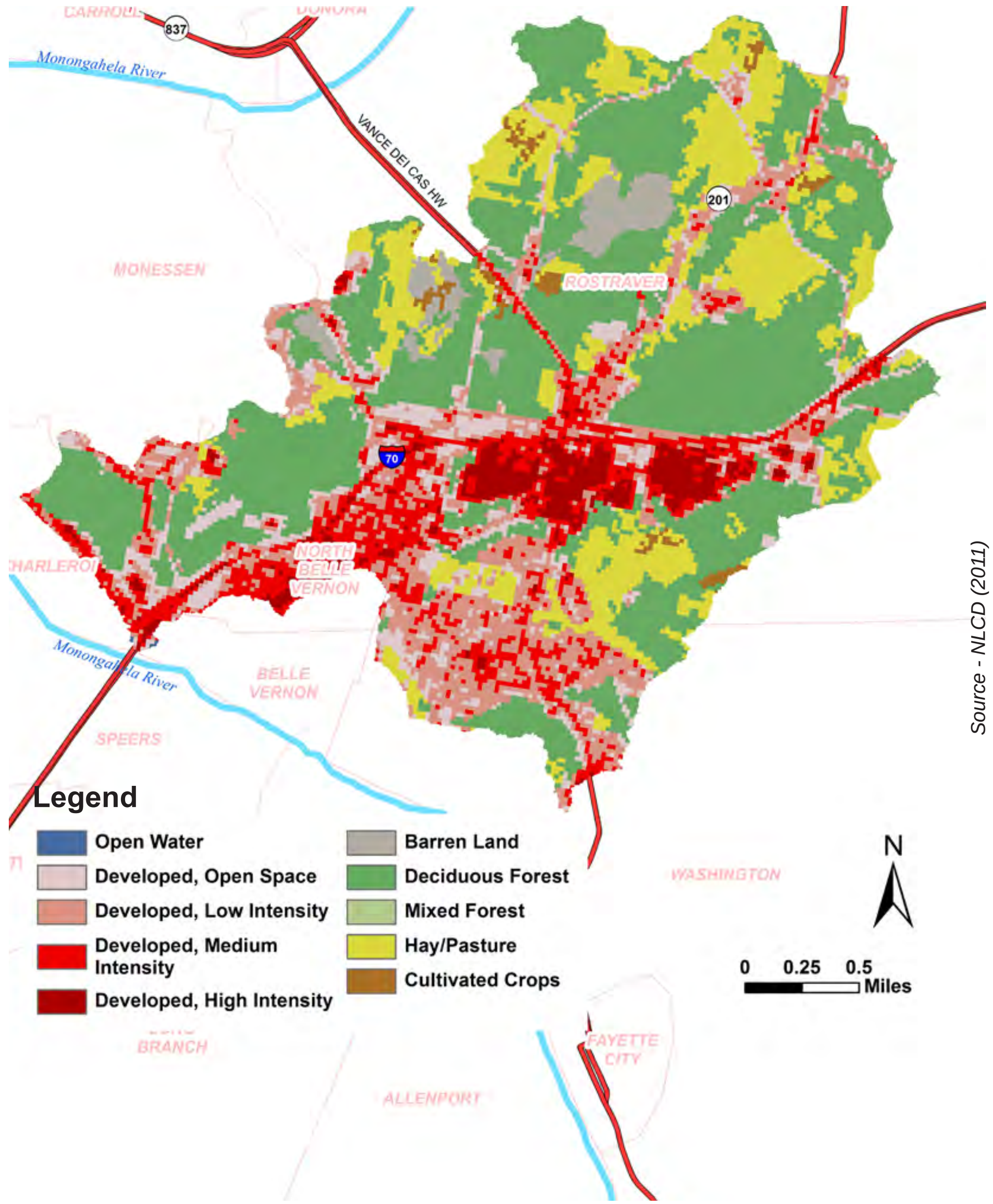
Landcover in this watershed is predominantly deciduous forest and low-moderate intensity developed land, with concentration of urbanized land and associated impervious surface around the town of Belle Vernon and the Interstate 70 corridor. There is also a good proportion of land in hay/pasture. Landcover data is based on the 2011 National Land Cover Dataset, created by the Multi-resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.

Landcover Class	Acres	Total Area (%)
Open Water	1	0.01
Developed- Open Space	385	9
Developed- Low Intensity	651	15
Developed- Medium Intensity	468	11
Developed- High Intensity	177	4
Barren Land	122	3
Deciduous Forest	1787	41
Mixed Forest	2	0.04
Hay/Pasture	716	16
Cultivated Crops	44	1

Source - WCIDC

City of Monessen Waterfront - Present day

Monongahela River Area of Interest Landcover Classification



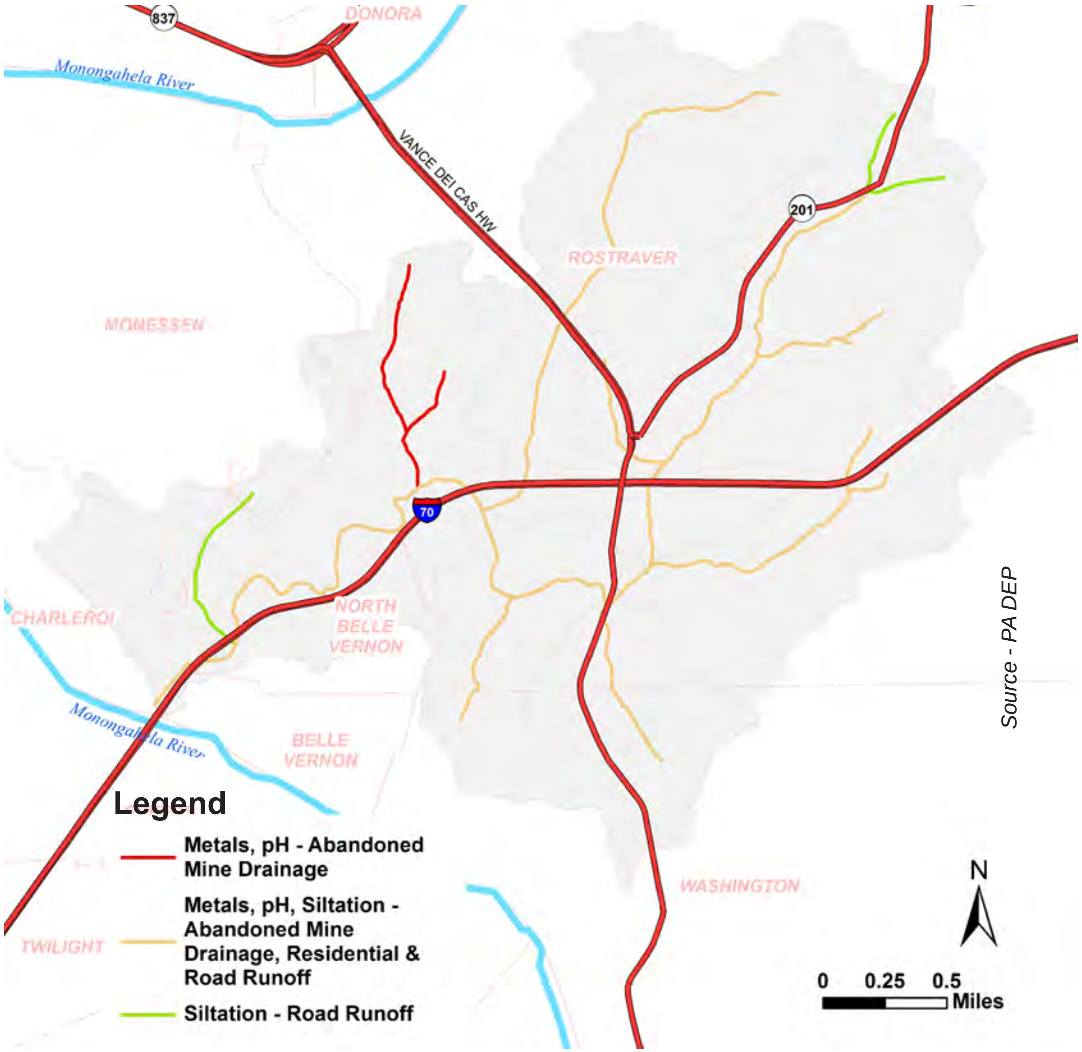
Source - NLCD (2011)

CURRENT WATER QUALITY IN THE MONONGAHELA RIVER WATERSHED AREA OF INTEREST

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection determined that all of the stream miles in the Monongahela Area of Interest are considered “impaired” for their designated use of maintaining aquatic life. Identified impairments include nutrients and siltation from residential land and road runooff, as well as metals and pH from Abandoned Mine Drainage. These are considered non-point sources, originating not from one identifiable point but instead from diffuse sources across the landscape.

Monongahela River Area of Interest Attaining & Impaired Streams



Source - PA DEP

TMDL status of the streams in this area of interest

Although these streams are identified as impaired, they are not currently listed under a TMDL, (Total Maximum Daily Load) agreement. However, the Monongahela River at this location is under a TMDL for PCB’s and Chlordane, the “Monogahela River TMDL.” This agreement seeks to reduce the non-point sources of pollution from PCB’s (from industrial processes) and Chlordane (once a common pesticide, now banned by the EPA). Although both chemicals are banned, sediment-bound chemicals are environmentally persistent and bio-accumulate in fish.

Source - WPCAMR

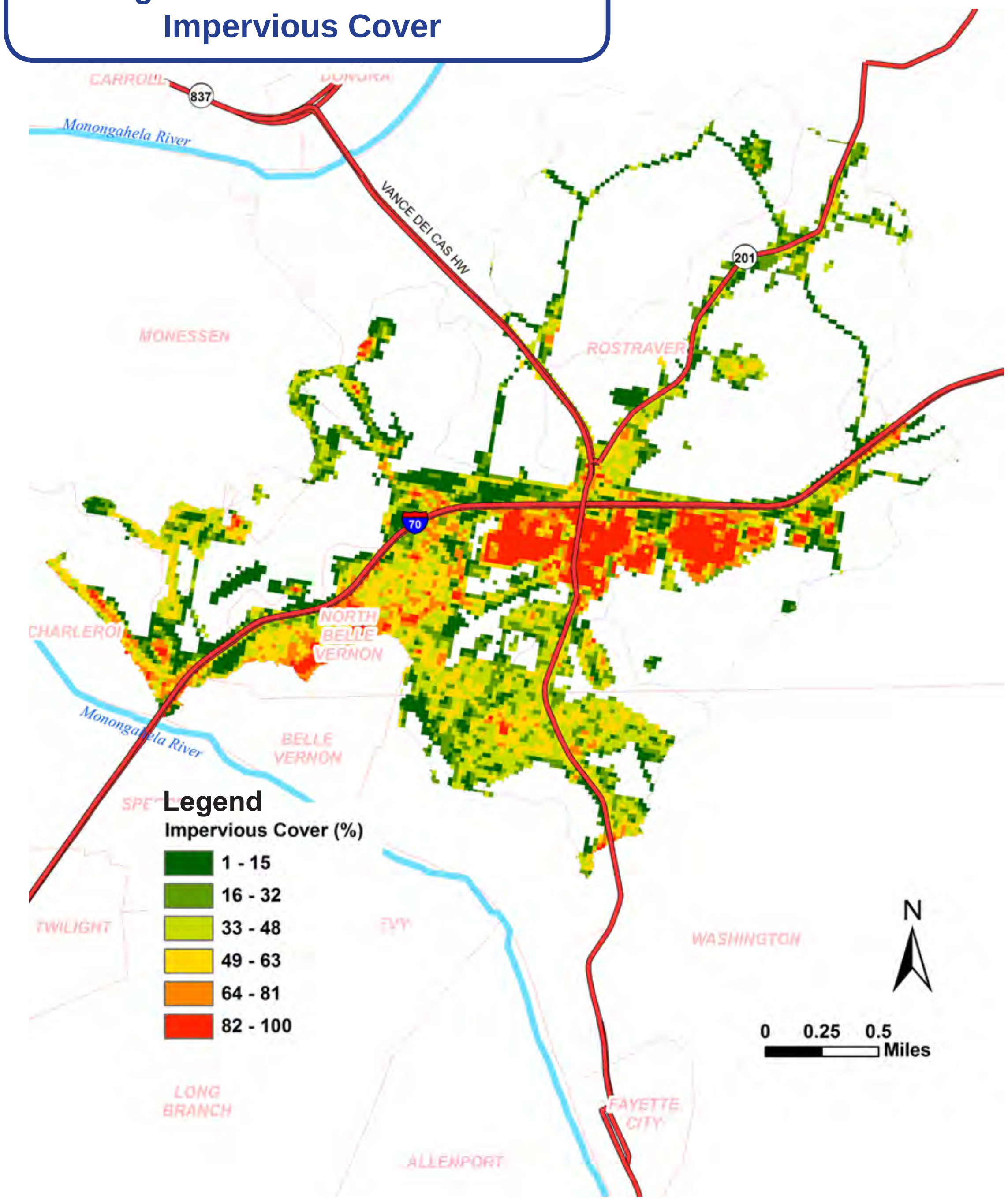
Abandoned Mine Drainage Pollution

WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE MONONGAHELA AREA OF INTEREST

As water accumulates and moves overland on impervious surfaces, it picks up pollutants from the surface of the landscape and delivers it to receiving waters. Development, particularly that which increases impervious surfaces on the landscape, increases the overland flow of water during storms and decreases infiltration to groundwater. Increased stormwater also increases the erosive force of overland flow, increasing sediment load and delivering it to downstream receiving waters. Below, a watershed map shows the concentration of impervious surface in the Area of Interest. Impervious surface data is from the 2011 National Land Cover Dataset.

Both sediment and pollution are a threat to water. Accumulated nutrients can lead to harmful algae blooms, which may affect wildlife habitat and water quality. Sediment accumulation in larger rivers represents the erosion, and loss, of valuable soil from upstream landscapes. The sediment is also a threat in the future as it continues to accumulate and add to stream bedloads.

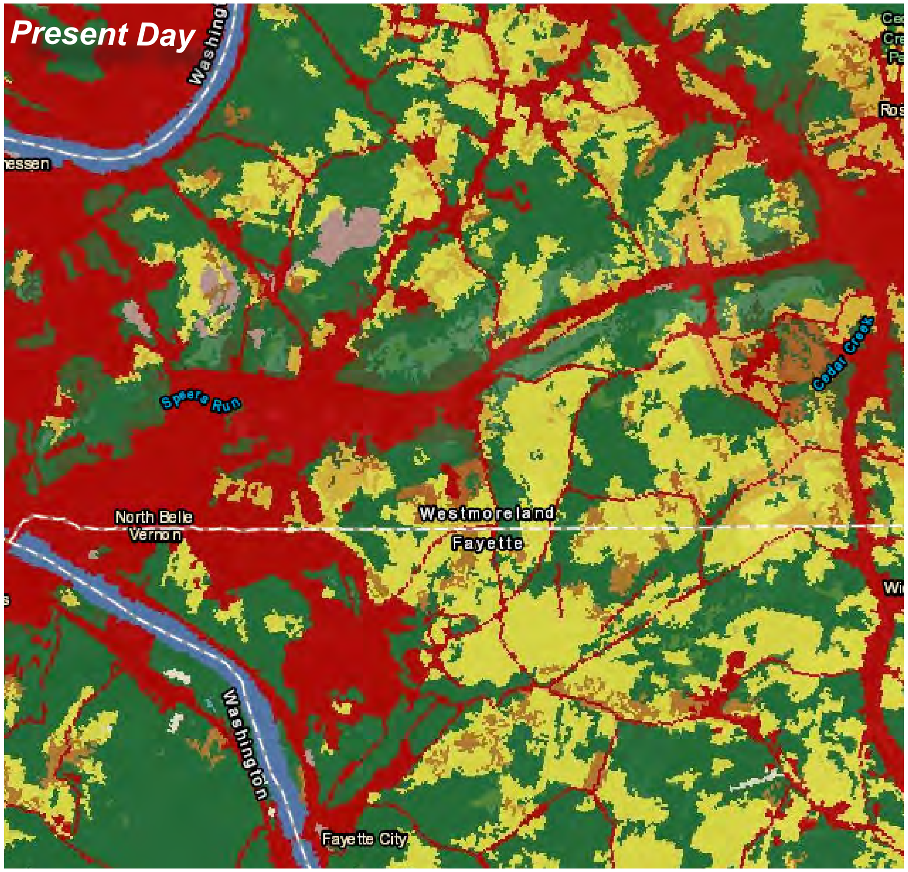
Monongahela River Area of Interest Impervious Cover

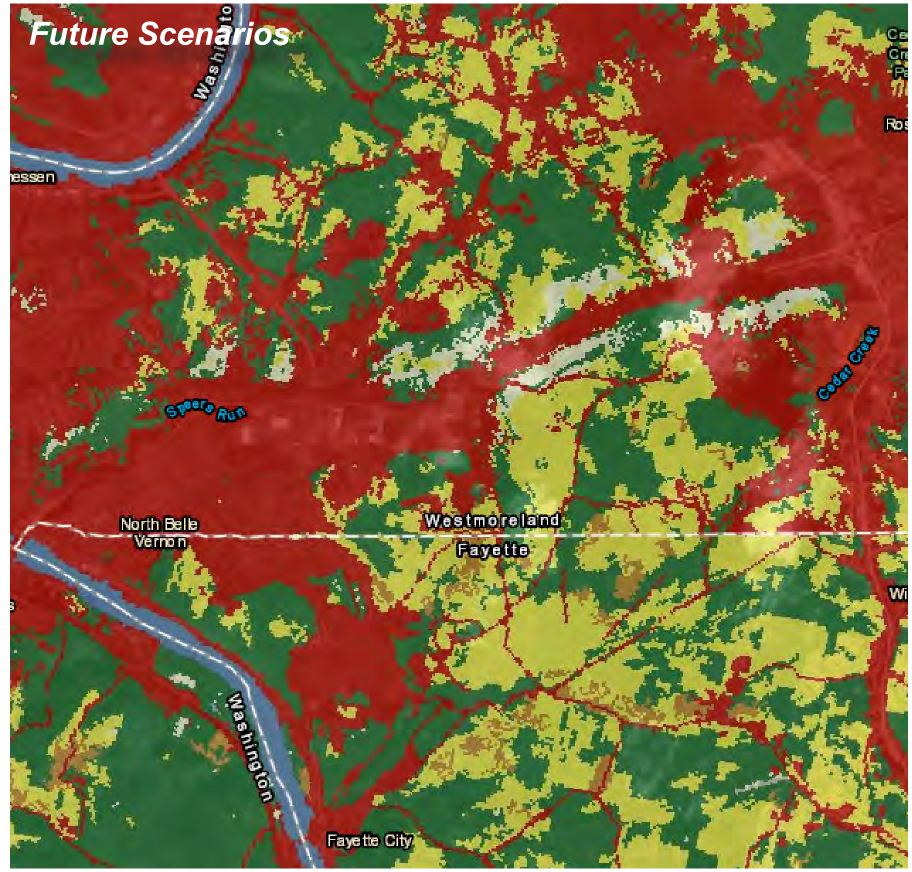


Source - NLCD

FUTURE TRENDS IN THE MONONGAHELA RIVER WATERSHED AREA OF INTEREST

This watershed will likely see increasing development and a reduction in forested and agricultural land. These land-use trends will add to stormwater runoff and non-point pollution loadings. There is tremendous opportunity to carefully plan now in order to mitigate the potential increase in flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source -ESRI

Legend

National Land Cover Database

- Open Water
- Perennial Ice/Snow
- Developed
- Barren Land (Rock/Sand/Clay)
- Forests
- Scrub/Shrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Herbaceous and Woody Wetlands

Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted increase in impervious surfaces. This analysis of land use change in the Monongahela Area of Interest specifically estimates

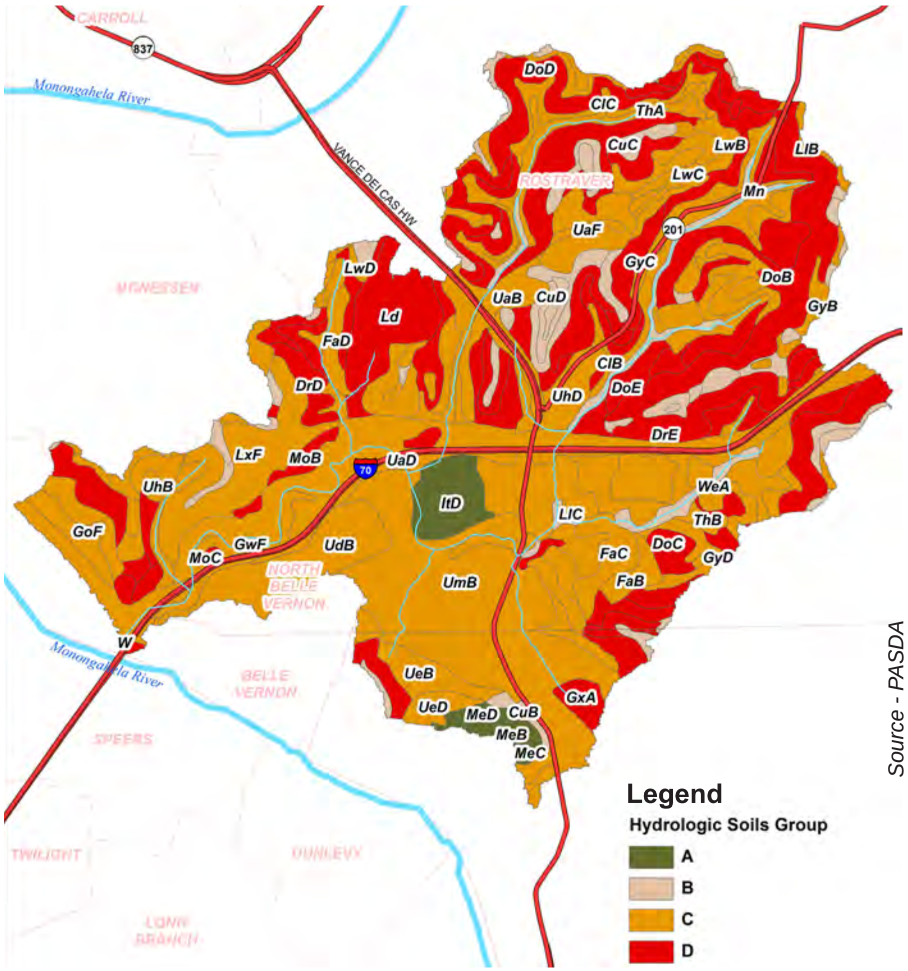
- A 35% *INCREASE* in developed land,
- A 15% *DECREASE* in forest cover
- A 33% *DECREASE* in agricultural cropland

