Land-use changes and water quality in the upper Salt River Watershed

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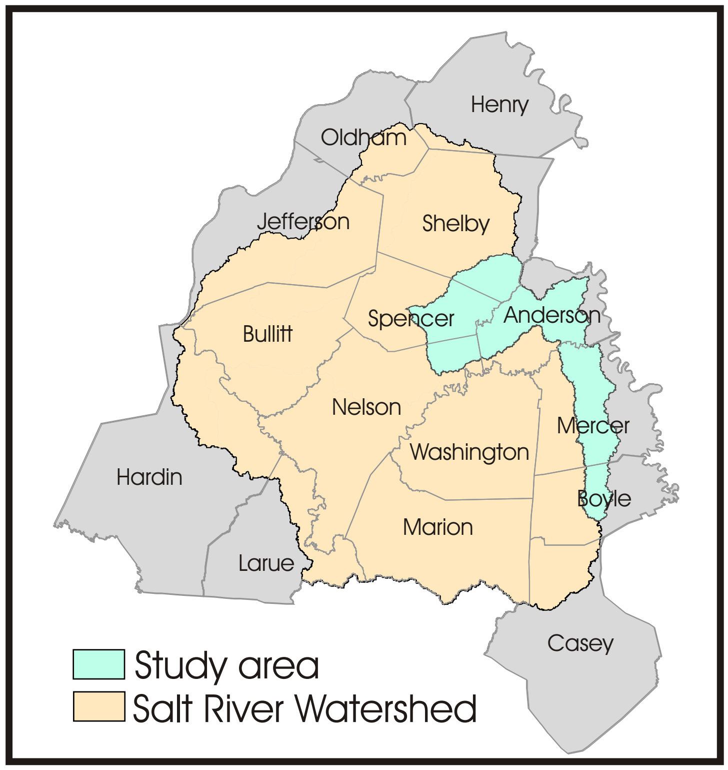

Land use

Water quality

Nonpoint-source (NPS) pollution occurs when contaminants such as fertilizers, pesticides, oil and gas, and excess sediment are transported in rainfall and snowmelt moving off the land and into streams and lakes. NPSs of pollution, also known as runoff or diffuse pollution, are the number one contributor to water pollution in Kentucky. How the land in your area is being used affects the types and amounts of contaminants that are transported by rainfall runoff into your local streams and lakes.

The U.S. Geological Survey (USGS), in cooperation with the Kentucky Department of Natural Resources Division of Conservation (KDOC), has developed an informational tool to demonstrate how available data can be used to look at land-use changes and water quality in the Salt River Watershed above Taylorsville Lake (upper Salt River) in parts of Anderson, Boyle, Mercer, Nelson, Spencer, and Shelby Counties, Kentucky. This work was funded, in part, by a grant from the U.S. Environmental Protection Agency (USEPA) under §319(h) of the Clean Water Act through the Kentucky Division of Water to the Kentucky Division of Conservation, Grant # C9994861-98.

What we found:

- Available data show that urban and pastureland in the region and study area is increasing while cultivated and undeveloped land is decreasing.
- Concentrations of nitrate in samples collected from the Salt River sampling site at Glensboro were never higher than the USEPA maximum contaminant level (MCL) for drinking water, which is 10 milligrams per liter (mg/L) for nitrate as nitrogen.
- Although concentrations of total phosphorus have declined (Kentucky Natural Resources and Environmental Protection Cabinet, 2000), all concentrations in samples collected from the Salt River sampling site at Glensboro were higher than the recommended goal of 0.10 mg/L of total phosphorus in flowing surface water (U.S. Environmental Protection Agency, 1986).
- Estimates of nitrogen and phosphorus loads and yields from the data collected at the Glensboro site were comparable with model results for the rest of the watershed.
- The data indicate that the combination of best-management practices (BMPs) and land-use changes in this watershed may be having a positive effect on water quality.

NPS pollution is controlled primarily through the adoption of practical and cost-effective land-management practices or BMPs. BMPs allow for everyday activities while reducing or preventing NPS pollution. The use of BMPs protects water quality while maintaining the economic value of Kentucky's land resources.