HYDROLOGIC WATERSHED MODELING:

INPUT PARAMETERS, MODEL CALIBRATION & FINAL RELEASE RATES FOR THE MONONGAHELA AREA OF INTEREST

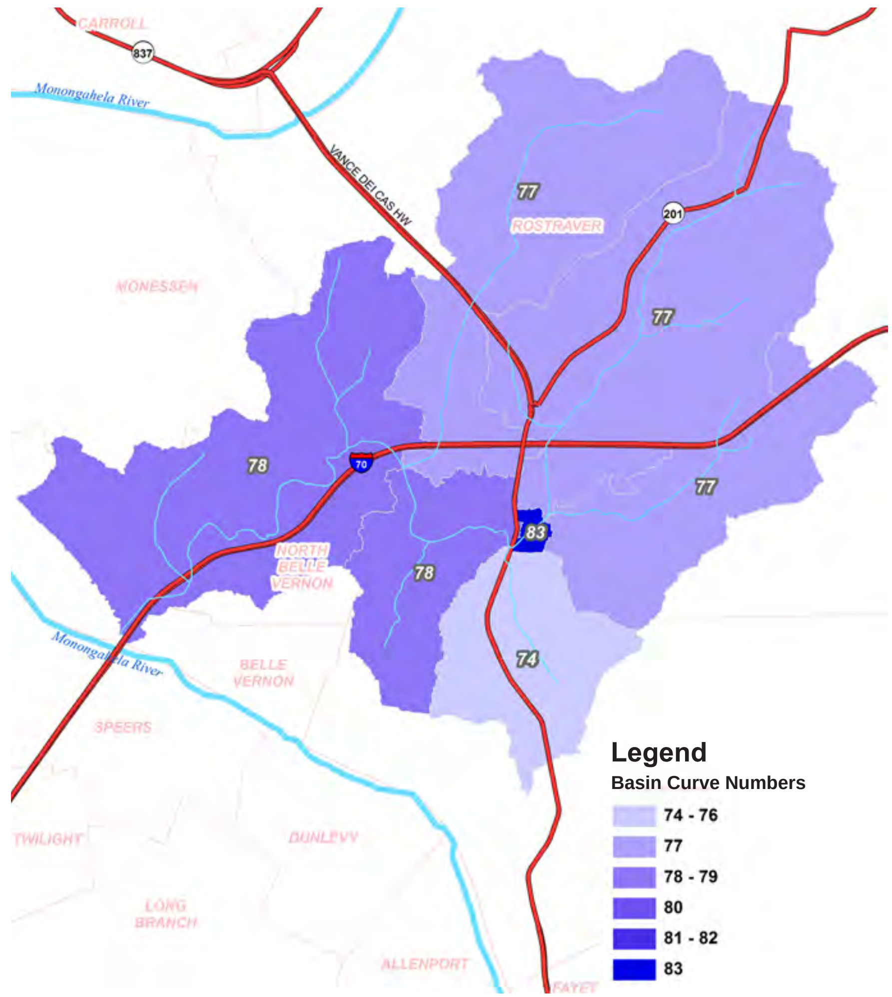
Controlling water now and in the future requires an understanding of current conditions and pollution sources. ***Parameters*** below and on the following pages were used in hydrological models to help us understand the contribution of different sub-watersheds to the flow of the whole, and possible future changes.

Hydrologic Soil Groups in the Monongahela Area of Interest
The map below is color-coded by the Hydrologic Soil Group, which indicates a soil's water holding capacity. Group A soils have low runoff potential and high infiltration rates, while Group D soils show the highest runoff potential with very low infiltration rates. Also shown are the specific soil names, please see appendix for a list and descriptions of individual soil types.



Source - PASDA

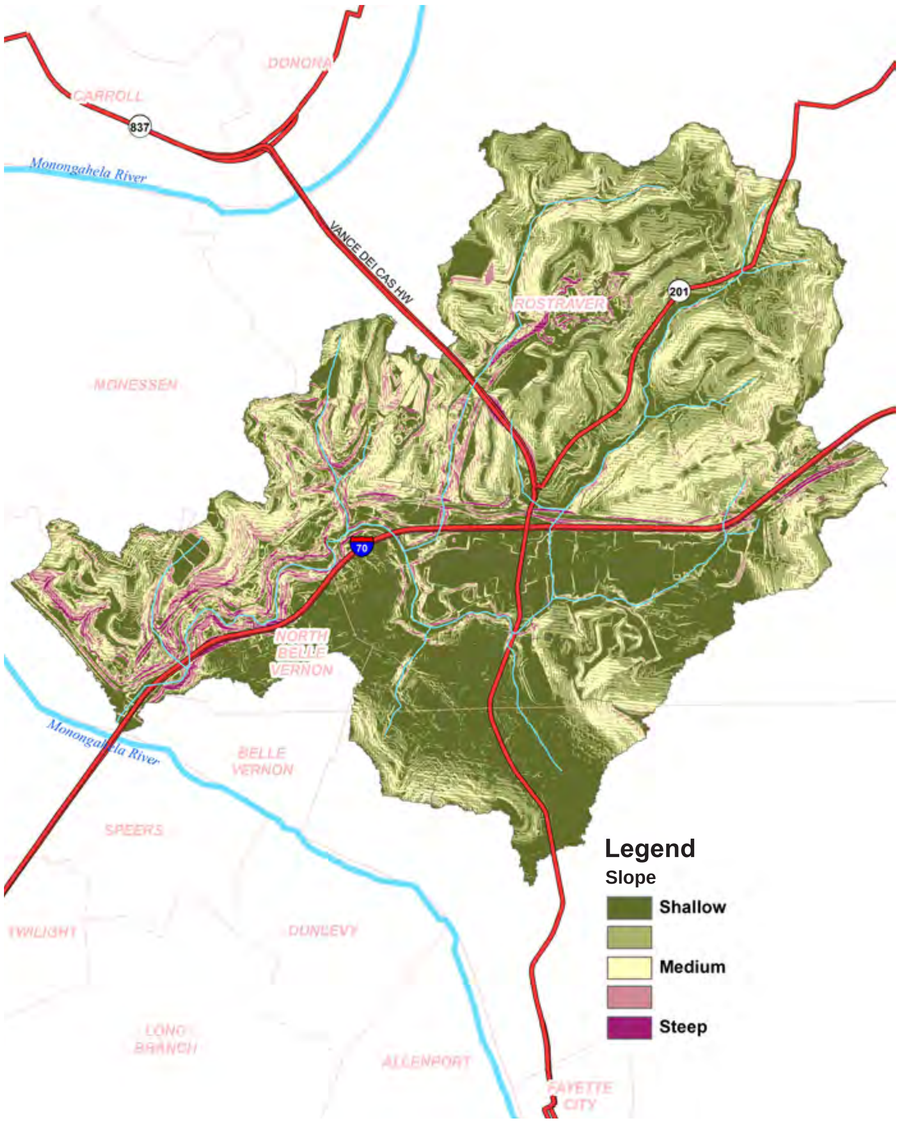
Basin Curve Numbers ("CN's") in the Monongahela Area of Interest are an empirical parameter that helps to predict direct runoff/infiltration from a parcel of land during a rain event. In the Monongahela area of interest, these range from 74-83. Watersheds with a higher curve number indicate higher runoff potential, leading to greater flooding and pollution delivery to streams.

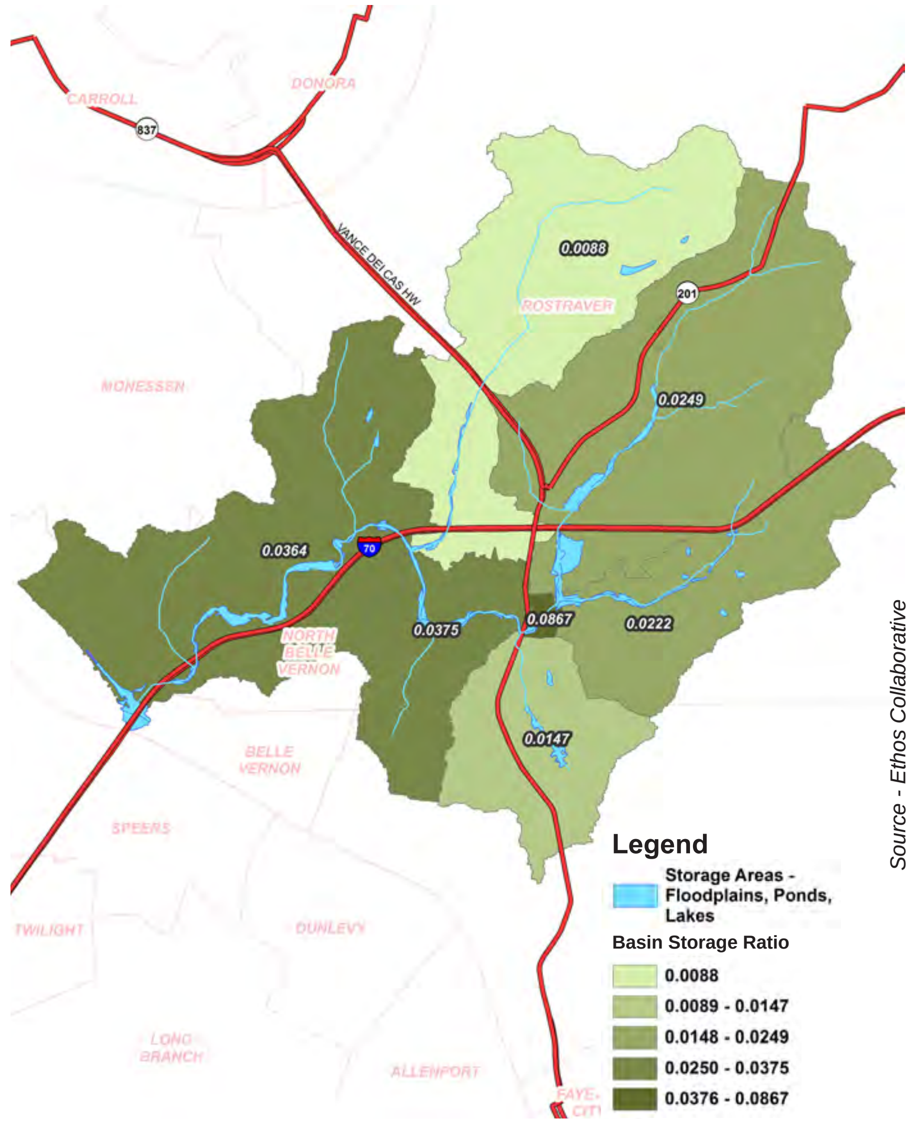


Source - Ethos Collaborative

Average Basin Slope (%) in the Monongahela Area of Interest
Generally most regions in this watershed show a moderate slope, with a range of values from 16.37% to 32.29%. Steeper slopes are found in the stream valleys and shallower slopes on the upland regions. Slope steepness contributes to overall runoff calculations, as steeper regions generally experience greater runoff during rain events.

The Basin Storage Ratio in the Monongahela Area of Interest
indicates the proportion of each sub-watershed that can store water in a storm, instead of directly increasing stream discharge. Storage areas include lakes, ponds and floodplains. Storage ratios range from 0.0008 to 0.1999, therefore the storage amount available in each sub-watershed varies from 0.08-20% of the sub-watershed area.





Source - Ethos Collaborative

MODEL CALIBRATION IN THE MONONGAHELA AREA OF INTEREST

Four sites were chosen as “areas of interest” and model results at these sites were compared to Stream Stats data for the same site. This approach allowed the calibration of hydrological models, in the absence of multiple stream gage locations in the watershed. The graphs below compares Model Results versus StreamStats for the 2, 5, 10, 50, and 100 year storms. There is a good correlation between model results and Streams Stats data. For the methodology used for calibration, validating statistics and comparisons refer to the methodology in the appendix.

Source - Ethos Collaborative

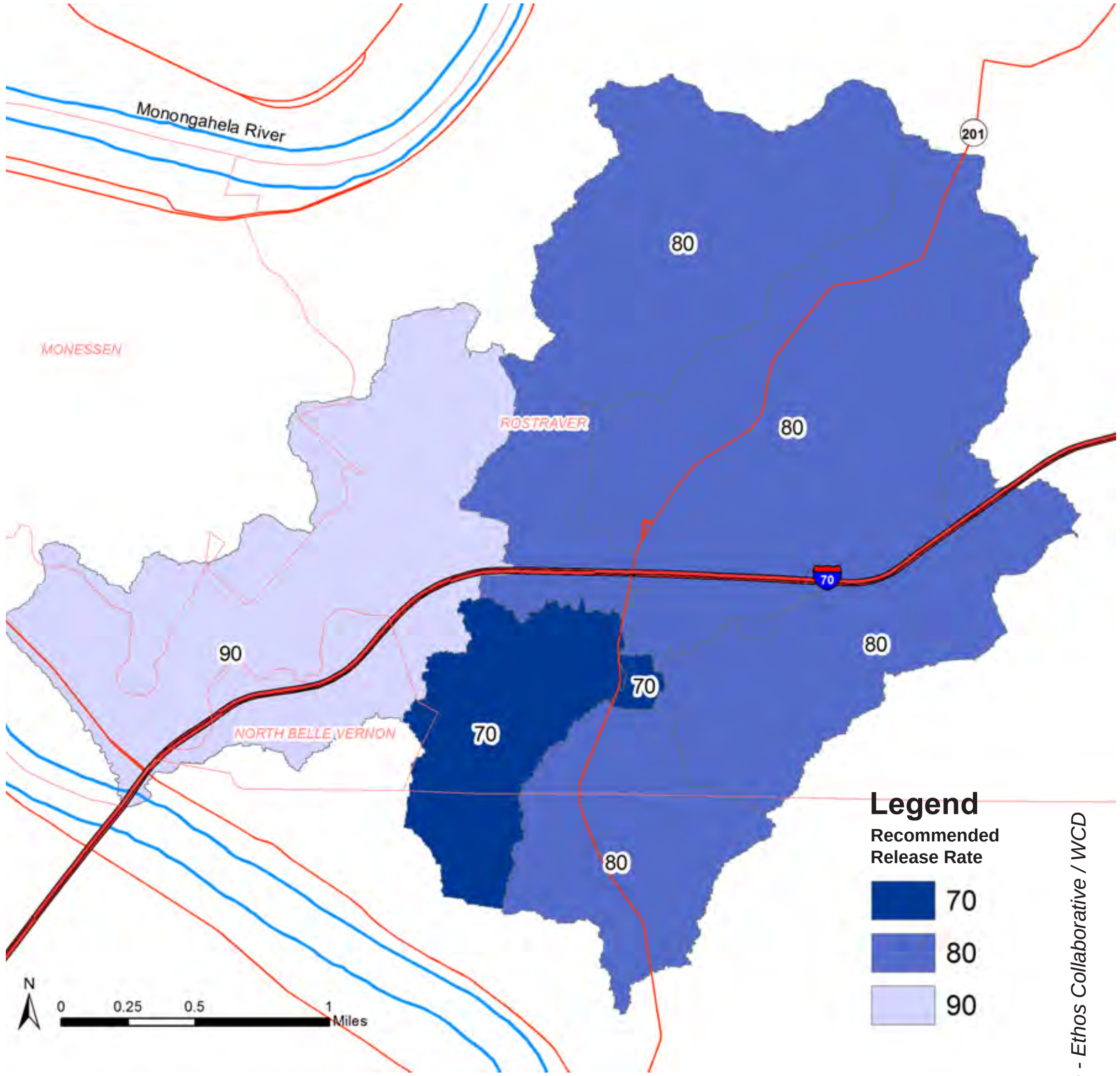
RECOMMENDED RELEASE RATE MAP FOR THE MONONGAHELA RIVER WATERSHED AREA OF INTEREST

Release rates are a tool that help determine the timing of when water can be released from a watershed. A release rate of 50% for a sub-watershed indicates that the rate at which stormwater moves out of the watershed and downstream must be reduced by half in any future development. In contrast, a release rate of 100% indicates that, with future development, stormwater can move off of the sub-watershed at the same rate that is does in the present. In other words, lower release rates require an increased control of runoff.

Release rates were calculated based on a hydrologic model of the area of interest using HEC-HMS, the U.S. Army Corps of Engineers (USACE) Hydrologic Modeling System, in conjunction with GEO-HMS (a GIS extension that allows for the manipulation of spatial data).

Final calculated release rates show a range in value from 50-100%. Darker colors and lower release rates indicate regions where future development must reduce runoff rates.

It should be noted that the methodology to calculate release rates focuses on the basin-wide contribution of upstream land on downstream flooding. In order to control more localized flooding, individual municipalities may enact stricter stormwater runoff controls.



Source - Ethos Collaborative / WCD

LANDSCAPE POLLUTION ACCUMULATION MODELING

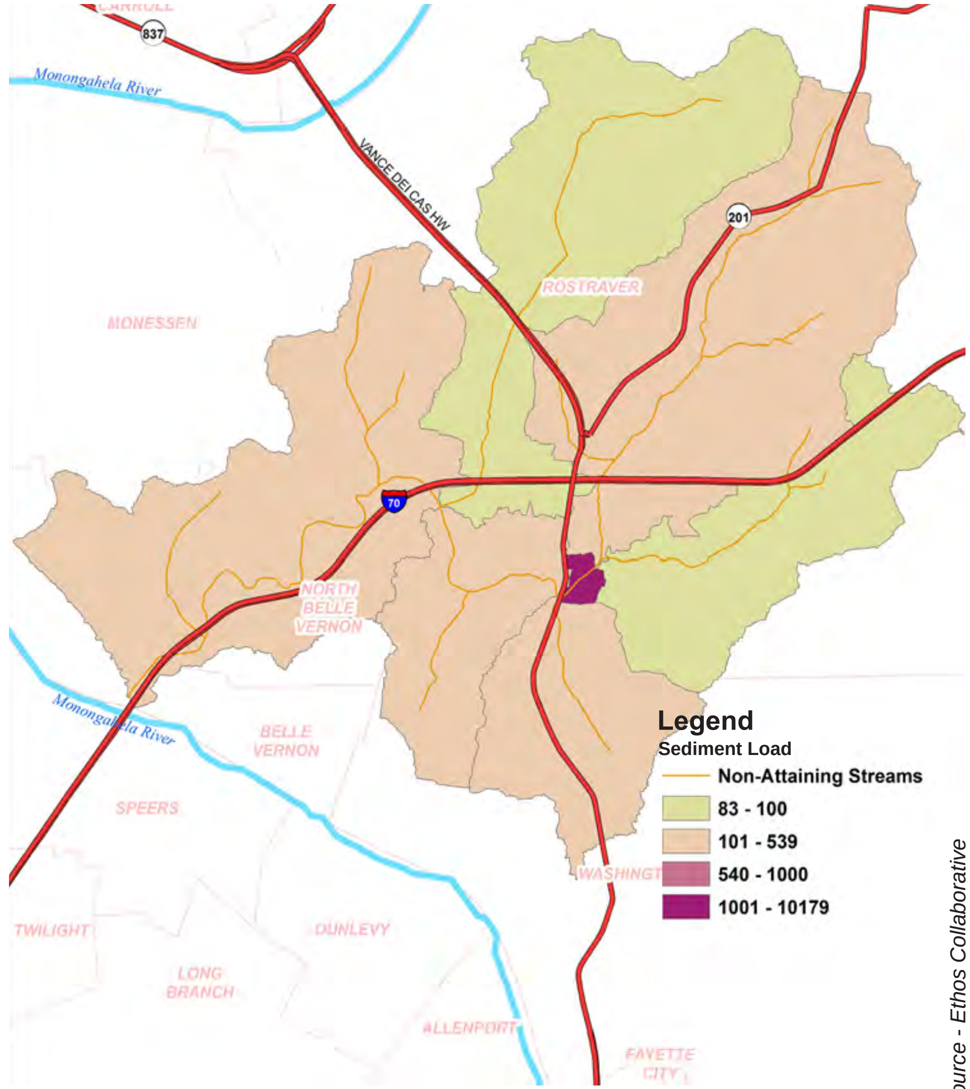
To understand where and how pollution-bearing runoff moves across the landscape, we modeled accumulation using ArcGIS in conjunction with a specialized terrain analysis toolset, (TAUDEM). This analysis allowed us to understand both pollution contributions and pollution reductions due to the underlying landscape. Please see the Methodology Appendix for further details about this process.

TOTAL SUSPENDED SOLIDS (TSS)

Sediment, or Suspended Solids, encompasses any number of particulate pollutants or natural particles, from a myriad number of sources. Shown to the right is the estimated sub-watershed export of sediment, in pounds per year.

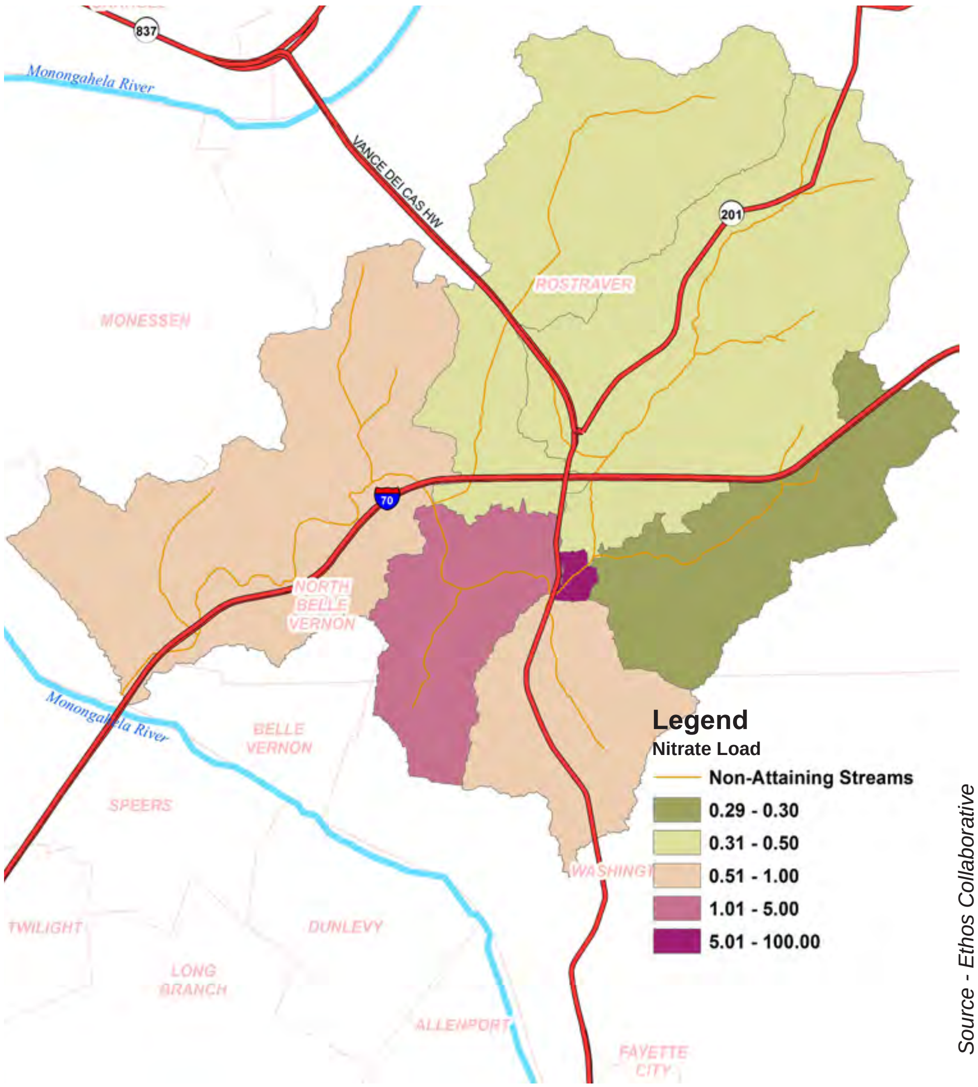
- The high percent of impervious surfaces in the town of Belle Vernon/North Belle Vernon and the nearby highway interchange collect solids during dry weather and then during wet weather contribute to high TSS loads draining from these watersheds. These sub-watersheds have little in the way of riparian buffers or other landscape features that help to slow, infiltrate, and absorb water, preventing it and associated pollutant loads from moving into the stream, and subsequently downstream.
- Significant contributions of TSS are also found in sub-watersheds where agricultural activities such as grazing and plowing take place. These regions in particular would benefit from the increase in riparian buffers as a way to capture water and associated pollutants before it reaches the stream.

Monongahela Area of Interest Annual Sediment Loading (lbs per acre per year)



Source - Ethos Collaborative

Monongahela Area of Interest
Annual Nitrate Loading
(lbs per acre per year)



Source - Ethos Collaborative

NITRATE ($TNO3^-$)

Nitrogen, here expressed as nitrate (NO_3^-), is a nutrient essential for plant and animal growth. Historically, biologically available nitrogen was a limiting factor in ecosystems, however industrial activities have increased biologically available nitrogen to the point where it is now considered a pollutant in many regions. Shown on the map to the right is the modeled sub-watershed export of nitrate, in pounds per year.

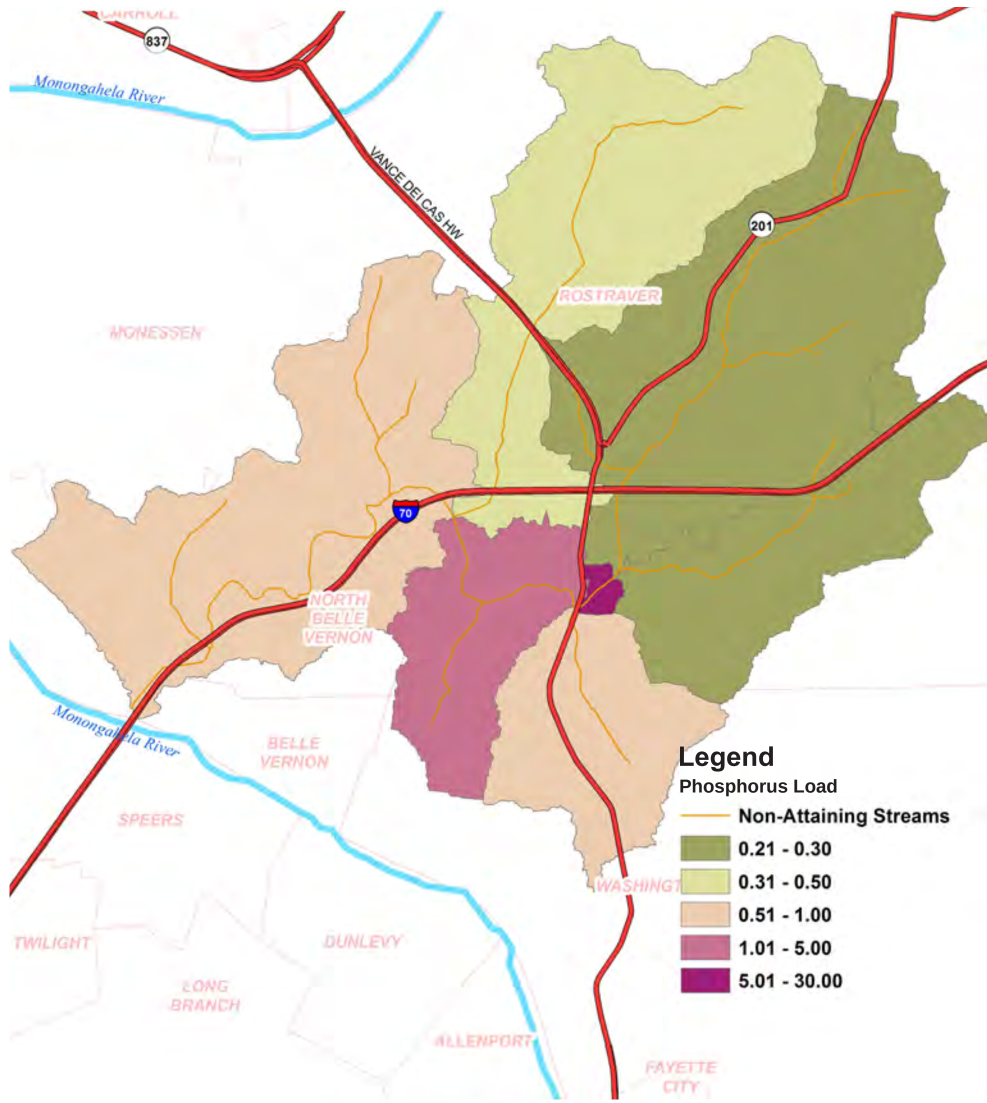
- Agricultural activities and residential areas both contribute fertilizer-sourced nitrogen to the watershed. Fertilizer applied to croplands and residential lawns can be washed from the land surface into streams.
- Nitrogen can be found in urine excreted from grazing animals. Urine-sourced nitrogen is biologically transformed to nitrate, which can then be transported downstream.
- Fixed nitrogen is emitted to the atmosphere when fossil fuels are burned. This nitrogen is deposited as nitrogen oxides or NOx, on the landscape, with concentrations found in near-road areas.
- Wastewater contains biologically available nitrogen. Wastewater treatment plants may not remove all of the nitrogen before treated water is discharged to streams. Septic systems may contribute biologically available nitrogen to groundwater.

TOTAL PHOSPHORUS (TP)

Phosphorus, here expressed as Total Phosphorus (TP) is a nutrient essential for life   Phosphorus, like Nitrogen, used to be a limiting nutrient for ecosystems. Industrial activities and fertilizer both contribute excess phosphorus to ecosystems. This phosphorus contributes to algae blooms in water bodies, eutrophication, and overall habitat deterioration. Shown on the map to the right is the modeled sub-watershed export of TP in pounds per year.

- Higher amounts of phosphorus are exported from the more urbanized sub-watersheds and the developed regions around the interstate highway. Phosphorus is sourced primarily from lawn fertilizer and roadway deposition. These sources produce both particulate and dissolved forms of phosphorus.
- Soil erosion is another contributor of phosphorus to streamwater. Erosion depletes the soil of valuable nutrients like phosphorus and transports the nutrient downstream,.
- Crops lands export Phosphorus to downstream environs, sourced from fertilizer applied to the fields. Fertilizer-sourced Phosphorus is likely in particulate forms, and therefore structural BMP's that filter and/or detain sediment and particles can help to mitigate downstream export.
- Wastewater contains phosphorus from human waste and detergents. Wastewater treatment plants may not remove all of the phosphorus before treated water is discharged to streams.

Monongahela Area of Interest
Annual Phosphorus Loading
(lbs per acre per year)



Source - Ethos Collaborative

OPPORTUNITIES FOR EFFECTIVE STORMWATER MANAGEMENT

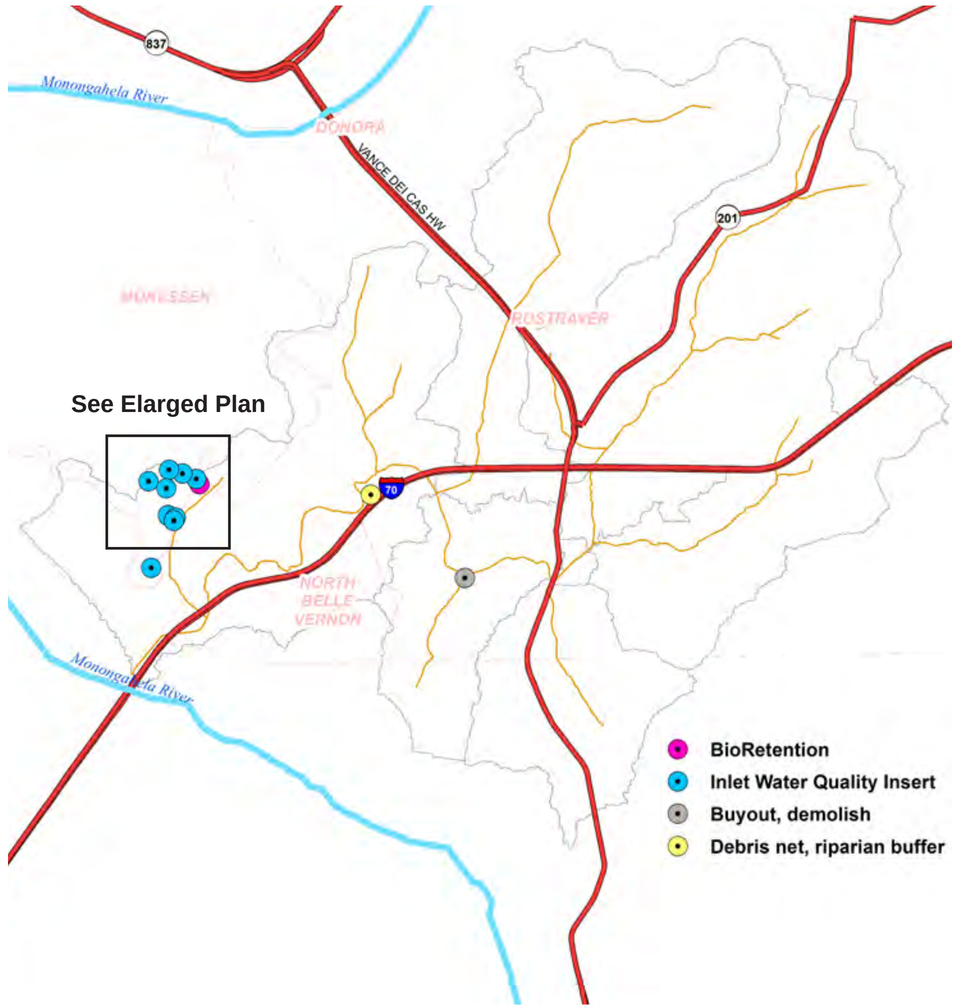
Based on Modeling Watershed Hydrology and Pollution Sources to Inform Smart Water Management:

Effective water management protects valuable resources and built infrastructure.
The Monongahela River and the soil used in agricultural lands in this watershed are both valuable resources that must be conserved for future generations. Conservation efforts should consider ways to manage water runoff that decrease soil erosion, pollution transport, and sedimentation in the reservoir.

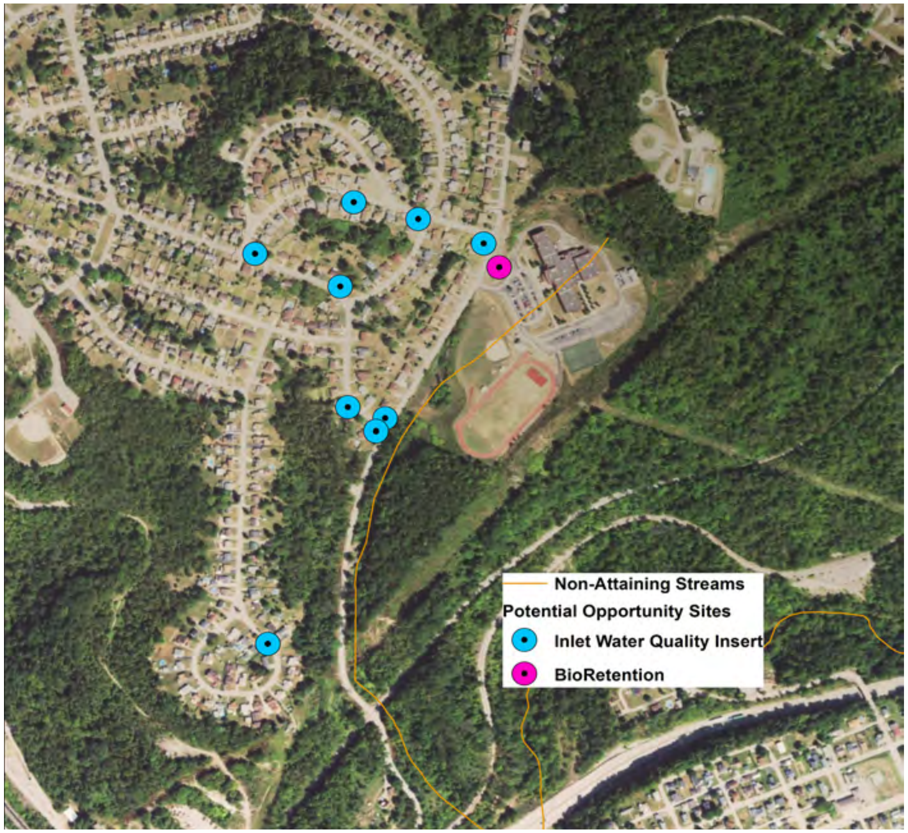
To increase water quality, we must decrease overland water quantity.
Water detained by increasing infiltration to groundwater encourages nutrient retention, or the uptake and filtration of pollutants by biota and soil. Together, the processes of detention and retention increase water quality through decreasing erosion and downstream transport.

Conceptual Ideas for BMP's/Landscape Restoration: Highlighting the potential for water and pollutant capture and retention.
Identified issues include stormwater runoff and associated erosion, as well as the identification of sites appropriate for Green Infrastructure such as stormwater retrofits, riparian buffer restoration, and stream restoration. When coupled with the landscape-based nutrient accumulation and decay modeling, this list can help to identify and prioritize projects for future conservation efforts.

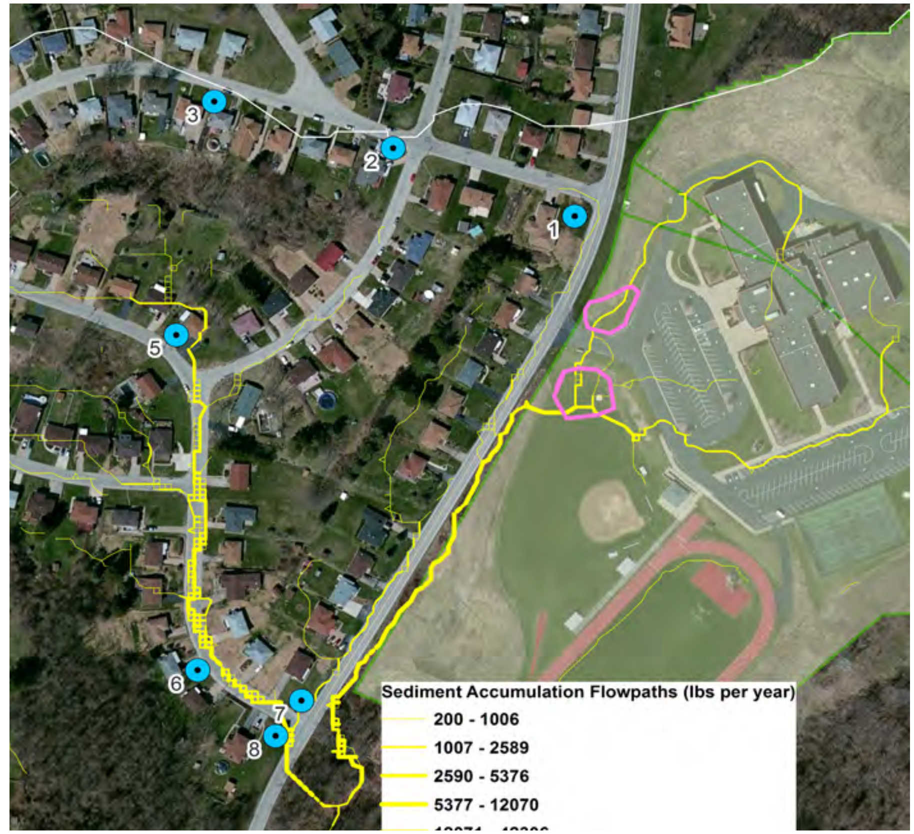
Opportunities for Effective Stormwater management
The sites identified below are considered "Opportunity Sites", or locations where known problems and the potential to fix the problems, both exist. This list was compiled based on reports made by local property owners to the Westmoreland Conservation District and by examination of the city of Monessen MS4 Pollution Reduction Plan (http://cityofmonessen.com/ms4_program.html)



Source - Ethos Collaborative / WCD



Enlarged plan showing opportunities



Enlarged plan indicating sediment acceleration

Source - Ethos Collaborative / WCD

CONCEPTUAL OPPORTUNITIES IN THE MONONGAHELA RIVER AREA OF INTEREST

Conceptual Opportunities: Bioretention Basin and Water Quality Inlet Control Structures

Above are the locations identified in the Monessen Pollution Reduction Plan, compiled by W.EC., Inc. (Bridgeville, PA). W.E.C., Inc, proposed that the identified inlet structures be retrofitted with water quality control structures and that a BioRetention Basin be built on the grounds of the local high school.

Water Quality Impacts of Stormwater Management

Retrofitting inlet structures would improve water quality by reducing a suite of pollutants including sediment, suspended solids, oil and grease, that are entrained in stormwater. The BioRetention Basin would aim to capture a similar range of material washing off of the roofs and parking lots of the school property.

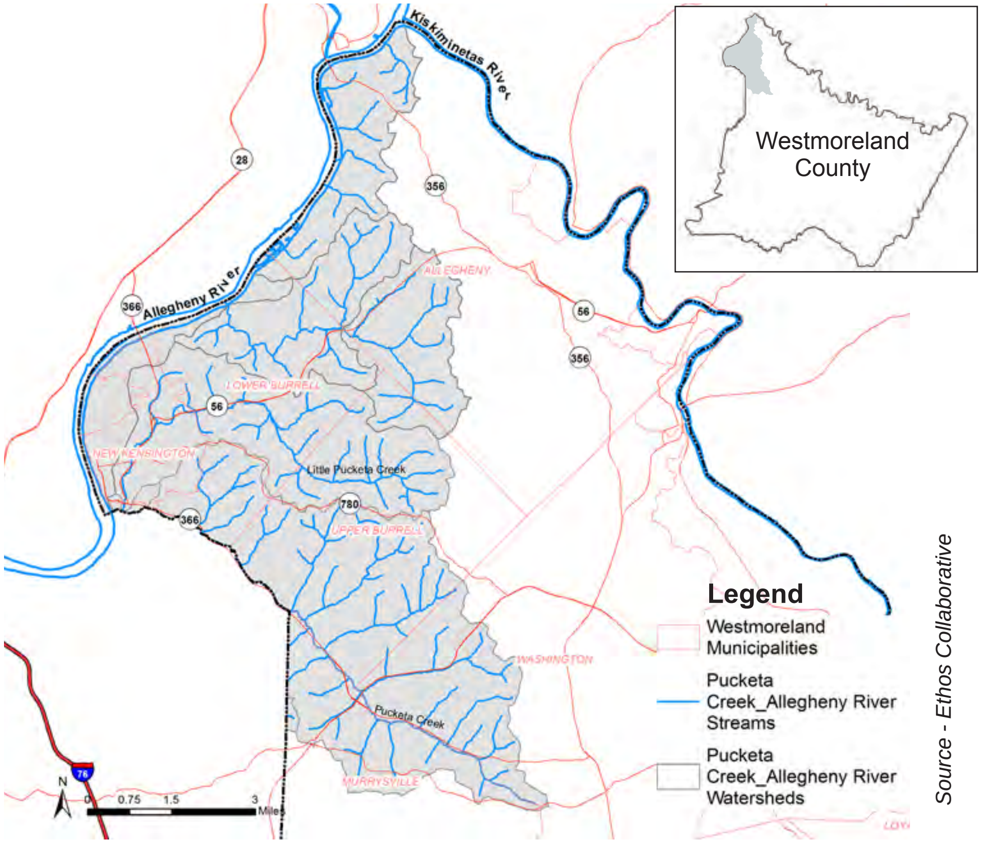
Conceptual Opportunities: Modeling to Inform Decision Making

Modeling the flow pathways and sediment accumulation provides valuable data to identify project priorities. For example, above the yellow lines indicate sediment accumulation pathways. These lines indicate that installing the Inlet Water Quality Inserts would likely be most effective at the lower part of the area of interest (inlets 5-8), rather than at the top (inlets 1,2,3) where they appear to receive less accumulated stormwater.

Water Quality Impacts of Stormwater Management

The Monessen High School grounds are shaded above. Surface flow paths show two areas (outlined in pink) that could potentially capture surface runoff and detain it either in a BioRetention basin (top pink area) or underground storage (bottom pink area).

PUCKETA CREEK, PLUM CREEK, ALLEGHENY RIVER WATERSHEDS AREA OF INTEREST



Source - Ethos Collaborative

Why is this watershed of particular interest?
This region has some historic flooding problems caused by development in low lying land and constant sprawling housing developments that radiate out from the historic urban centers of the City of New Kensington and the City of Lower Burrell. The region also contains very steep slopes that form multiple subwatersheds that rapidly flow into the main stems of Pucketa Creek, Little Pucketa Creek, and Chartiers Run causing flash flooding and sediment accumulation.