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Project Background

The upper Salt River Watershed includes parts of Anderson, Boyle, Mercer, Nelson, Spencer, and Shelby Counties, Kentucky. The watershed, upstream from the Taylorsville Reservoir dam, covers about 353 square miles. Principal land use historically has been for agricultural purposes. In recent years, the urban/suburban residential population has increased considerably. Data from the U.S. Census Bureau indicate that several of the counties in the watershed had the largest percentage of population increase during 1990-99 (U.S. Census Bureau, 2000). These counties and their rankings compared to the 120 counties in Kentucky include Spencer County (1st out of 120), Anderson County (8th out of 120), and Nelson County (10th out of 120). Land-use changes such as the conversion of cropland into residential, commercial, industrial, and other non-agricultural uses will continue to occur.

In the early 1980's, the principal issues in the upper Salt River Watershed were associated with the high concentrations of phosphorus (naturally occurring and from fertilizer applications) and nitrogen (largely from agricultural practices) in Taylorsville Lake and the streams upstream from the lake. In 1990, the Taylorsville Reservoir Hydrologic Unit Area of the upper Salt River was approved for special funding by the USEPA and the U.S. Department of Agriculture (USDA). Funds were allocated for this 319 project to implement BMPs as a means to control NPS pollution in the watershed. The Kentucky Heritage Resource Conservation and Development Council believed the program to be a success, and therefore applied for and received funding for other 319 projects in the area. Such projects include the Riparian Area Demonstration Project in Boyle County and the Chemical Mixing Facility. Documentation of the results of the 319 project is described in Kentucky Division of Water (KDOW) Technical Report No. 4 (Kentucky Natural Resources and Environmental Protection Cabinet, 2000). Although numerous BMPs were instituted and water-quality data were collected during the project, the relative impact of the BMPs to water-quality change could not be scientifically assessed to any degree of accuracy. Also, the changes in land use were not well documented nor were they related to changes in water quality.

The USGS, in cooperation with the KDOC, has developed a demonstration project related to NPSs of nutrients in the Salt River Watershed above Taylorsville Lake (upper Salt River) in parts of Anderson, Boyle, Mercer, Nelson, Spencer, and Shelby Counties, Kentucky. The project goal is to demonstrate how available spatial data can be used in a geographic information system (GIS) approach as an improved informational tool. The specific objective is to convey to stakeholders, through the use of GIS analyses and presentations of available data both in the near term at farm-day outings and in the longer term as a computer based toolbox, the importance of NPS of nutrients in the 353 square mile upper Salt River Watershed.

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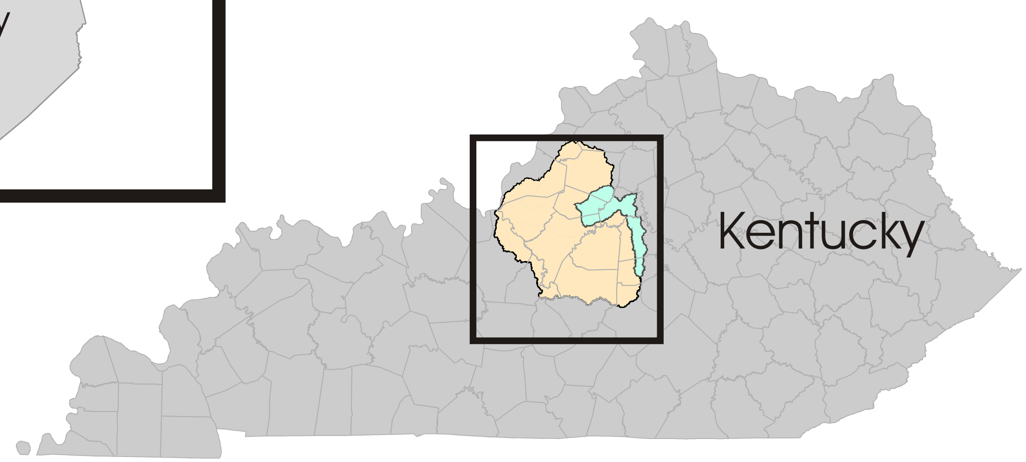
Location of study area