Assets in the Watershed
A majority of the region is covered under one of the three MS4 permits that exist for the City of New Kensington, the City of Lower Burrell, and Allegheny Township. They are all currently in the process of meeting these MS4 requirements which has led to the engagement of several local engineering firms to produce Pollutant Reduction Plans that will inventory current stormwater related systems and develop plans to implement projects with the intent of improving water quality. The Westmoreland Conservation District has historically engaged with local governments in the region to implement several water quality pilot projects.

REGION OVERVIEW

The Pucketa Creek, Plum Creek, Allegheny River Area of Interest is approximately 51mi^2/32,640 acres and contains 112.94 miles of streams that drain west eventually into the Allegheny River. The Area of Interest contains several subwatersheds and streams of interest including Pucketa Creek, Little Pucketa Creek, and Chartiers Run. The landcover is primarily deciduous forest and low intensity development and open space. The urbanized land exists in a concentration on the western edge of the watershed, along the Allegheny River, in the form of the City of New Kensington, the City of Arnold, and the City of Lower Burrell. The watershed also contains several state highway corridors including Route 56, Route 366, and Route 780 which serve as conduits for both vehicles and stormwater.

WATERSHED SNAPSHOT

- ***Area: 51 mi^2/32,640 acres***
- ***Water Quality: Impaired for aquatic life due to abandoned mine drainage, siltation, nutrients, metals, and residential runoff.***
- ***Characterization: This area of interest consists largely deciduous forested and low intensity development and open space with urbanized areas in the west.***
- ***The City of New Kensington is the most densely populated region of this watershed and is currently working to reduce pollution as part of an MS4 Pollution Reduction Plan.***

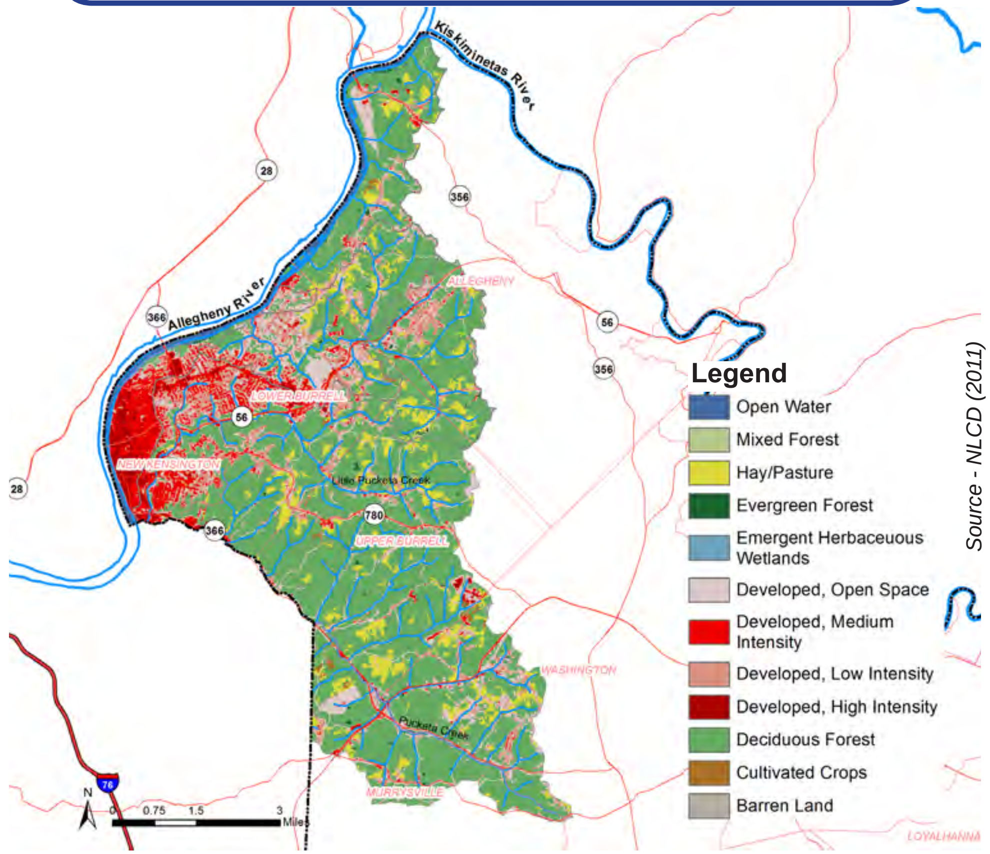
Landcover / Landuse

Landcover in this region is predominantly deciduous forest due to the geographic nature of steep forested valleys that form the subwatersheds of Pucketa Creek, Little Pucketa Creek, and Chartiers Run. Theses forested subwatersheds are dotted with sprawling housing developments that appear as the topography allows. The lower lying areas of the region typically are associated with the main stem of the streams listed above and also contain higher concentrations of development. This mix of higher intensity development in low lying areas along main streams leads to significant flooding events in the region and legacy sediment accumulation. This accumulation of sediment in relatively flat, slow moving streams, leads to restricted flows especially at existing encroachments, such as bridges, and results in flooding.

Landcover data is based on the 2011 National Land Cover Dataset, screated by the Multi-resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.

Landcover Class	*Acres*	*Total Area (%)*
Open Water	376	1.28
Developed, Open Space	3235	11.02
Developed, Low Intensity	3778	12.87
Developed, Medium Intensity	2084	7.10
Developed, High Intensity	622	2.12
Barren Land	21	0.07
Deciduous Forest	17003	57.91
Evergreen Forest	61	0.21
Mixed Forest	30	0.10
Shrub/Scrub	2074	7.06
Herbaceuous	79	0.27
Hay/Pasture	14109	31
Cultivated Crops	3697	8.1

Pucketa Creek, Plum Creek, Allegheny River Area of Interest Landcover Classification

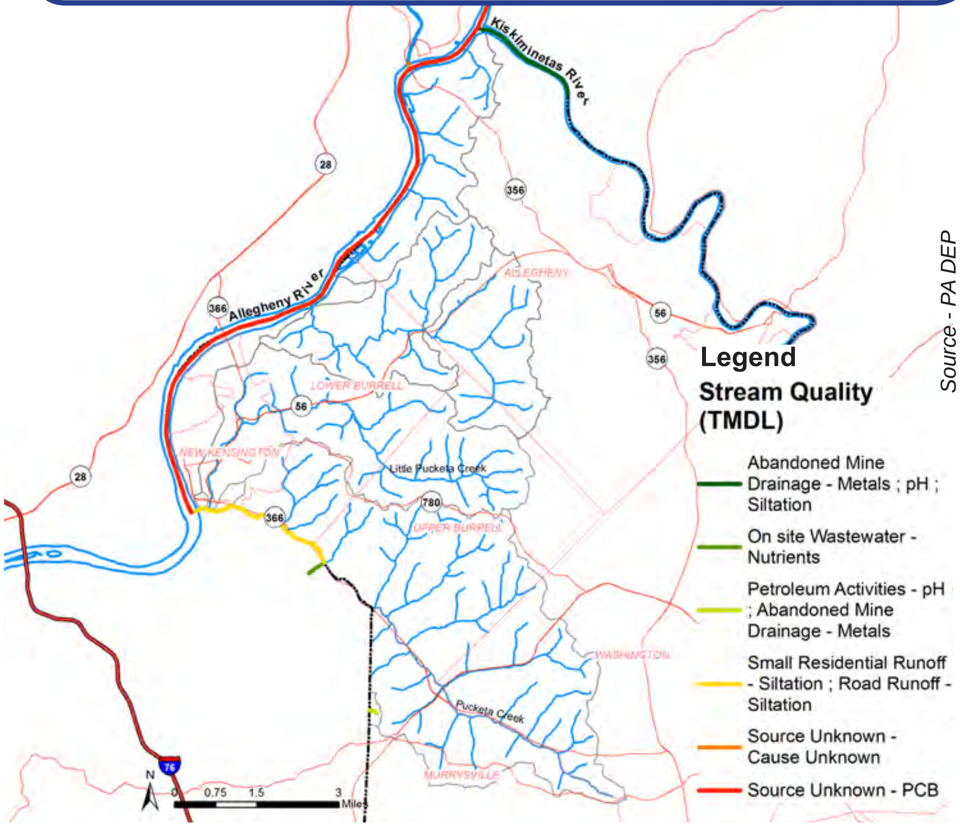


Source - NLCD (2011)

Photo by Rob Cronauer

Little Pucketa Creek - Debris Basin

Pucketa Creek, Plum Creek, Allegheny River Area of Interest Attaining & Impaired Streams



Source - PA DEP

CURRENT WATER QUALITY IN THE PUCKETA - PLUM - ALLEGHENY RIVER WATERSHEDS AREA OF INTEREST

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection identified 98 stream miles as "attaining" their designated use of supporting aquatic life, 15 stream miles as "non-attaining" for that designated use, and the remaining are unclassified. Identified impairments include nutrients from on-site wastewater treatment, siltation residential runoff, as well as runoff and nutrients from derelict lands, and petroleum activities within the watershed. These are considered non-point sources, originating not from one identifiable point but instead from diffuse sources across the landscape.

TMDL status of the streams in this area of interest

The primary TMDL contained within this watershed is a siltation issue along the lower stretch of Pucketa Creek. This excess sediment accumulation is not only harmful for aquatic life, but also contributes significantly to flooding in the region. The other primary TMDL's exists in the section of the Allegheny River along the western edge of the region and in the Kiskiminetas River along the northern edge of the region. The only known source of impairment for these TMDL's are Abandoned Mine Drainage points that exist throughout the area.

Photo by Mark Jackson

Stream Sampling for macroinvertebrates

Photo by Mark Jackson

Allegheny River at New Kensington

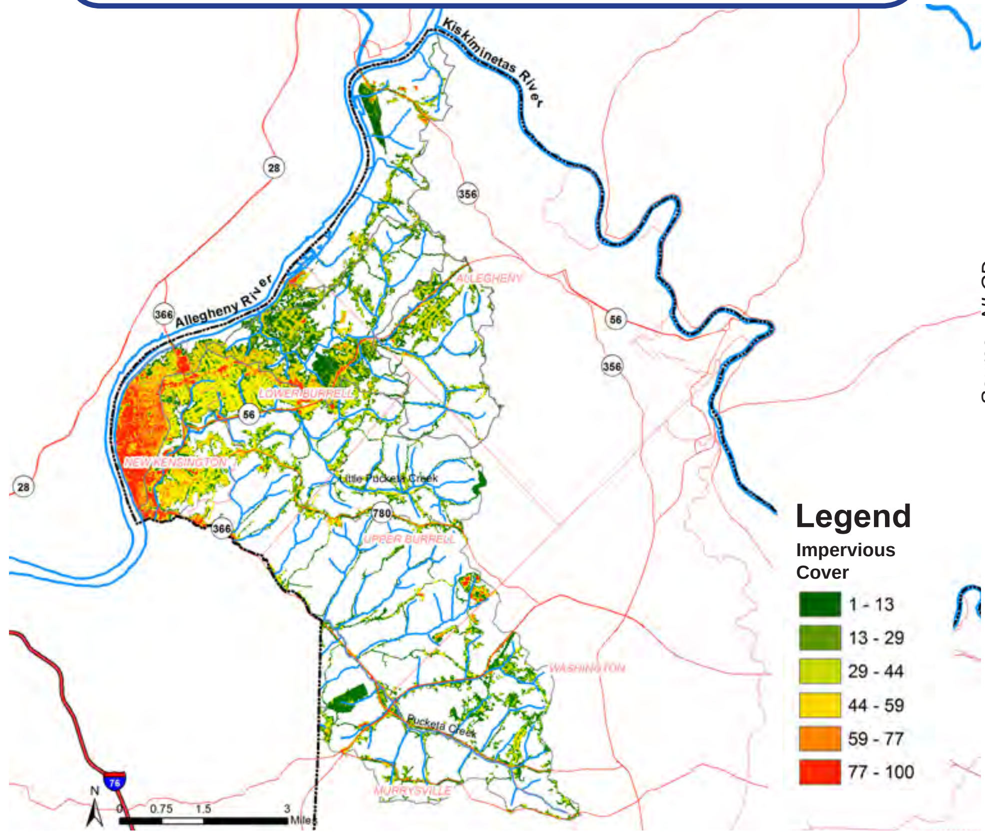
WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE PUCKETA - PLUM - ALLEGHENY AREA OF INTEREST

As water accumulates and moves overland on impervious surfaces, it picks up pollutants from the surface of the landscape and delivers it to receiving waters. Development, particularly that which increases impervious surfaces on the landscape, increases the overland flow of water during storms and decreases infiltration to groundwater.   Increased stormwater also increases the erosive force of overland flow, increasing sediment load and delivering it to downstream receiving waters.

Here, a watershed map shows the high concentration of impervious surface in the area of the City of New Kensington and then the intensity radiates out towards the City of Lower Burrell. From here the impervious surface follows the major highway corridors with residential developments forming pockets of impervious surface throughout the region. Even though a majority of these development have stormwater detention systems, several are designed to outdated standards which do not adequately address rate release for smaller storms, such as the 2 year/24 hr storm. These storms can produce significant concentrated flows from the developments that contributes to flooding, erosion, and general pollutant transport downstream.

As stormwater runoff increases, so does the water's capacity to carry sediment and nutrients such as Nitrogen and Phosphorus. Stormwater may drop sediment and pollutants when the flow/energy of the water decreases.
Both the sediment and the pollution are a threat to water. Accumulated nutrients can lead to harmful algae blooms, which may affect wildlife and water quality in the reservoir. The sediment accumulation represents the erosion, and loss, of valuable soil from upstream landscapes.

Pucketa Creek, Plum Creek, Allegheny River Area of Interest Impervious Cover



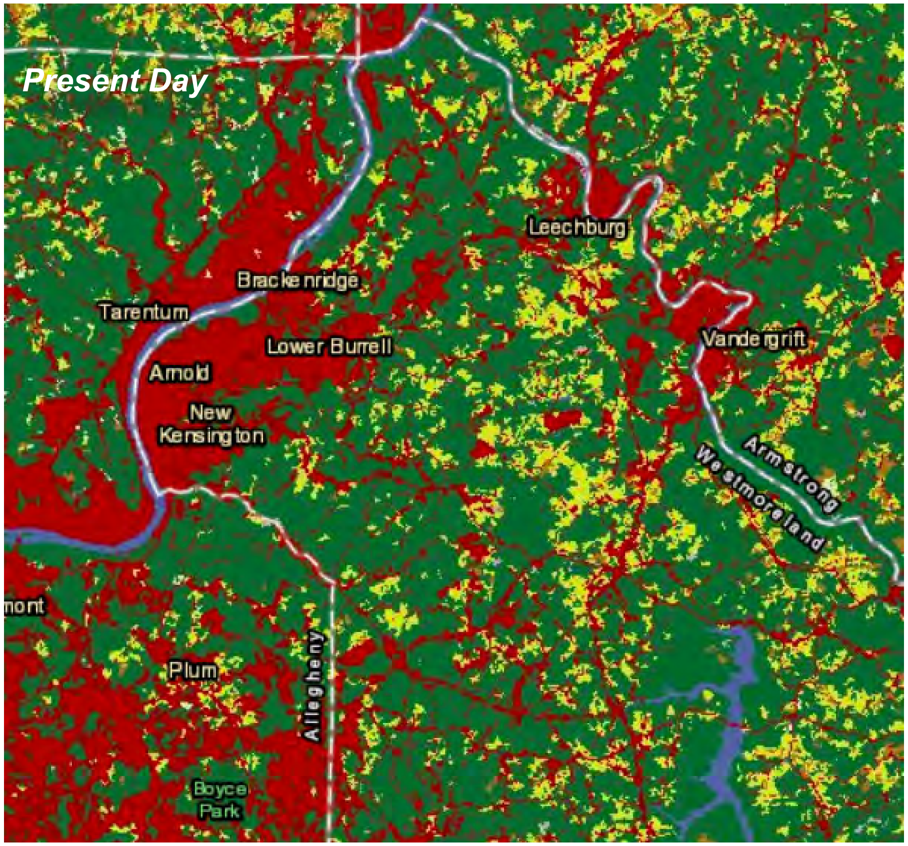
Source - NLCD

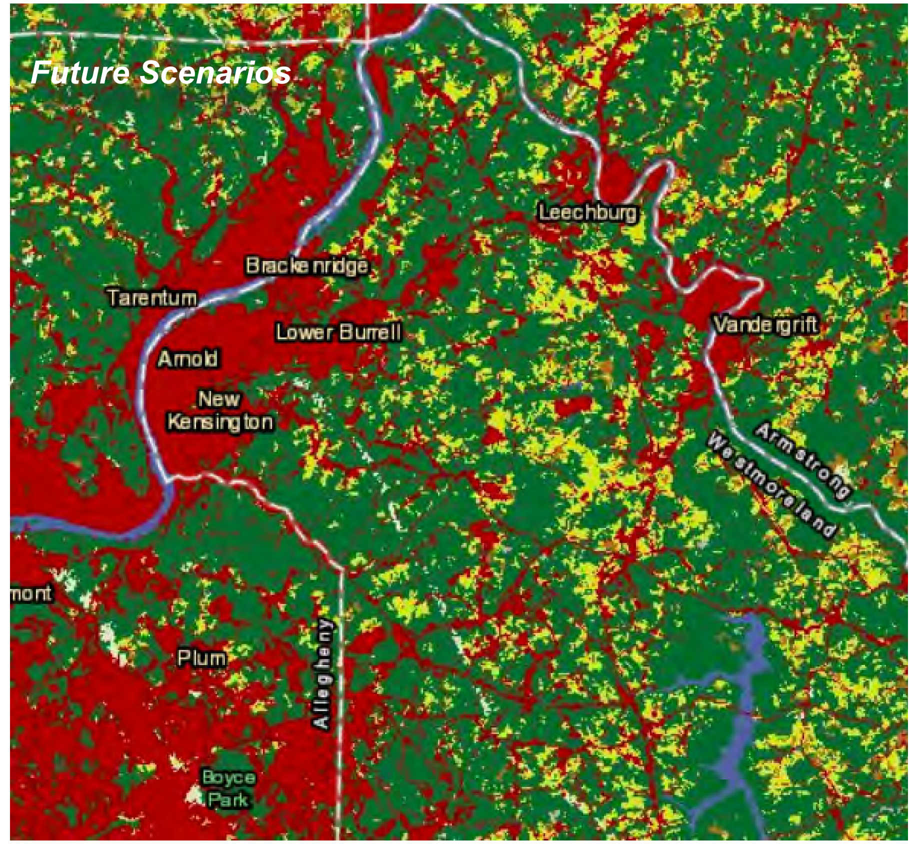
Photo by Rob Cronauer

Valley High School - Pervious Parking Lot

FUTURE TRENDS IN THE PUCKETA CREEK - PLUM CREEK - ALLEGHENY RIVER WATERSHEDS

This watershed will likely see slight increases in development and accompanying slight reductions in forested and agricultural land. These land-use trends will likely add to stormwater runoff and non-point pollution loadings. Carefully planning now to mitigate the effects of these changes will help to decrease flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source - ESRI

Legend

National Land Cover Database

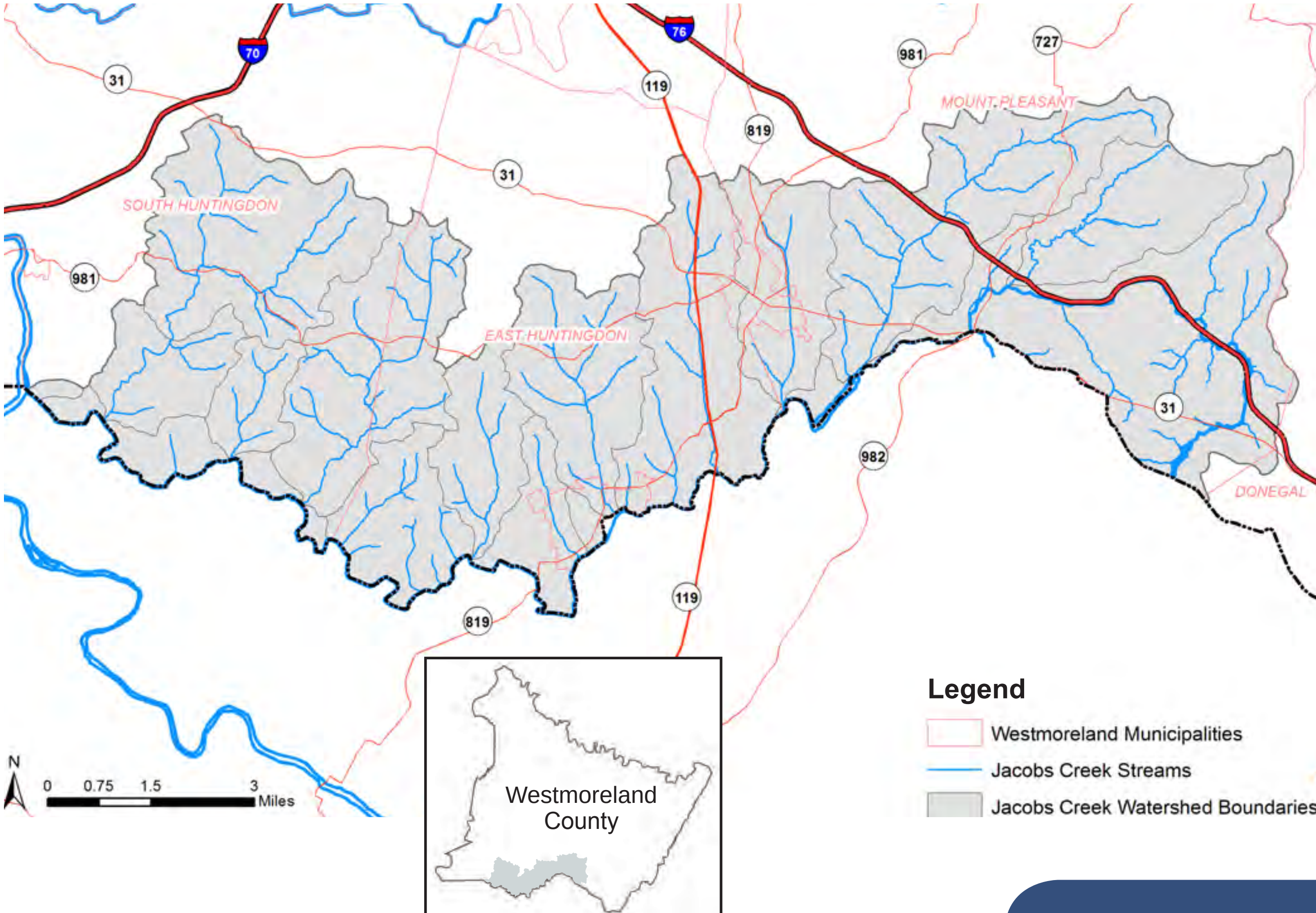
- Open Water
- Perennial Ice/Snow
- Developed
- Barren Land (Rock/Sand/Clay)
- Forests
- Scrub/Shrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Herbaceous and Woody Wetlands

Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted changes in landcover types. Predictions indicate only a slight increase in impervious surfaces. This analysis of land use change in the Conemaugh Area of Interest specifically estimates

- A 9% *INCREASE* in developed land,
- A 6% *DECREASE* in forest cover
- A 0.4% *DECREASE* in agricultural cropland

JACOBS CREEK WATERSHED AREA OF INTEREST



Source - Ethos Collaborative

Why is this watershed of particular interest?
This region was has historically had major flooding issues which at one point lead to the Jacobs Creek Flood Control Project. Even though this project was a success, flooding still occurs upstream in the watershed due to lack of regulation and stormwater detention.

Assets in the Watershed
Both the Boroughs of Scottdale and Mount Pleasant have been very active in pursuing stormwater projects to alleviate flooding and improve water quality. The Jacobs Creek Watershed Association serves as the curator for a majority of these projects and serves as a major asset for the watershed.

REGION OVERVIEW

The Jacobs Creek Area of Interest is approximately 71 mi^2/45,510 acres and contains 150 miles of stream that drain south, forming Jacobs Creek, which eventually outlets into the Youghiogheny River. The landcover is primarily forested and agricultural land with pockets of density spreading out from the areas of Scottdale and Mount Pleasant. The watershed is split almost in the middle by Highway 119 which is a major transportation route running North and South through the county. There are also several state roads running through the watershed such as, Route 819, Route 31, Route 981, and Route 982. A majority of these routes transect between rural farmland to small historic towns and suburbs.

WATERSHED SNAPSHOT

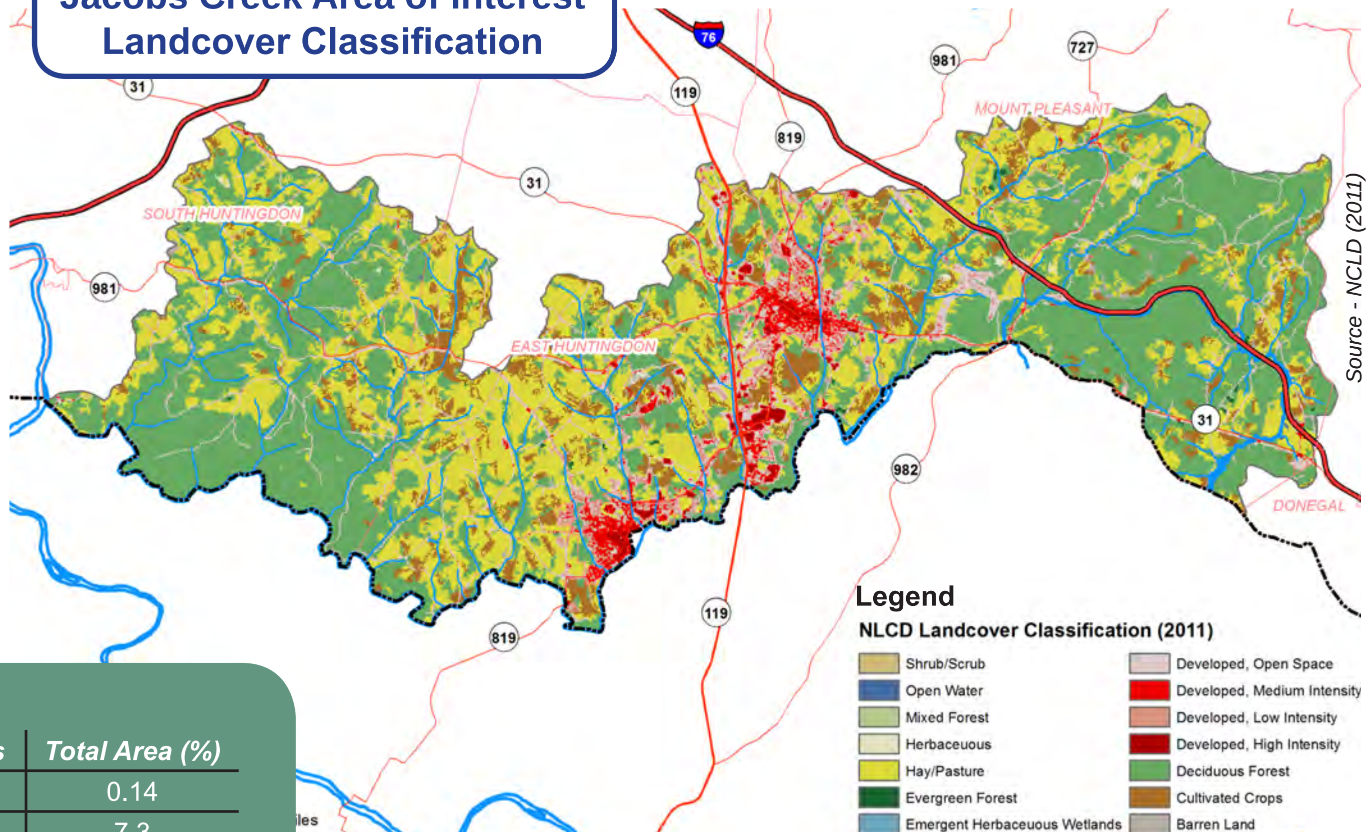
- ***Area: 71 mi^2/45,510 acres***
- ***Water Quality: Impaired for aquatic life due to abandoned mine drainage, siltation, nutrients, metals, and impoundments.***
- ***Characterization: This area of interest consists largely forested and agricultural land with pockets of developed land in the center of the watershed.***
- ***Scottdale Borough, the most densely populated region of this watershed, is currently working to reduce pollution as part of an MS4 Pollution Reduction Plan.***

Landcover / Landuse

The landcover for the watershed is mix between a majority of deciduous forest and agricultural land consisting of pasture and cultivated crops. The concentrations of medium density developed land surrounded by low intensity development represent the areas of Scottdale and Mount Pleasant and their immediate suburbs.

Landcover data is based on the 2011 National Land Cover Dataset, created by the Multi-resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.

Jacobs Creek Area of Interest Landcover Classification



Source - NCLD (2011)

Landcover Class	*Acres*	*Total Area (%)*
Open Water	66	0.14
Developed, Open Space	3315	7.3
Developed, Low Intensity	2006	4.4
Developed, Medium Intensity	1092	2.4
Developed, High Intensity	303	0.7
Barren Land	210	0.5
Deciduous Forest	20553	45.2
Evergreen Forest	65	0.14
Mixed Forest	17	0.04
Shrub/Scrub	7	0.02
Herbaceuous	71	0.16
Hay/Pasture	14109	31
Cultivated Crops	3697	8.1

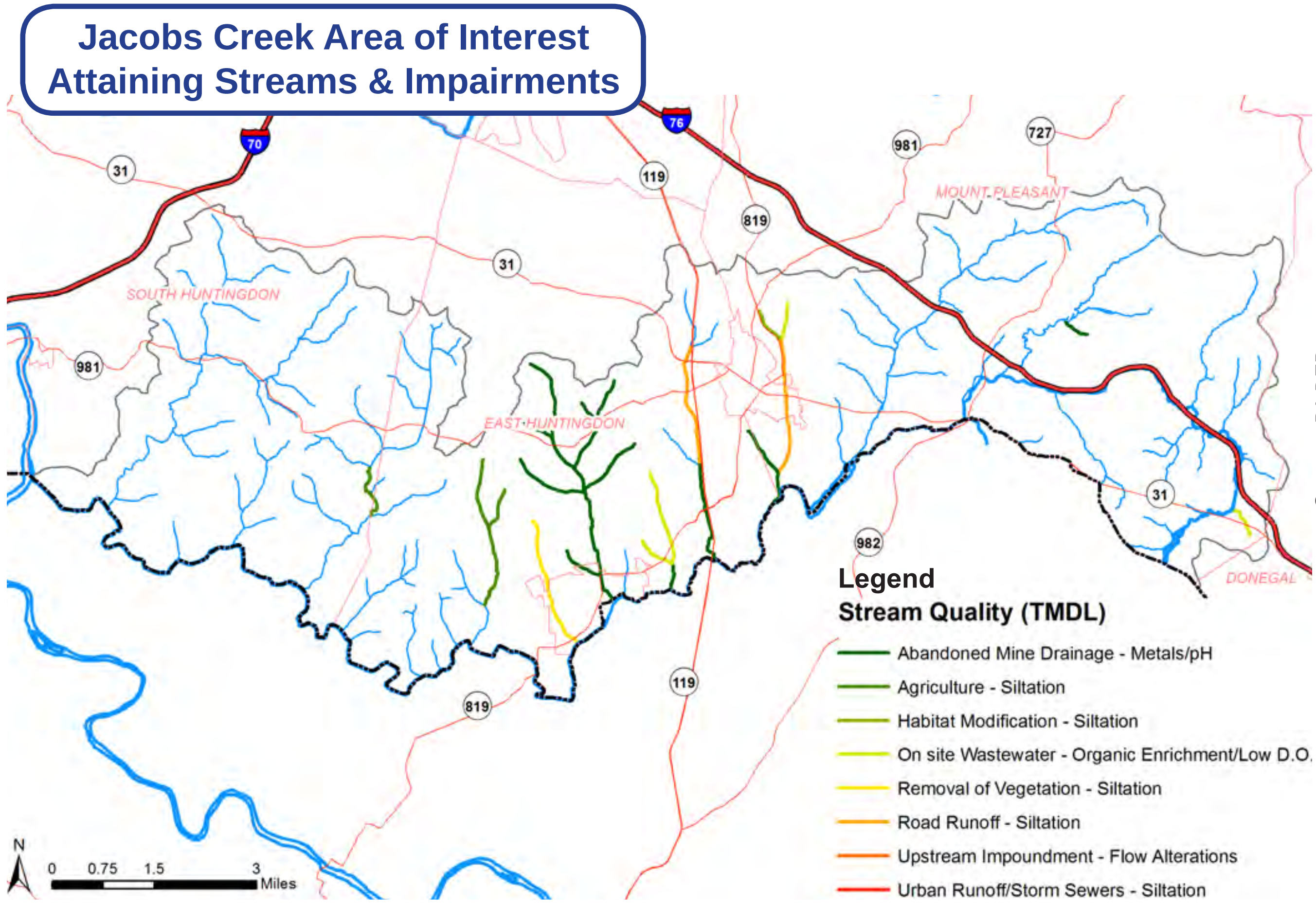
Photo - Jacobs Creek Watershed Association

Bridgeport Dam Reservoir

CURRENT WATER QUALITY IN THE JACOBS CREEK WATERSHED AREA OF INTEREST

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection identified 113 stream miles as “attaining” their designated use of supporting aquatic life, 37 stream miles as “non-attaining” for that designated use, and the remaining are unclassified. Identified impairments include metals/ph from abandoned mine drainage, siltation from agriculture and urban/road runoff. These upstream impairments in the subwatersheds filter down to the main stem of Jacobs Creek causing several segments to be impaired for sediment from various sources.



Source - PA DEP

Photo by Mark Jackson

Jacobs Creek - Stream Stabilization

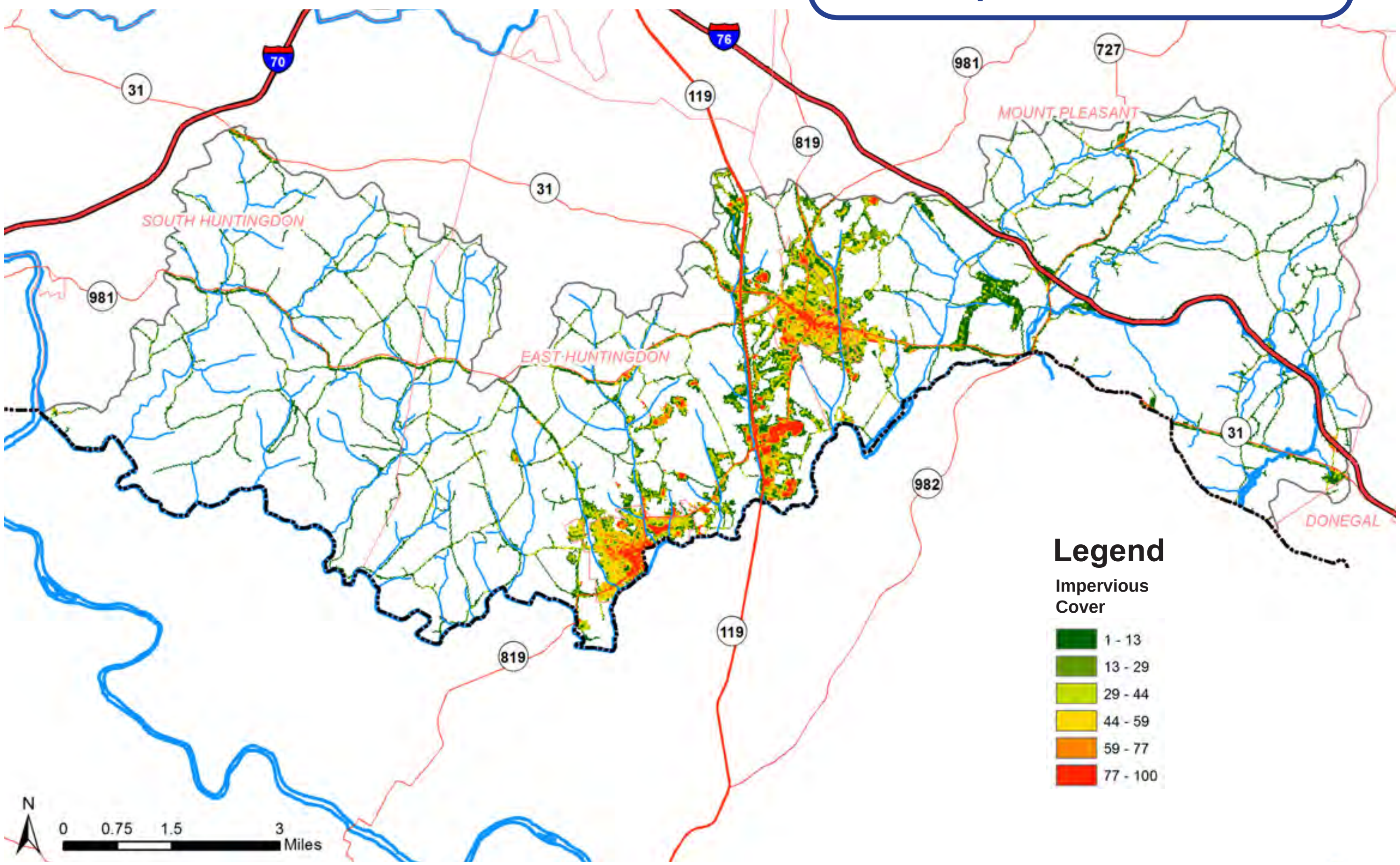
Photo by Stephen Simpson

Jacobs Creek

WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE JACOBS CREEK AREA OF INTEREST

Here, a watershed map shows the concentration of impervious surface in the areas of Scottdale and then stretching north east to Mount Pleasant. These two areas of development also straddle the high concentration of impervious surface that is Route 119 and its businesses. You will also notice the impervious surfaces that are associated with the state road corridors that run through the watershed. These surfaces play a major role in pollutant transfer in these areas due to a lack of regional stormwater infrastructure. Several municipality in the watershed also address the issue of stormwater management differently which can result in watershed related issues.

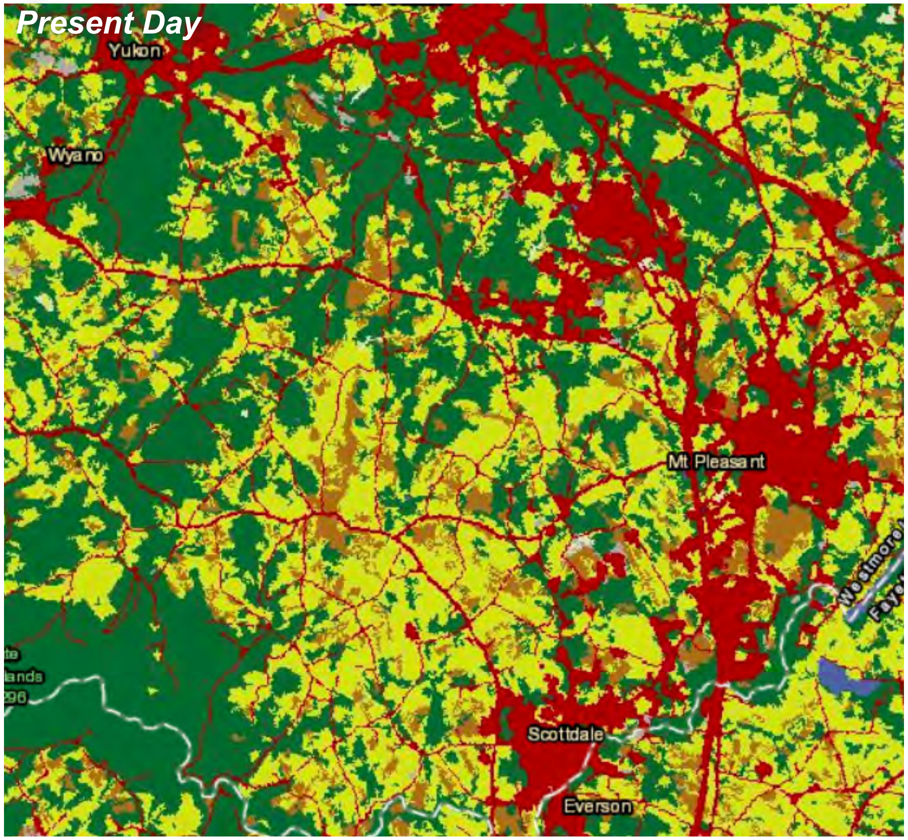
Jacobs Creek Area of Interest Impervious Cover

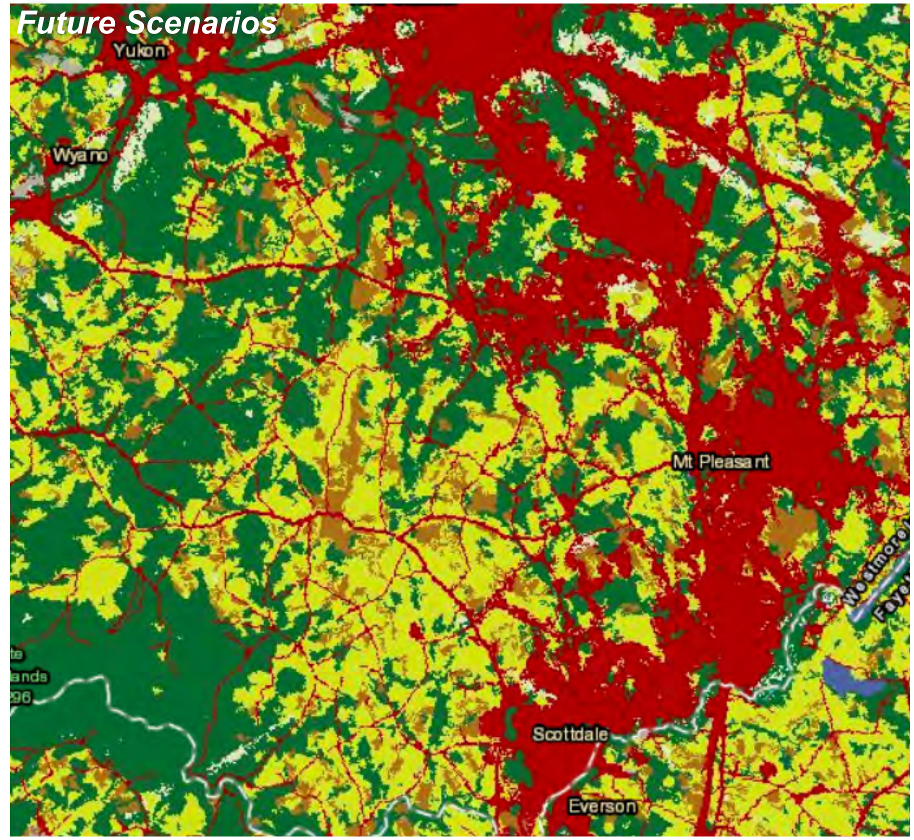


Source - NLCD (2011)

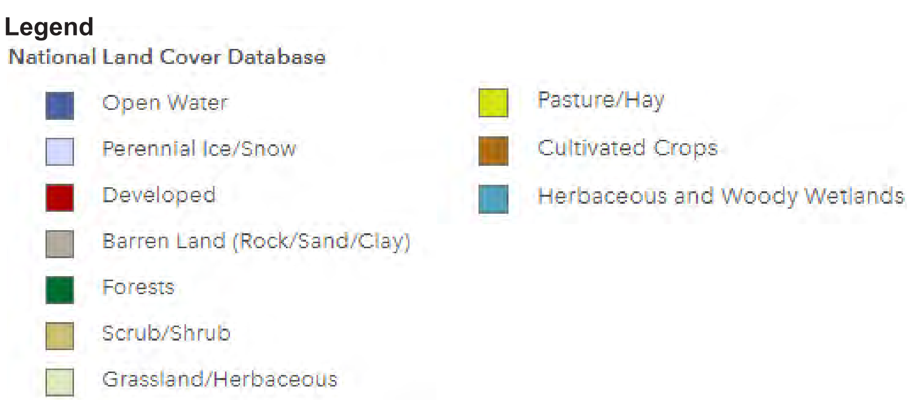
FUTURE TRENDS IN THE JACOBS CREEK WATERSHED

This watershed will likely see significant increases in development and accompanying reductions in forested and agricultural land. These land-use trends will likely add to stormwater runoff and non-point pollution loadings. Carefully planning now to mitigate the effects of these changes will help to decrease flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source - ESRI