Study area
Salt River Watershed

Zoom to region



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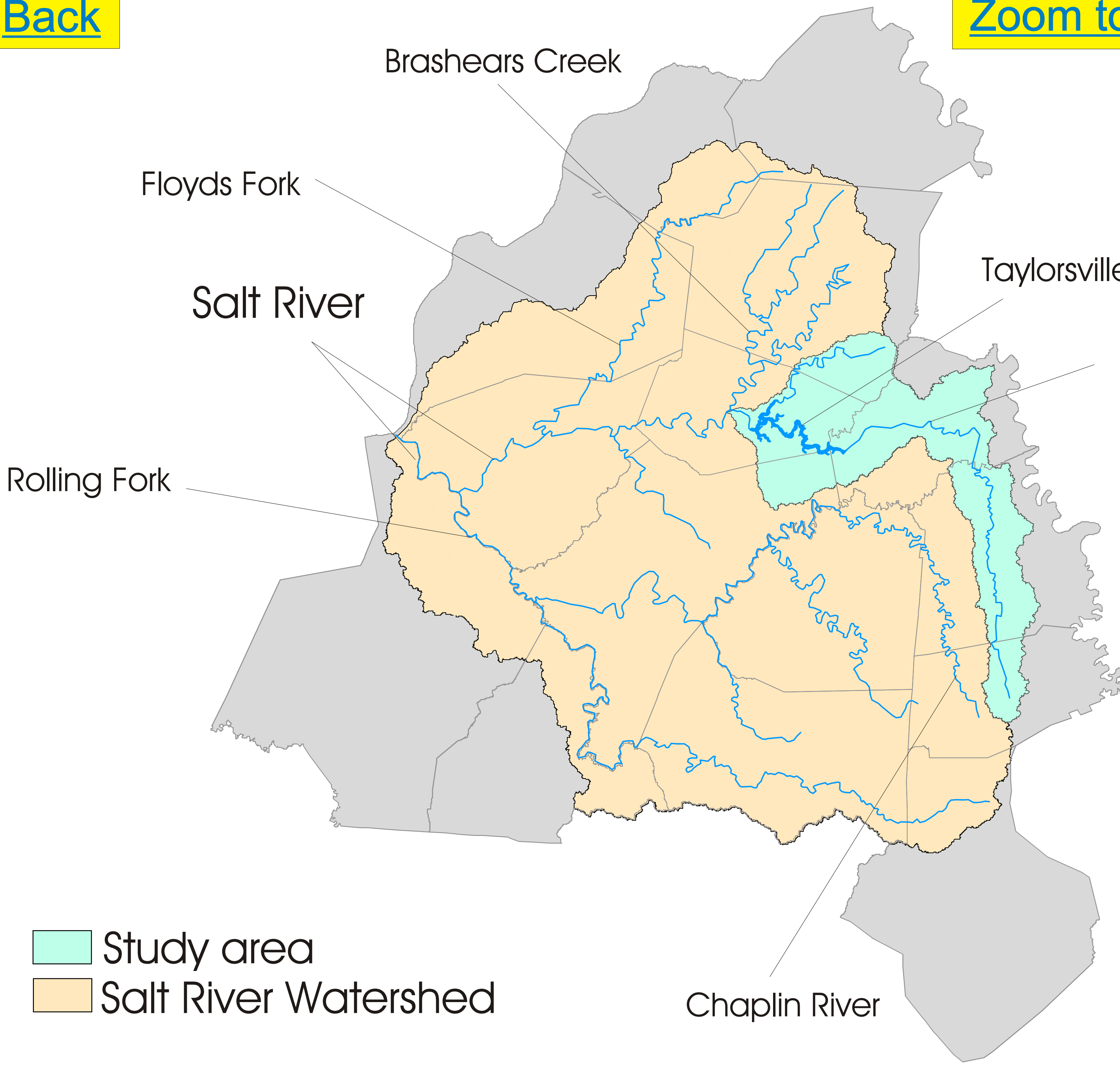
Zoom to study area