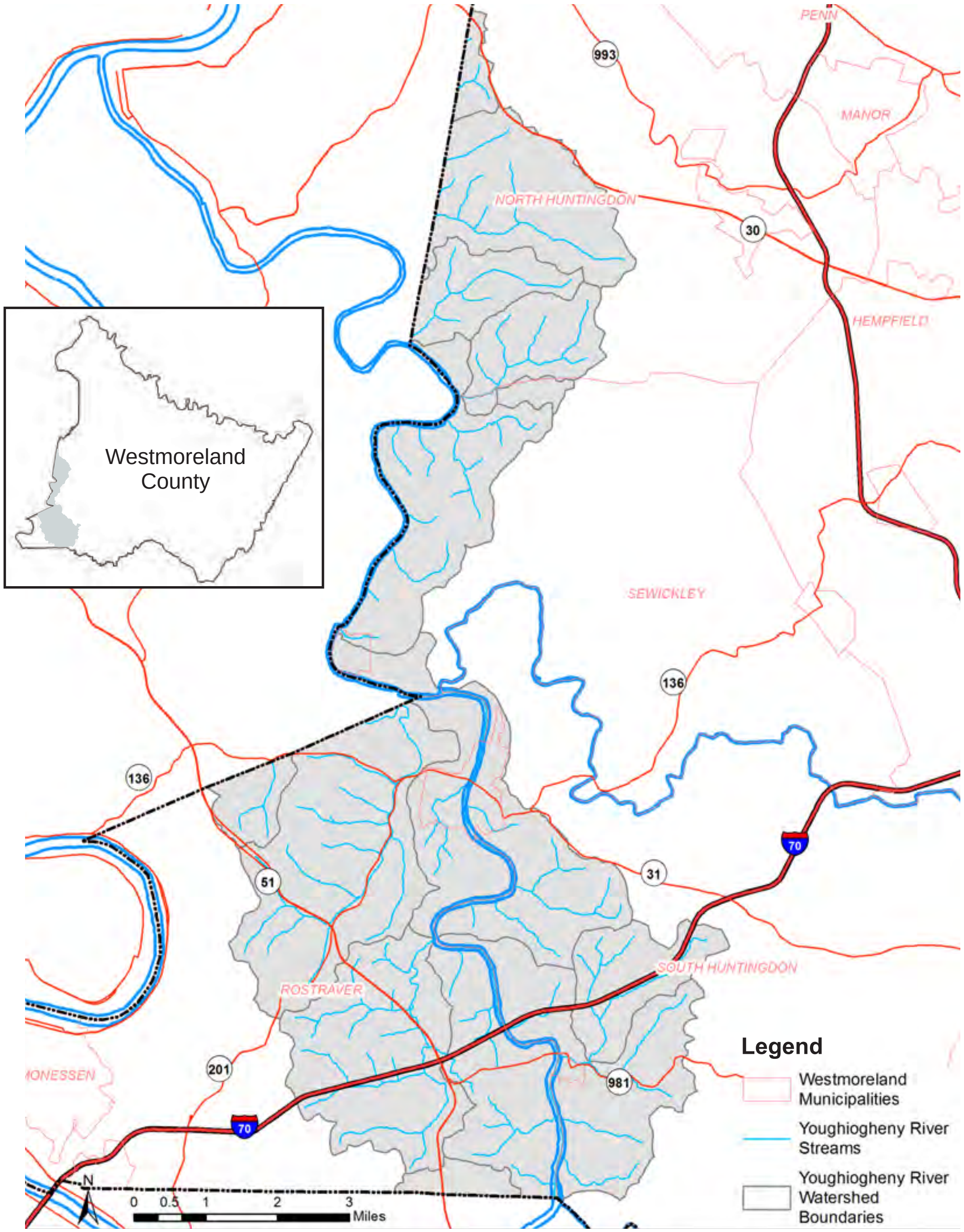


Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted changes in landcover types. Predictions indicate only a slight increase in impervious surfaces. This analysis of land use change in the Conemaugh Area of Interest specifically estimates

- A 37% *INCREASE* in developed land,
- A 7% *DECREASE* in forest cover
- A 10% *DECREASE* in agricultural cropland

YOUGHIOGHENY RIVER WATERSHED AREA OF INTEREST



Source - Ethos Collaborative

REGION OVERVIEW

The Youghiogheny River Area of Interest is approximately 47 mi^2/30,210 acres and contains 119 miles of streams that drain into the Youghiogheny River. Landcover in this watershed is predominantly deciduous forest and hay/pasture, with a concentration of urbanized land and associated impervious surface around the towns of Rostraver, West Newton, and North Huntington. the watershed also contains several major roadways including, the PA Turnpike, Route 51, and Route 30 at the very northern border.

Why is this watershed of particular interest?

This region was identified due to the rapidly developing areas of Rostraver and North Huntington Townships. these areas have seen considerable increases in development over the past several decades as people began to spread from Allegheny County and the Pittsburgh region. The two areas are suited along major transportation corridors and were surrounded by relatively cheap open land, which led to significant increase in both large commercial and residential complexes which have the ability to produce tremendous amounts of stormwater flow.

Assets in the Watershed

The Youghiogheny River flows through several communities designated as MS4 which have been working toward meeting the program requirements by establishing pollutant reduction

WATERSHED SNAPSHOT

- ***Area: 47.2 mi^2/30,210 acres***
- ***Water Quality: Impaired for aquatic life due to abandoned mine drainage, siltation, nutrients, metals,***
- ***Characterization: This area of interest is largely forested and agriculture, with pockets of developed land spread throughout the watershed.***
- ***Rostraver Township, the most densely populated region of this watershed.***

plans. The river is a well-used recreation destination for boating and fishing and for bicycling and hiking along the scenic river trail that runs its length.

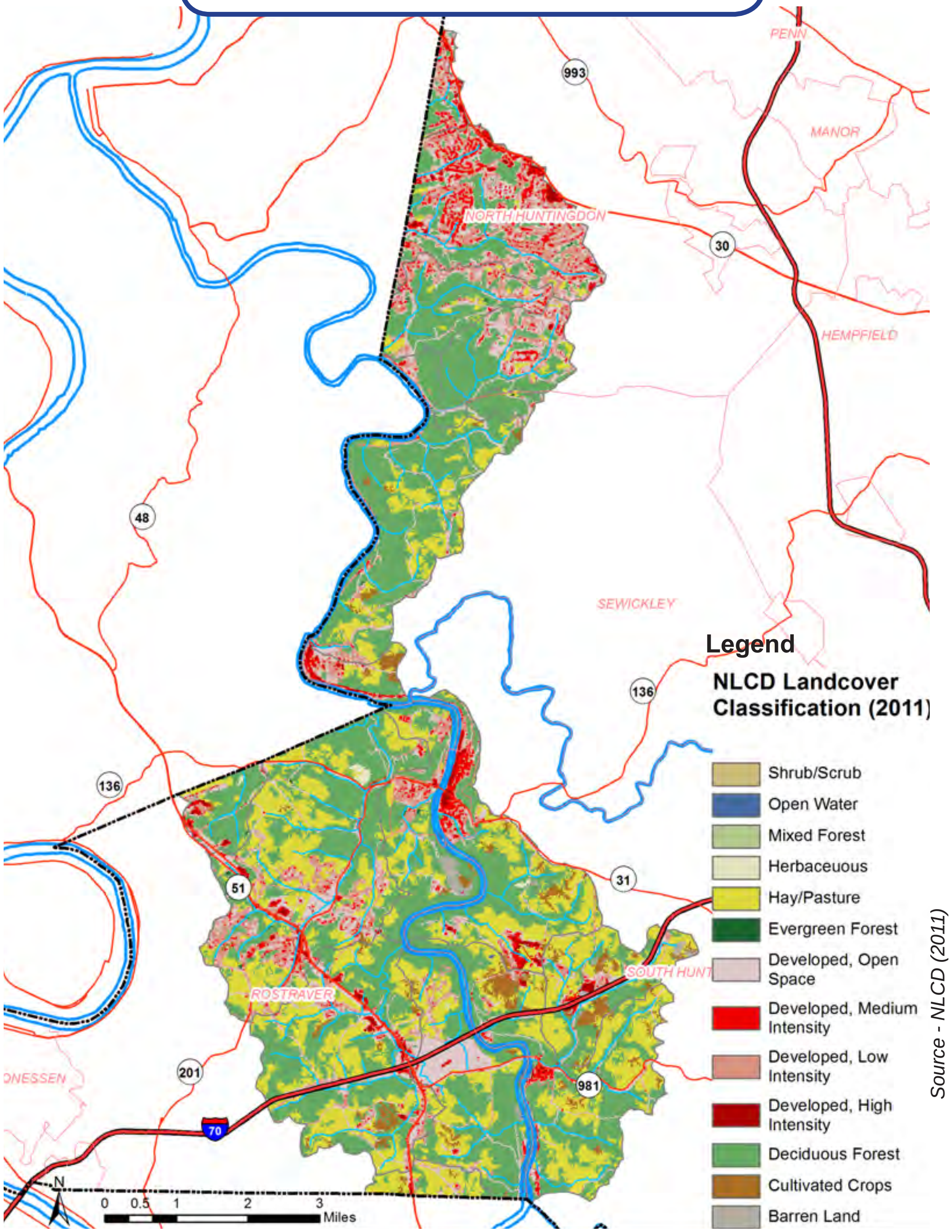
Landcover / Landuse

Landcover in this watershed is predominantly deciduous forest and hay/pasture, with a concentration of urbanized land and associated impervious surface around the towns of Rostraver, West Newton, and North Huntington. These areas were historically agricultural with small towns existing along the river and major highway corridors. As sprawl from the Pittsburgh region headed east, these agricultural lands with easy access to highways became developed into large housing complexes and strip malls, both which are associated with high impervious percentages and ultimately increase stormwater runoff and contributes to water pollutant and migration.

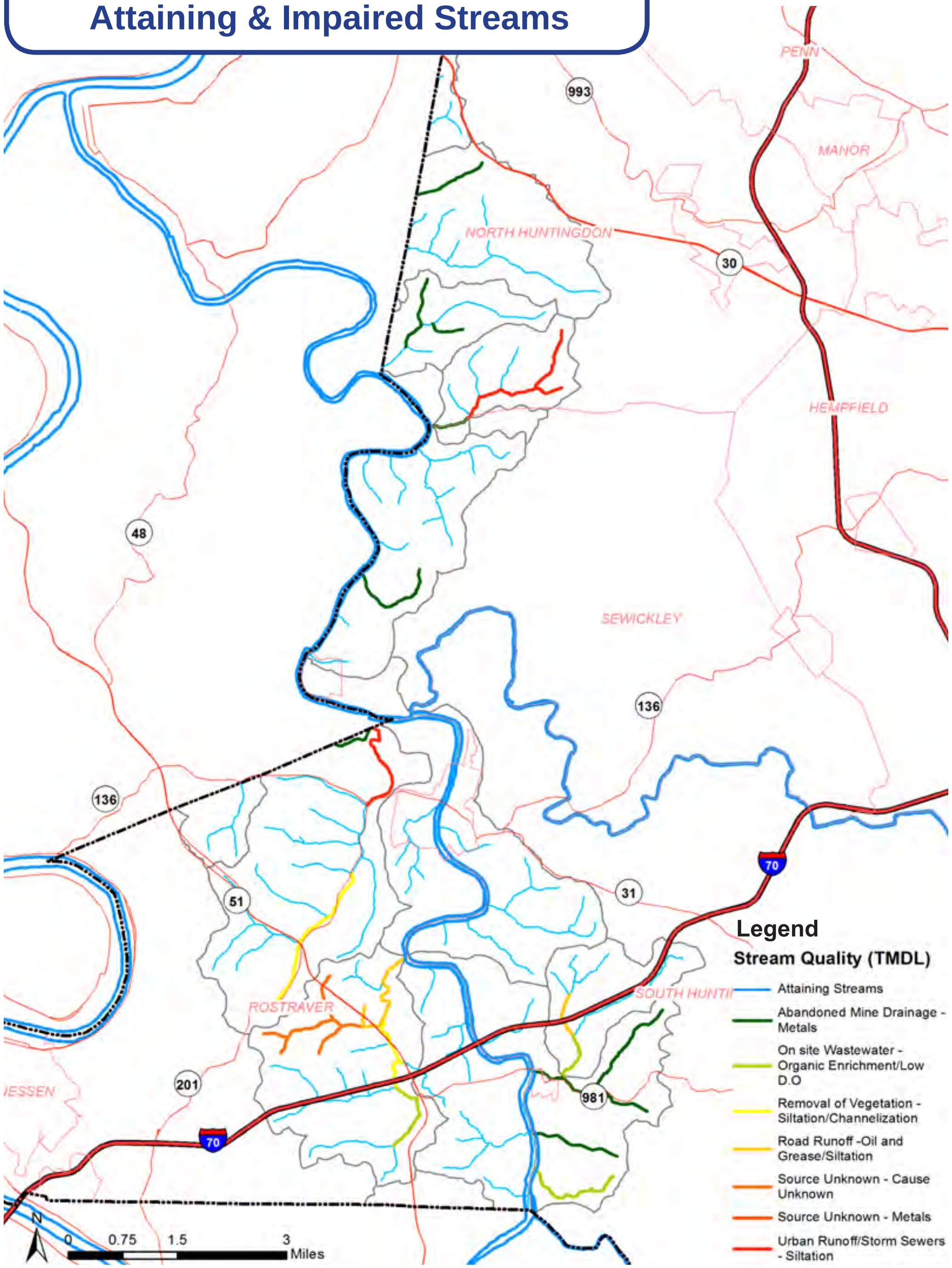
Landcover data is based on the 2011 National Land Cover Dataset, created by the Multi-resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.

Landcover Class	*Acres*	*Total Area (%)*
Open Water	579	1.9
Developed- Open Space	3,555	11.8
Developed- Low Intensity	3,531	11.7
Developed- Medium Intensity	1,328	4.4
Developed- High Intensity	298	1
Barren Land	154	0.5
Deciduous Forest	12,758	42.2
Evergreen Forest	17	0.06
Mixed Forest	17	0.06
Shrub/Scrub	4	0.01
Herbaceous	48	0.16
Hay/Pasture	7,192	23.8
Cultivated Crops	728	2.4

Youghiogheny River Area of Interest Landcover Classification



Youghiogheny River Area of Interest
Attaining & Impaired Streams



Source - PA DEP

CURRENT WATER QUALITY IN THE YOUGHIOGHENY RIVER WATERSHED AREA OF INTEREST

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection identified 88 stream miles as “attaining” their designated use of supporting aquatic life, 31 stream miles as “non-attaining” for that designated use, and the remaining are unclassified. Identified impairments include abandoned mine drainage, on site wastewater, organic enrichment, siltation, and oil and grease. These are considered non-point sources, originating not from one identifiable point but instead from diffuse sources across the landscape.

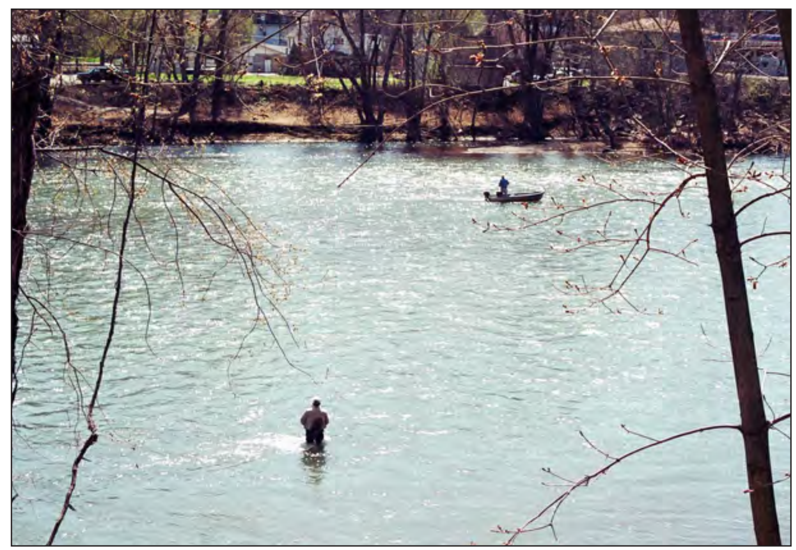


Photo by Mark Jackson

Youghiogheny River at West Newton

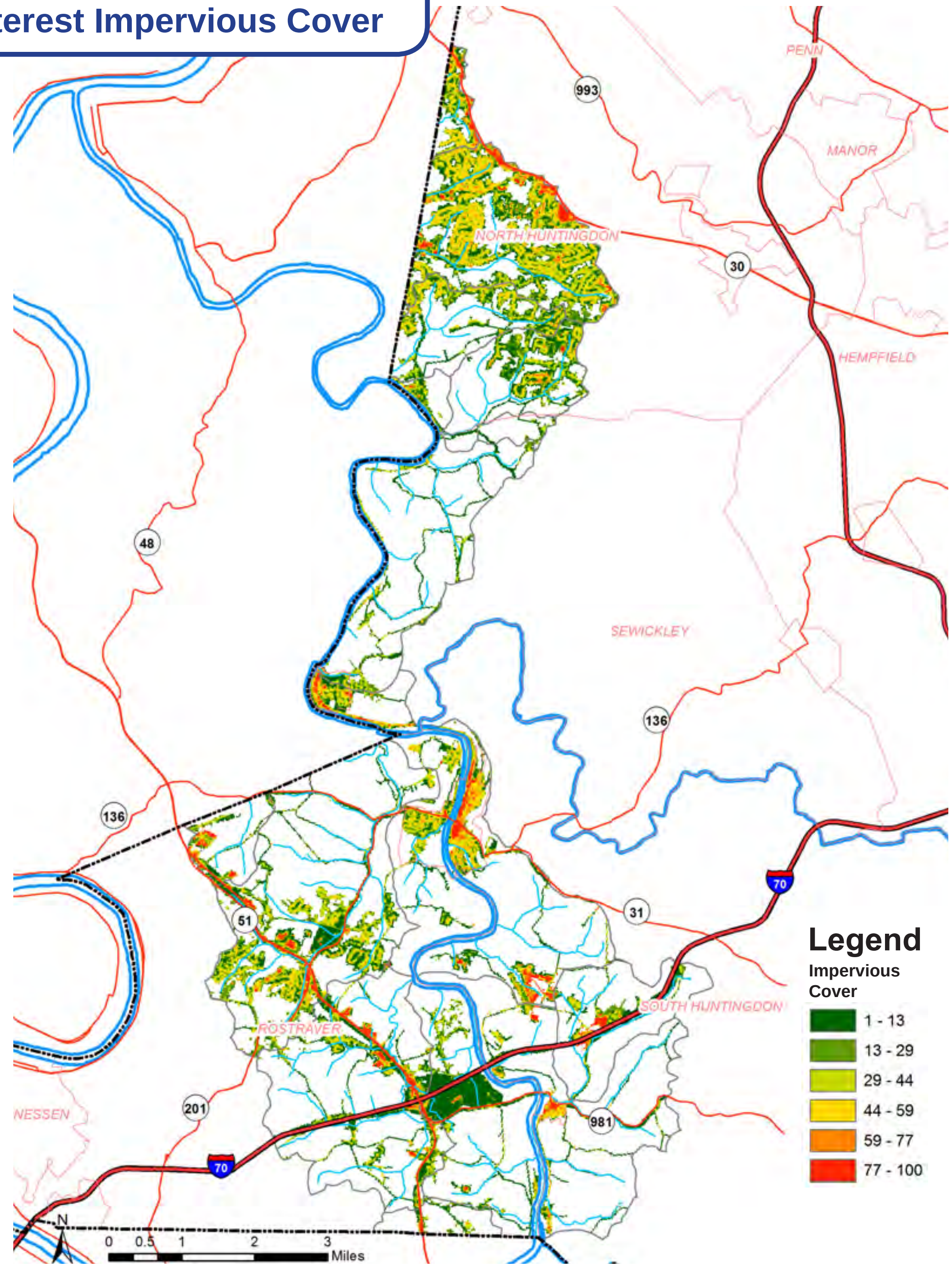
WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE YOUGHIOGHENY RIVER WATERSHED AREA OF INTEREST

The highest concentrations of impervious surfaces in the watershed exist along the major highway corridors and at a few points along the Youghiogheny River. From there the development radiates outward in the form of medium to low intensity development, which can range between 13% - 77% impervious surface. This wide range of impervious surface intensities can produce both flooding and water pollution problems. These high concentration flows can transport pollutants from parking lots as well as pollution from sediment due to the erosive forces of the stormwater that is produced by these large expanses of impervious surface.