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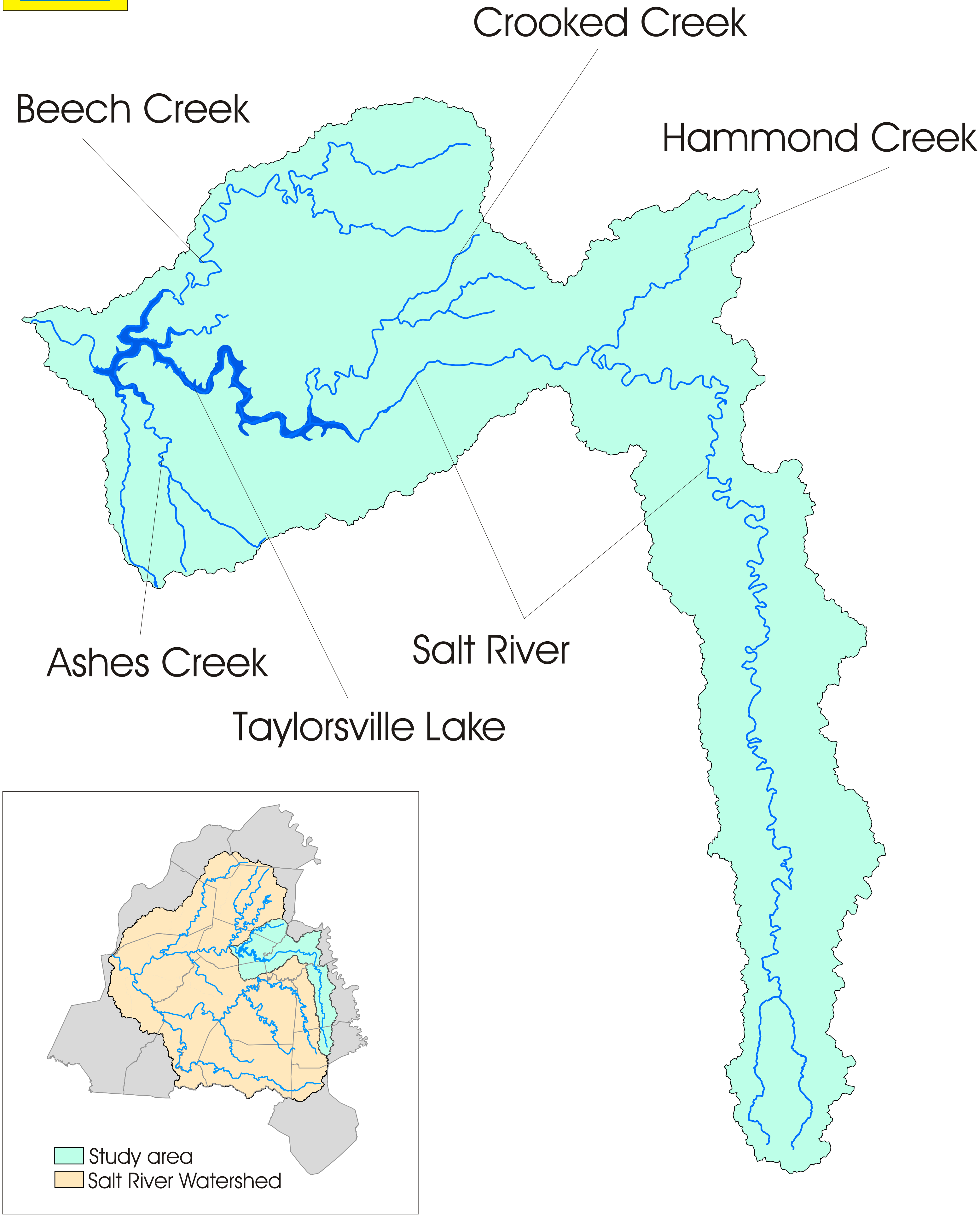
Crooked Creek
Beech Creek
Hammond Creek
Ashes Creek
Salt River
Taylorsville Lake
Study area
Salt River Watershed

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Land use

What is the difference between land use and land cover?

Land use refers to the way humans use the land on which they live. Trying to measure how land is being used over large areas when those uses are constantly changing is very difficult. One way scientists measure how land is being used is by evaluating from a picture what the surface of the land is covered with, such as roads, trees, or buildings. The use of the land can then be inferred from how the land is covered. If the picture shows the land is covered with houses, for example, the land use is categorized as urban. A land-cover study can be done with photographs from an airplane or images from a satellite in space. Scientists then use a variety of supporting information including topography, census data, agricultural statistics, soil characteristics, other land-cover maps, etc., to help determine and label the land-cover types. Twenty-one classes of land cover were mapped by several Federal agencies to describe how the land in the United States is being used.

For this project, the 21 classes of land cover were grouped together into 4 general categories:

- Developed - includes buildings, roads, parking lots, etc.
- Undeveloped - includes forest, shrub land, etc.
- Water - includes lakes, ponds, etc.
- Agriculture - further broken down into cultivated and pasture

How do the different types of land use affect water quality in a watershed?

Agricultural land is used to grow crops or raise farm animals. Farmers may apply chemicals such as fertilizers, herbicides, or insecticides that can be transported into the river by runoff. Other effects include both soil erosion resulting in sediments and runoff of animal wastes containing pathogens and nutrients entering the streams.

Forest land may be a natural area that is undisturbed or an area where selective harvesting occurs. A forest area that is managed as a natural area may have little effect on the waters within the watershed; however, a forest that is poorly harvested for lumber may affect the watershed through soil erosion especially from poor logging and road design.

Developed areas include small communities and suburban areas of homes. Land disturbance during construction can be a major effect on water quality, especially if sediment controls are not used. Many homes depend upon septic systems, which can be sources of bacteria, pathogens, and nutrients if not designed and maintained properly. Chemicals such as fertilizers, insecticides, and herbicides, which are applied to lawns, trees, and shrubs by homeowners, are carried off by storm water. The increase of impervious surfaces (roads, parking lots, etc.) and modifications to "improve" drainage (ditches and storm sewers) can result in flash flooding of urban streams. Flash floods can result in severe bank erosion, which increases sediment deposition and affects aquatic habitats.

Let's look at land cover in the upper Salt River Watershed...

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Land-use changes

Land use and land cover play a major role in NPS runoff and water quality in Kentucky. In the entire six-county region of the upper Salt River Watershed, land-use and land-cover patterns are changing in response to changes in population growth and economic shifts in farming practices. Two data sets were pulled together to quantify these changes.

In the first comparison Graph 1 , data from the USDA-Natural Resources Conservation Service (NRCS) National Resources Inventory (NRI) indicate that there was a steady decrease (about 7 percent) of the total land in pasture and cultivated crops from 1982 to 1997. During the same period the total land in urban uses increased about 4 percent, and the total land as undeveloped (idle land) increased about 3 percent.

NRI data = URBAN and UNDEVELOPED land are increasing over time;
PASTURE and CULTIVATED land are decreasing

In the second comparison Graph 2 , data from satellite imagery-the National Land Cover Data (NLCD) and the Kentucky Land-Cover Data (KLCD)-indicate that pasture and cultivated land increased by 1 percent, urban land increased by 4 percent, and undeveloped land declined by 5 percent from 1992 to 2000. This indicates that urban land in the region is replacing undeveloped land. A closer look at the data show that cultivated land actually declined by about 8 percent from 1992 to 2000, while land interpreted as pasture increased by about 9 percent. This would indicate that urban and pasture land in the region is replacing cultivated and undeveloped land. Regional satellite images

Satellite data = URBAN and PASTURE land are increasing over time;
CULTIVATED and UNDEVELOPED land are decreasing

Combined analysis = URBAN land is increasing over time;
CULTIVATED land is decreasing; and
PASTURE and UNDEVELOPED land has mixed results

Looking at the trends in land use just within the upper Salt River Watershed study area (Graph 3 , also using the 1992-2000 satellite data), pasture land increased by 5 percent, urban land increased by 4 percent, cultivated land declined by 5 percent, and undeveloped land declined by 4 percent. Again, this would indicate that urban and pastureland in the watershed is replacing cultivated and undeveloped land.