Photo - Jacobs Creek Watershed Association

Bridge over the Youghiogheny River at its confluence with Jacobs Creek

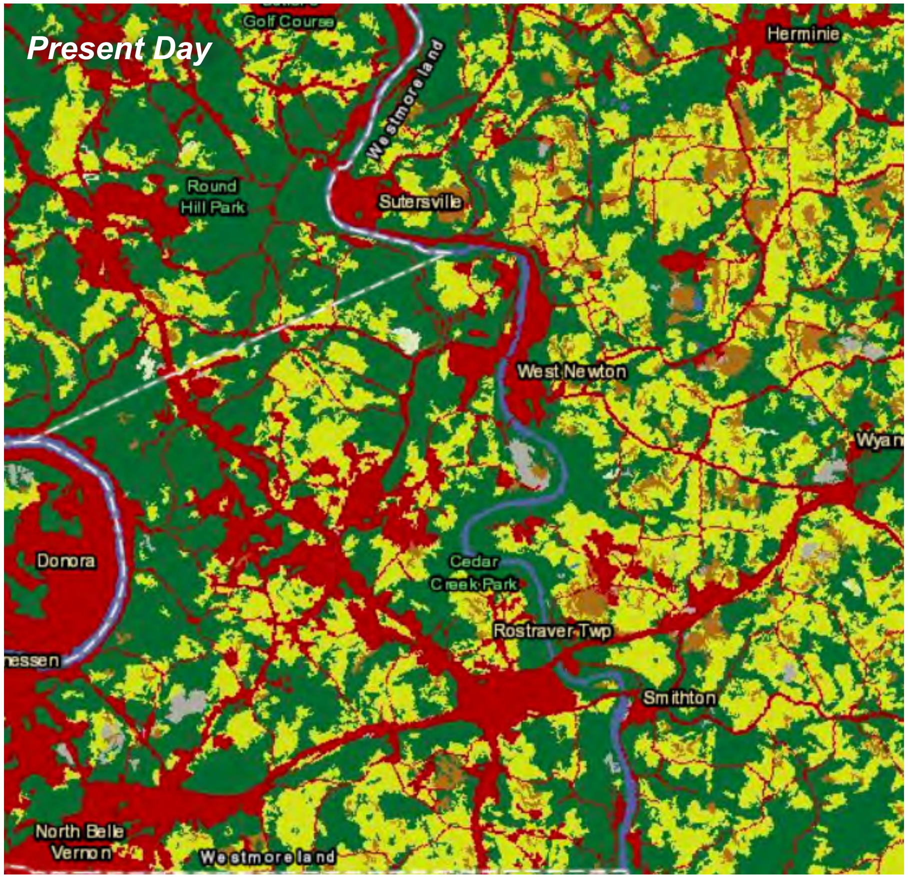
Youghiogheny River Area of Interest Impervious Cover



Source - NLCD

FUTURE TRENDS IN THE YOUGHIOGHENY RIVER WATERSHED

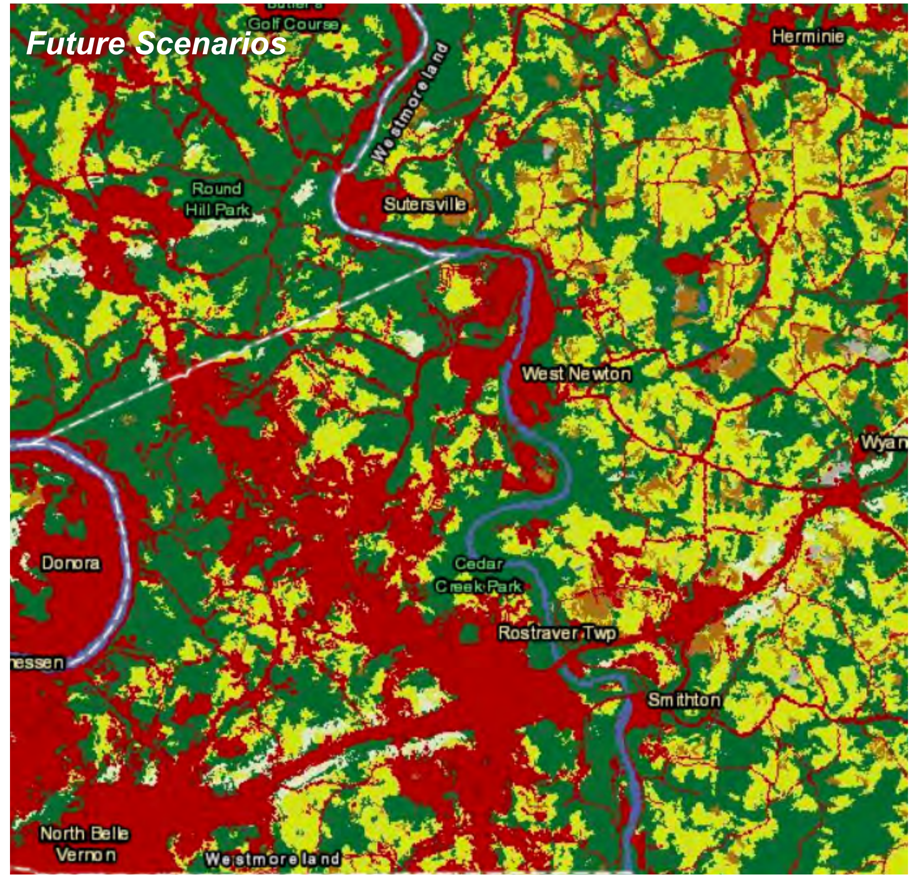
This watershed will likely see significant increases in development and accompanying significant reductions in forested and agricultural land. These land-use trends will likely add to stormwater runoff and non-point pollution loadings. Carefully planning now to mitigate the effects of these changes will help to decrease flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).



Legend

National Land Cover Database

- Open Water
- Perennial Ice/Snow
- Developed
- Barren Land (Rock/Sand/Clay)
- Forests
- Scrub/Shrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Herbaceous and Woody Wetlands



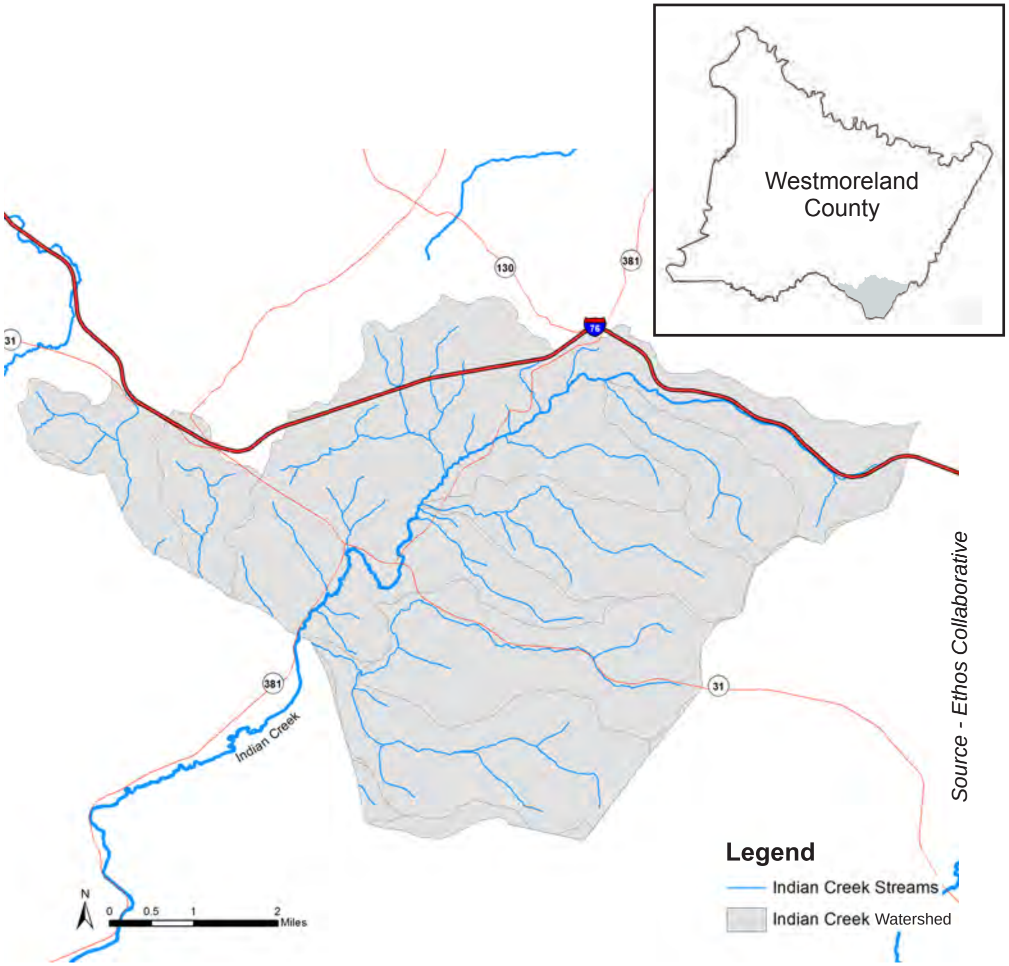
Source - ESRI

Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted changes in landcover types. Predictions indicate only a slight increase in impervious surfaces. This analysis of land use change in the Conemaugh Area of Interest specifically estimates

- A 32% *INCREASE* in developed land,
- A 11% *DECREASE* in forest cover
- A 16% *DECREASE* in agricultural cropland

INDIAN CREEK WATERSHED AREA OF INTEREST



Why is this watershed of particular interest?
This region was identified to be studied due to the ongoing watershed restoration work being done by the Mountain Watershed Association, which is a non profit aimed at protecting, preserving, and restoring the Indian Creek watershed. The area is also of significant regional value as a outdoor recreation and resort destination. This watershed houses the two largest mountain resorts in the geographic region, which brings visitors from several surrounding counties and states to enjoy the beautiful scenery of this watershed.

Assets in the Watershed
The Mountain Watershed Association pursues on-the-ground restoration of past environmental damage, such as coal and shale gas extraction impacts. The organization is focused on holding polluters and environmental regulators accountable in order to protect both the local communities and the environment. This typically comes in the form of conducting site investigation, performing water quality sampling, and if necessary, taking legal actions to ensure compliance with state and federal laws. The group is also currently working on developing the Youghiogheny River Water Trail and the Indian Creek Valley Trail.

REGION OVERVIEW

The Indian Creek Area of Interest is approximately 35 mi^2/22,400 acres in size. Landcover in the watershed is primarily forest with over 80% of the area being forested. This watershed does not have the traditional development pressure as some of the other studied, however its location along the Pa Turnpike and several other state roads has allowed it to be a particularly popular spot for both natural recreation and resource extraction. This can produce a very interesting balancing act between allowing for resource extraction while preserving the natural state of the watershed which has allowed it to become a regional destination for outdoor recreation and enjoyment.

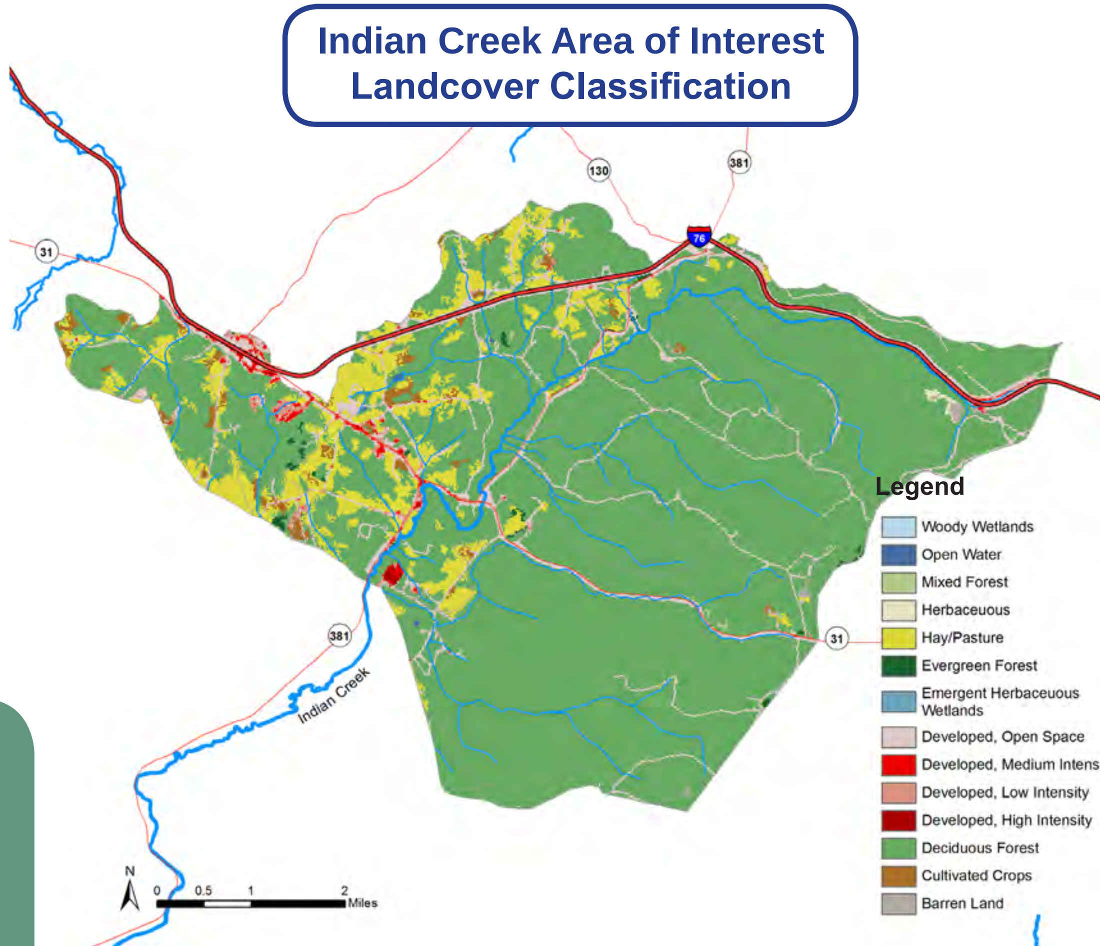
WATERSHED SNAPSHOT

- ***Area:* 35 mi^2/22,400 acres**
- ***Water Quality:* No impairments**
- ***Characterization:* This area of interest consists largely of forested and agricultural land with a pocket developed land in the north west of the watershed.**
- ***Donegal area is the home to several local outdoor attractions such as Seven Springs Mountain Resort and Hidden Valley Resort.***

Landcover / Landuse

Landcover in this watershed is predominantly deciduous forest, with over 80% being forested. The watershed also does not contain any significant amount of developed area, except for the Donegal area. The total developed percentage of the watershed is less than 10%, with virtually all development following one of the state route corridors.

Landcover data is based on the 2011 National Land Cover Dataset, created by the Multi-resolution Land Characteristics Consortium (MRLC). Refer to www.mrlc.gov for methodology.



Source - NLCD (2011)

Landcover Class	*Acres*	*Total Area (%)*
Open Water	10	0.05
Developed, Open Space	1351	6.09
Developed, Low Intensity	322	1.45
Developed, Medium Intensity	214	0.97
Developed, High Intensity	41	0.18
Barren Land	46	0.21
Deciduous Forest	18016	81.23
Evergreen Forest	69	0.31
Mixed Forest	25	0.11
Herbaceuous	18	0.08
Hay/Pasture	1818	8.20
Cultivated Crops	246	1.11
Woody Wetlands	0	0.00
Emergent Herbaceuous Wetlands	2	0.01

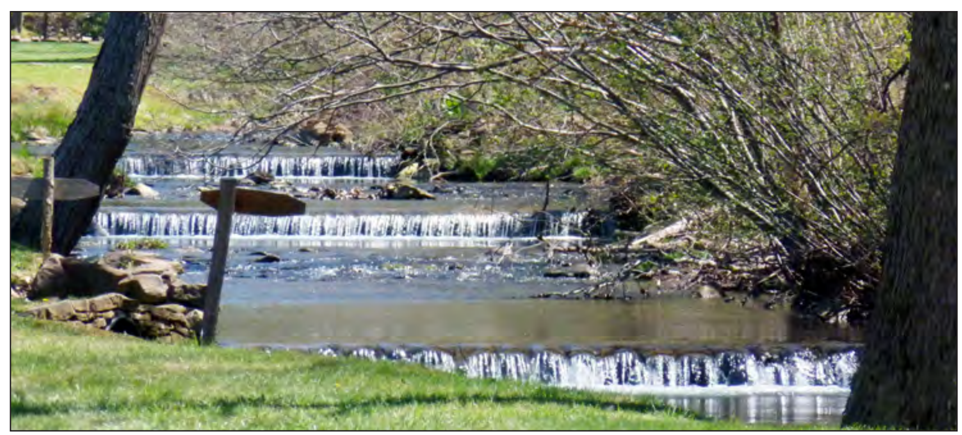
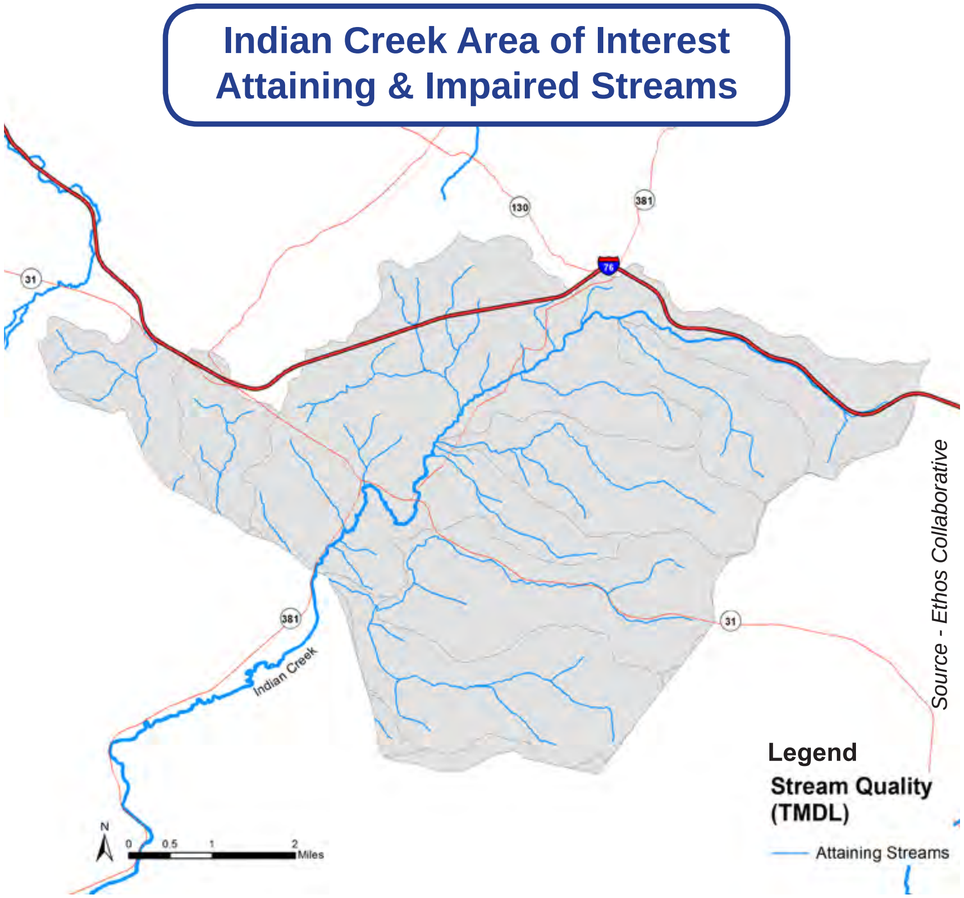


Photo by Stephen Simpson

Indian Creek



CURRENT WATER QUALITY IN THE INDIAN CREEK WATERSHED AREA OF INTEREST

Non-point source pollution

In all, the Pennsylvania Department of Environmental Protection identified the entire watershed as “attaining” for their designated uses. The lack of development and the expanse of forested land helps to contribute to the high level of water quality in the watershed. This high level of water quality has let to the watershed being home to some of the regions most popular and successful outdoor attraction, from skiing to white water rafting. This historic use as a recreational destination mixed with the recent influx of shale gas development in the area has raised concerns for several environmental groups, as they are concerned their regions most precious resource, water, becoming polluted by the gas extraction process.

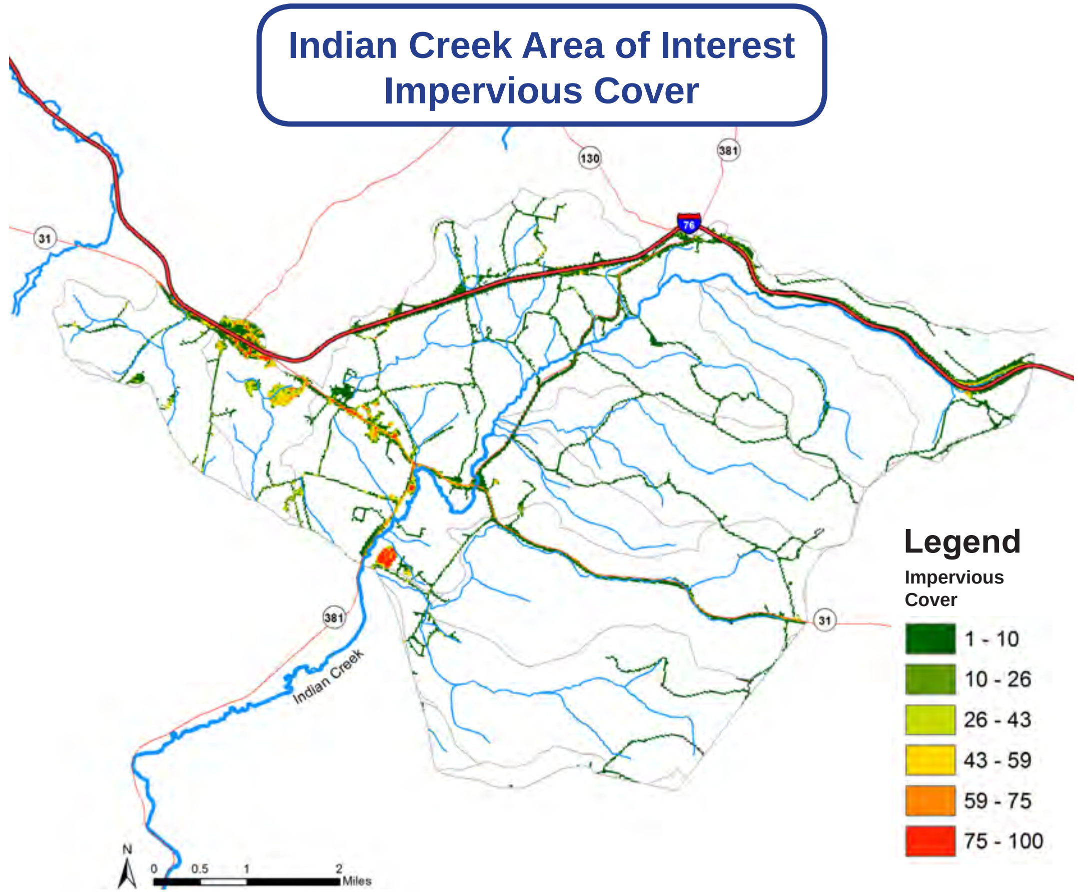
A riparian buffer along an Indian Creek tributary

Indian Creek Trail - Mountain Watershed Tour

WATER QUALITY AND WATER QUANTITY ARE INEXTRICABLY LINKED IN THE INDIAN CREEK WATERSHED AREA OF INTEREST

As water accumulates and moves overland on impervious surfaces, it picks up pollutants from the surface of the landscape and delivers it to receiving waters. Development, particularly that which increases impervious surfaces on the landscape, increases the overland flow of water during storms and decreases infiltration to groundwater. Increased stormwater also increases the erosive force of overland flow, increasing sediment load and delivering it to downstream receiving waters. Here, a watershed map shows the concentration of impervious surface in the area of Donegal and around roads.

As stormwater runoff increases, so does the water's capacity to carry sediment and nutrients such as Nitrogen and Phosphorus. Stormwater may drop sediment and pollutants when the flow/energy of the water decreases. Both the sediment and the pollution are a threat to water. Accumulated nutrients can lead to harmful algae blooms, which may affect wildlife and water quality in the reservoir. The sediment accumulation represents the erosion, and loss, of valuable soil from upstream landscapes.