Study area satellite images

Note:
Difference between NRI data and satellite imagery-The NRI data are based on a compilation of field-survey and map data targeted around specific sampling locations. When compared to satellite-imagery data, the NRI data appear to be over-estimating the amount of farm and urban land (items that readily stand out in a visual survey) in the region and under-estimating the forest and undeveloped land. The satellite imagery is a computerized interpretation of 100 by 100-foot sections of the landscape. When compared to NRI data, the satellite-imagery data appear to be providing higher estimates of the amount of forested and undeveloped land (details that are more easily enumerated in a photographic survey). It easily could be that pasture and undeveloped land might be hard to distinguish in a computerized-image survey and that narrow strips of forest land along riparian zones and fence rows might be discounted in visual surveys. Such differences in techniques lead to these different land-percentage results. What is really important is that each technique is providing data consistent enough to detect the differences or changes in land use over time, and that is indeed what is happening.

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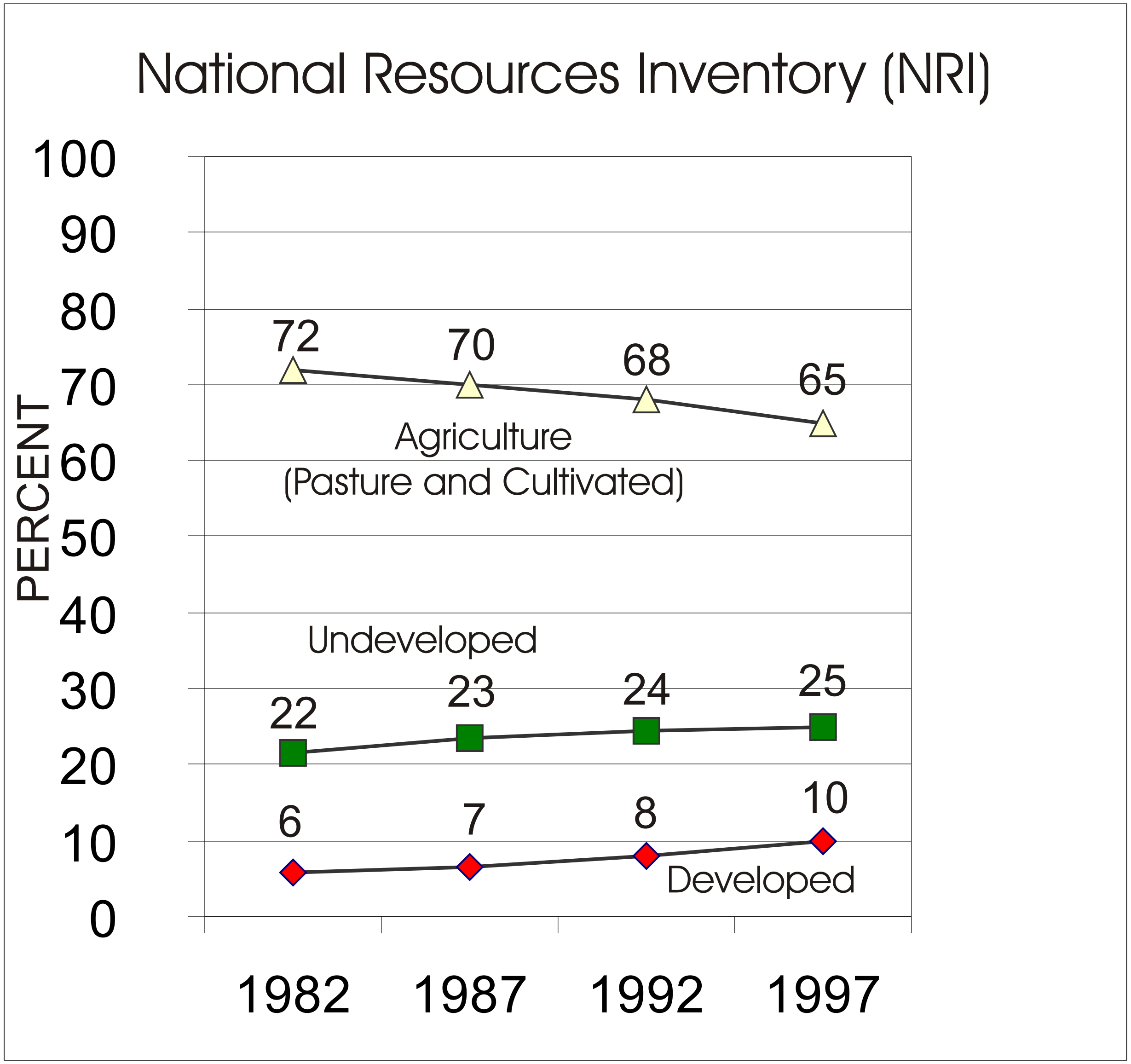
Graph 1



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NRI data = URBAN and UNDEVELOPED land are increasing over time; PASTURE and CULTIVATED land are decreasing

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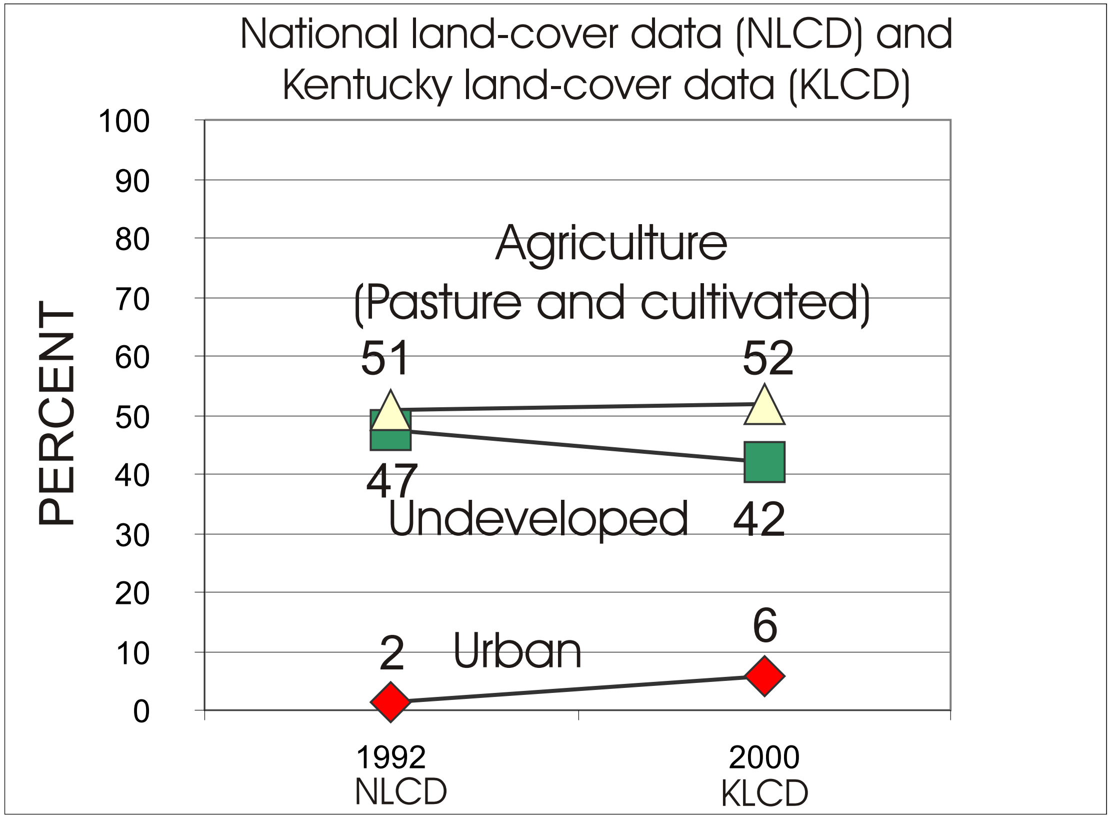
Graph 2



In the second comparison (graph 2), data from satellite imagery (the National Land Cover Data (NLCD) and the Kentucky Land Cover Data (KLCD)) indicate that in the region, pasture and cultivated land increased by 1 percent, urban land increased by 4 percent, and undeveloped land declined by 5 percent from 1992 to 2000. This indicates that urban land in the region is replacing undeveloped land. A closer look at the data show that cultivated land actually declined by about 8 percent from 1992 to 2000, while land interpreted as pasture increased by about 9 percent. This would indicate that urban and pastureland in the region is replacing cultivated and undeveloped land.