Source - NLCD (2011)

Photo by Mark Jackson

Marcellus Gas Well Pad

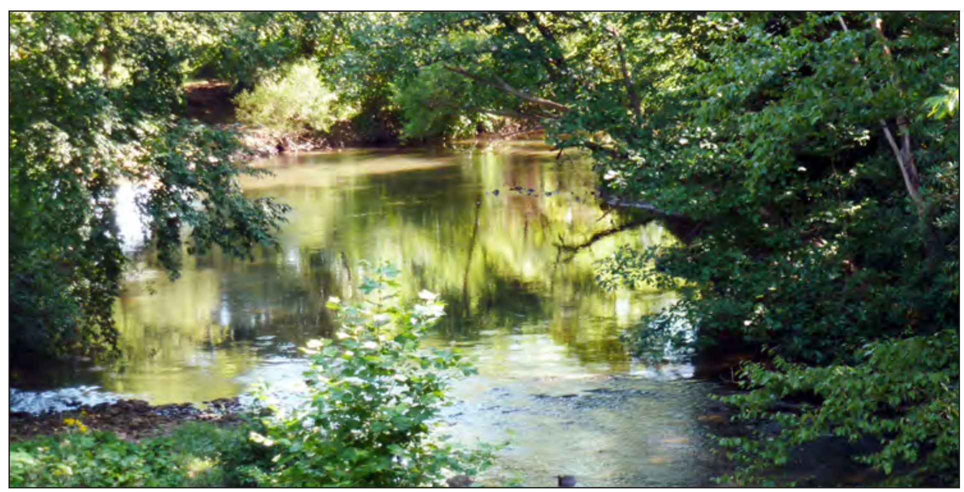
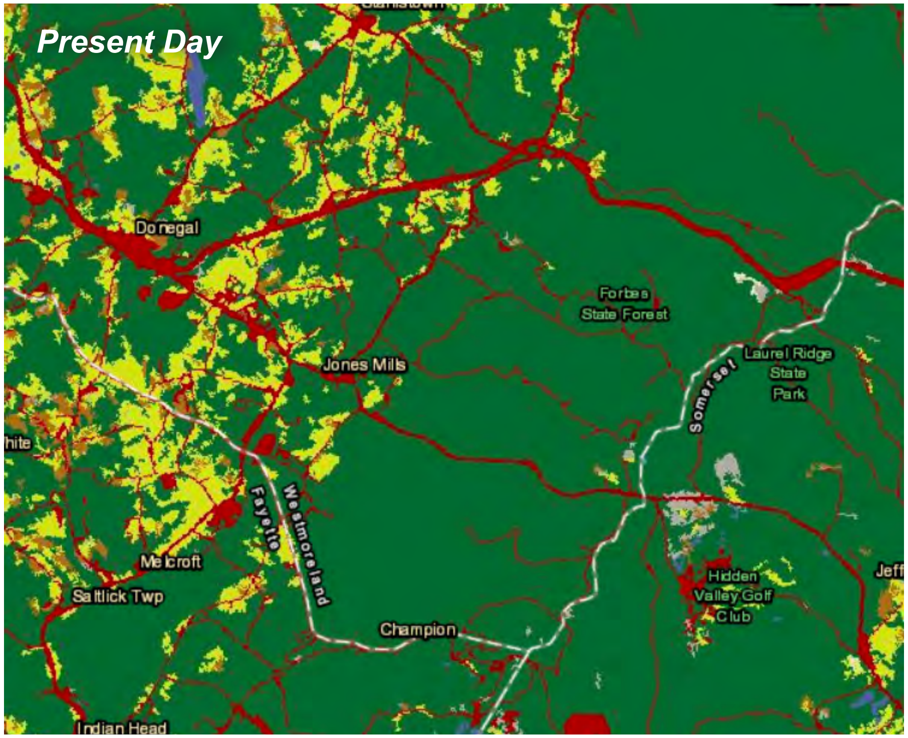


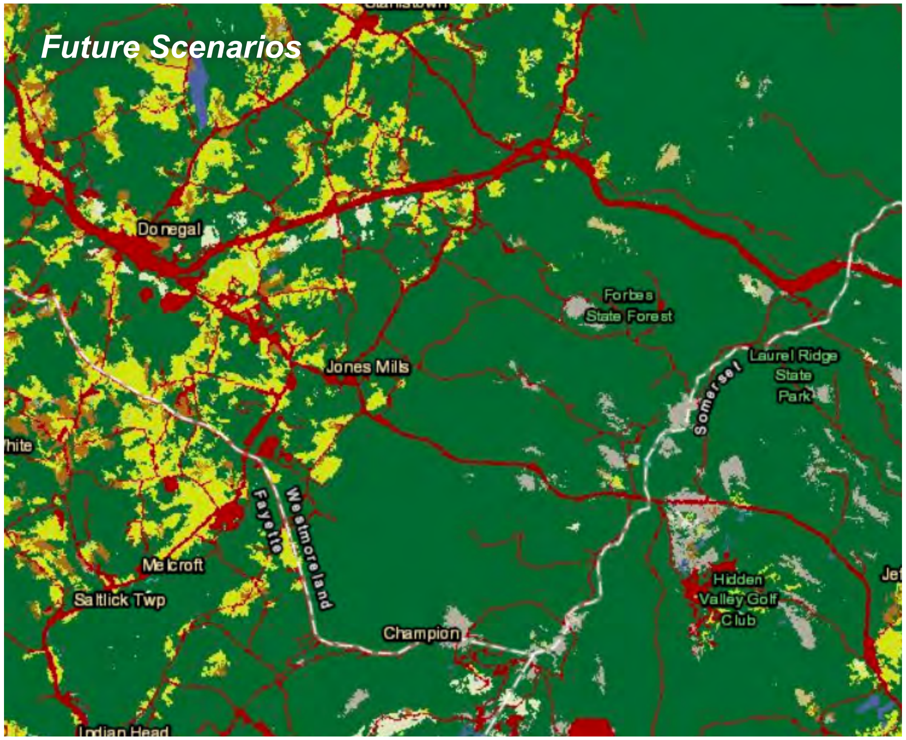
Photo by Stephen Simpson

Indian Creek

FUTURE TRENDS IN THE INDIAN CREEK WATERSHED AREA OF INTEREST

This watershed will likely see slight increases in development and accompanying slight reductions in forested land. These land-use trends will likely add to stormwater runoff and non-point pollution loadings. Carefully planning now to mitigate the effects of these changes will help to decrease flooding and pollution delivery downstream. The projections below are compiled from the ESRI GREEN INFRASTRUCTURE Online Mapping tool, developed in conjunction with the Clark Labs (http://www.esri.com/about-esri/greeninfrastructure).





Source - ESRI

Legend

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- Pasture/Hay
- Cultivated Crops
- Herbaceous and Woody Wetlands

Specific predictions of change in land-use

Above, a visual comparison of land use in 2011 versus predicted land use in 2050 highlights the forecasted changes in landcover types. Predictions indicate only a slight increase in impervious surfaces. This analysis of land use change in the Conemaugh Area of Interest specifically estimates

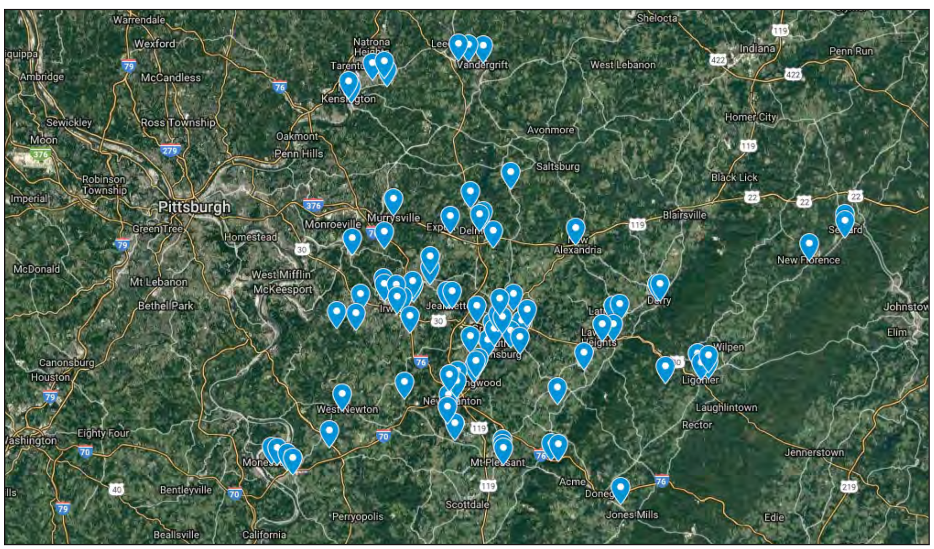
- A 9% *INCREASE* in developed land,
- A 6% *DECREASE* in forest cover
- A 0.4% *DECREASE* in agricultural cropland

CONCEPTUAL PROJECTS AND COSTS

In Chapter 4, IMPACTS, we discussed numerous stormwater issues identified across the county and our watersheds, which generally fall into one of seven categories, or any combination of the seven:

- Flooding
- Inadequate infrastructure
- Water pollution
- Accelerated erosion
- Habitat loss or damage
- Sedimentation and
- Other.

In the same chapter, the **Stormwater Issues** map shows clusters of stormwater complaints and hotspots in the county where multiple complaints and combined issues have been identified. A second map, Conceptual Stormwater Projects, shown below, identifies potential project locations and conceptual projects within each watershed to address these stormwater issues and the pollutants identified in the modeling and reduce the incidence of further degradation of our water resources.



Potential stormwater projects

Conceptual projects like stream restoration and infiltration practices should be chosen specifically for the location and purpose to reduce stormwater volumes, improve water quality, and to solve existing stormwater issues identified across the county within each watershed.

The following projects are the most conventional and can be designed and implemented to abate the most common stormwater issues:

- Land acquisition in flood hazard areas
- Stream restoration, streambank restoration, flood plain restoration
- AMD / AML abatement and restoration
- Mechanical pollutant capture
- Flood control structures and
- Green infrastructure and stormwater management retrofits including:
  - o tree planting
  - o water quality detention basin
  - o permeable paving
  - o infiltration practices
  - o green roof and
  - o more

Westmoreland Conservation District (WCD) has many years of experience with this wide range of projects. Project sheets from the BMP Portfolio describing the design, construction, costs, and maintenance responsibilities of stormwater management retrofit projects that have been completed are located in the Appendices, and summarized here.

LAND AQUISITION

When a property or a neighborhood experiences repeated flooding, stability of a home or neighborhood is at risk. Recurring flooding can escalate costs for the property owner, the community and the state, and property values can be impacted; even injury or loss of life can occur. Additionally, emergency responders may risk their own lives to lend assistance to those impacted by rising waters. For these reasons, federal and state governments, sometimes with grant funding support from FEMA, have acted to intervene in some flood hazard areas by offering voluntary buyout programs to homeowners that have been subject to repeated flooding. Once purchased, a home or homes would be

demolished and the property designated as open space, or returned to a natural state as a flood plain or riparian buffer. Property acquisition is the most permanent form of flood hazard mitigation.
Learn more at www.fema.gov.

STREAM RESTORATION

With population growth and the growth of cities, many small streams – which provide numerous clean water and recreational benefits – were buried. During much of our industrialization period, we did not realize the many benefits that small streams afforded us, so we often enclosed them in pipe systems. Small streams can provide a wide array of benefits to communities, such as nutrient and pollution removal, groundwater recharge, and flood mitigation. **Stream daylighting** is a relatively new approach that exposes some or all of a previously buried river, stream, or stormwater drainage and exists in several forms including:

- Natural restoration – restoring a stream to natural conditions;
- Architectural restoration – restoring a stream to open air, with flowing water located within a constructed channel; or
- Cultural restoration – celebration of a buried stream through markers or public art used to inform the public of the historic stream path, although the stream remains buried.

- from American Rivers

Streambank restoration involves using hard armoring and bio-engineered plantings to prevent erosion of a stream. Certain water-loving plants with extensive root growth, such as willows, are used in this type of project. Stabilizing an eroded streambank can restore habitat and save the loss of thousands of tons of soil each year from a relatively short segment of stream. Economic benefits accrue also as damage to infrastructure is prevented.

Floodplain restoration requires more land, but it is effective for both environmental and safety reasons. Many streams in southwestern Pennsylvania have become incised, that is, they have eroded downward into their bed, forming a rectangular slot through which they flow. During floods, the excess water they carry has no place to spread out and be stored naturally. Floodplain restoration opens up an incised channel and allows the water to slow down as it spills out into the floodplain, thus reducing peak flows downstream.

A **riparian buffer** is a permanent area of perennials, trees, and shrubs located adjacent to streams, lakes, ponds, and wetlands. Riparian forests are the most beneficial type of buffer for they provide ecological and water quality benefits. Restoration of this ecologically sensitive habitat is a responsive action to past activities that may have eliminated any vegetation. - from PA DEP Stormwater Management BMP Manual, 2006

Photo by Kathy Hamilton

Impaired stream corridor before restoration, Westmoreland County Community College (WCCC), near Youngwood.

. Photo by Rob Cronauer

WCCC stream corridor after riparian buffer restoration

AMD / AML ABATEMENT AND RESTORATION

Many of our county's streams have an orange hue. The water smells of sulfur or iron, the rocks in the bed are coated with orange mud, and aquatic life is absent. Although many long-time county residents accept this as normal, it really is a form of pollution by water coming from long-abandoned underground coal mines.

Abandoned Mine Drainage (AMD) can be either net acidic or net alkaline water laden with heavy metals such as iron, aluminum, manganese and others as well as sulfates. AMD originates through the oxidation of sulfide minerals (primarily Pyrite, FeS2). These sulfide minerals, while stable in their undisturbed environment, can be encountered during coal mining or other earth disturbance activities. Once exposed to oxidizing conditions, the sulfide minerals readily oxidize and quickly dissolve in surface and groundwater resulting in AMD pollution.

Photo by Brandon Battistella, Adam Eidemiller, Inc.

This abandoned mine drainage passive treatment system in Lowber, PA, helps remove iron oxide pollutants from the mine water discharging from an old deep mine. The iron oxide gradually settles out as the mine water travels through a system of ponds and wetlands. The cleaned water then enters the Sewickley Creek.

Treatment of AMD is frequently accomplished by allowing the mine discharge to settle out in large ponds, where natural processes allow the iron and other materials to come out of the water. Some of our watershed associations, including Mountain, Loyalhanna, and Sewickley, have AMD treatment sites cleaning up our streams.

MECHANICAL CAPTURE OF POLLUTANTS

Hydrodynamic structures are devices designed to improve water quality by using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff. Often placed in storm inlets and manholes integral with a stormwater conveyance system, these devices are used in high density areas where there is limited space for stormwater water quality systems that require vegetation to break down pollutants.

The goal of **street sweeping** is to clean streets on a regular basis by either machine sweeping, hand cleaning, or flushing to eliminate debris and pollutants before they enter a storm sewer system or water of the commonwealth.

A **debris basin or netting system** captures and removes trash and floatables from stormwater and Combined Sewer Overflow (CSO) discharges. Flow energy drives floating debris and trash into a basin or a disposable mesh netting systems where pollutants are contained. Three-dimensional netting technology removes litter, trash and debris while providing a larger surface area than traditional two-dimensional screens and can accommodate a larger volume of material with lower maintenance frequency. Debris basins require a feasibility study, an engineered plan, and a funding source, but there are many commercially available systems available meeting a variety of parameters and budgets.

FLOOD CONTROL STRUCTURES

Flood control projects are long term structural solutions to a community's flood problem. Considered in response to requests from municipalities, state and federal legislators, county and state government officials and private residents, recurring flood problems are investigated to determine the feasibility of providing solutions to these flood problems. Potential projects must be evaluated by assessing the magnitude and frequency of flooding, performing a hydrologic and hydraulic analysis, evaluating flood control alternatives, estimating construction costs,

Flood control: Conemaugh Dam. Photo from US Army Corps of Engineers

assessing environmental impacts, performing an economic analysis to determine a benefit/cost ratio, determining local sponsor responsibilities, and if appropriate, preparing project design for construction. Types of flood protection projects can include: concrete channels, concrete floodwalls, compacted earthen levees, channel improvements or a combination of a number of these types of alternatives. The main objective of flood control is to minimize property damage and the possibility of loss of life. A program to manage the inspection and rehabilitation of completed flood control projects also must be devised to protect and maintain the structure once complete. Flood control projects are expensive and take years to complete with the evaluation, assessment, analysis, design, funding and construction.

Due to the cost of flood control projects, the question may be raised: Can stormwater management practices be constructed instead? Can a green roof or a rain garden take the place of a flood control dam? The simple answer is that it would take an extremely high number of stormwater management practices to manage a water volume equal to what a flood control project manages. Stormwater management is for the neighborhood; flood control is for the region.

GREEN INFRASTRUCTURE / STORMWATER MANAGEMENT RETROFIT PROJECTS

Tree Planting

Trees historically do more for stormwater management than almost any other type of management techniques, whether by preserving an existing tree or planting a new one. The amount of branching in a canopy of a tree is dwarfed by the amount of root system it has underground. Trees cool the water runoff before it reaches a waterway, keep the soil moist to promote faster infiltration rates, provide a large amount of water uptake, and break down pollutants.

Photo by Kathy Hamilton

Planting canopy trees.

Photo by Matt Zambelli

Frick Hospital water quality basin in Mt. Pleasant, PA.

Water Quality Detention Basin

A **water quality stormwater basin** is a detention pond that intercepts stormwater runoff, provides volume reduction and removes pollutants. Stormwater quality improvement can be made by BMPs including a forebay, a micropool, a wet pool, or even a wetland. The longer the runoff remains in a stormwater basin, the more effective the basin will be in treatment of pollutants, the removal of sediments, nutrients, metals, organic chemicals, or oil and grease from runoff, especially if a vegetated edge is maintained.

A stormwater basin can come in many forms: as constructed wetlands which are shallow marsh systems planted with emergent vegetation designed to treat stormwater runoff; as wet ponds/ retention basins which include a permanent pool for water quality treatment; or as dry extended detention basins that provide temporary storage of runoff and function hydraulically to attenuate stormwater runoff peaks.

The dry detention basin, as constructed in countless locations since the mid-1970's and representing the primary BMP measure even until today, has served only to control the peak rate of runoff, although some water quality benefit is accrued by settlement of the larger particulate fraction of suspended solids and trash. An extended detention basin enhances pollutant removal by modifying the basin outlet structure. Some volume reduction is also achieved in a dry basin through infiltration and some evaporation takes place during detention, but these are negligible. Existing detention basins constructed as volume control only can become water quality basins by retrofitting riser structures and basin layout to provide sediment and nutrient removal, infiltration or extended detention time.

Permeable Paving

The ability to infiltrate the rain where it falls is the key to utilizing permeable paving systems. Given that many thousands of acres of parking exist in our county, providing a 'green' or environmentally friendly way to park cars without generating extra runoff is quite important. Permeable paving should be constructed on nearly level to gently sloping sites with a deep stone base to provide volume for storage and slow infiltration rates. The surface course may consist of porous asphalt, porous concrete, concrete blocks, bricks, or plastic grids. More expensive than other stormwater management techniques, permeable paving allows the paving to manage its own volume of stormwater runoff and can provide a signature look to the finished site.

Photo by Kathy Hamilton

Permeable paving demonstration at J.Roy Houston Convervation Center, Greensburg, PA.

Infiltration practices

An infiltration system encourages stormwater to soak into underlying layers of soil to replenish the groundwater, to provide water uptake by vegetation and to break down pollutants in the process. Infiltration systems come in many shapes, sizes and styles. An infiltration basin is a shallow impoundment that stores and infiltrates runoff over a level, uncompacted (preferably undisturbed) area with relatively permeable soils. An infiltration trench is a "leaky" pipe in a stone filled trench with a level bottom, and may be used as part of a storm sewer system, especially to replace a relatively flat section of storm sewer.

A **rain garden** (also called **bioretention**) is an excavated shallow surface depression planted with specially selected native vegetation to treat, capture, and provide uptake of runoff. As its name implies, a rain garden can be a rather attractive area, landscaped to fit in to the surroundings, and while functional, can also add beauty to a property. Stormwater from a roof or paved area fills the rain garden and soaks slowly into the ground; some is taken up by the plants during the growing season also.

Photo by Kathy Hamilton

A wet rain garden at the GreenForge building, Greensburg, PA

Photo by Kathy Hamilton

A greenroof covers 9,000 square feet at the GreenForge building, Greensburg, PA.

Green Roof

A **green roof** is a layer of vegetation that is grown on and completely covers an otherwise conventional flat or pitched roof (less than 3 percent slope), endowing the roof with hydrologic characteristics that more closely match surface vegetation than the roof. The overall thickness of an extensive green roof may range from 2 to 6 inches and may contain multiple layers, consisting of waterproofing, synthetic insulation, drainage layer, engineered growth media, separation fabrics, and non-invasive vegetation. Vegetated roof covers can be optimized to achieve water quantity and water quality benefits. Through the appropriate selection of materials, even thin vegetated covers can provide significant rainfall retention and detention functions.

EFFECTIVENESS VALUES

The PA DEP has created a list of BMPs and their effectiveness titled 'NPDES Stormwater Discharges from Small Municipal Separate Storm Sewers BMP Effectiveness Values,' which is available on their website. Primarily intended for use by MS4s that are developing and implementing Pollutant Reduction and TMDL Plans to meet permit requirements, the values consider pollutant reductions from both overland flow and reduced downstream erosion. Following design considerations, operation and maintenance, and construction sequences outlined in the PA DEP Stormwater BMP Manual, or other technical guidance, this table can be used as a guide to reduce impairments. http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=11069&DocName=3800-PM-BCW0100m%20BMP%20Effectiveness%20(Final).pdf

COSTS

Costs vary from project to project, related to location, size, materials, technique, and other factors. Techniques should be chosen to meet the existing site conditions and to solve the identified stormwater issue. The adjacent chart is a representation of gallons of runoff treated and cost of BMP construction per gallon of runoff treated.

Learn more by reviewing the BMP Portfolio pages in the Appendices.

FUNDING

Funding sources can be found at federal, state, and local levels, or local communities or organizations can create authorities or funding streams of their own to provide the funds to pursue project development. Many opportunities are listed in the IWRP Chapter 6: Action Plan under "Initiatives."

Stormwater Volume Control

during 1 inch rainfall

Stormwater Treatment Costs

per gallon