Satellite data = URBAN and PASTURE land are increasing over time;
CULTIVATED and UNDEVELOPED land are decreasing

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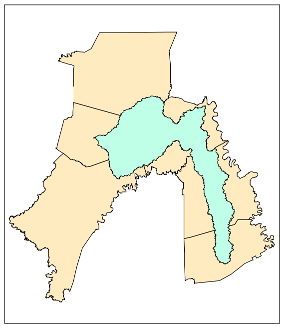
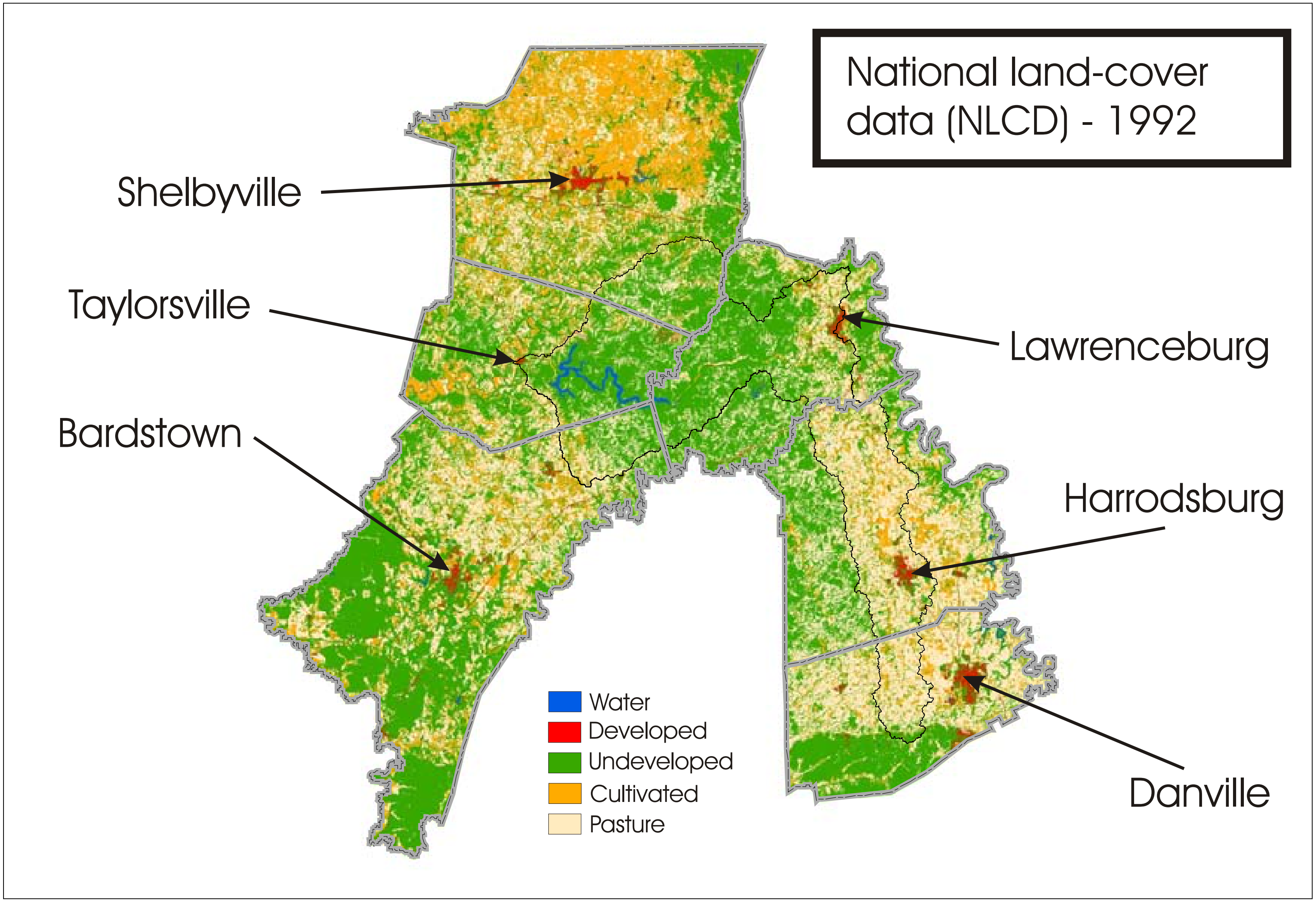
Counties and study area





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Kentucky land-cover data - 2000

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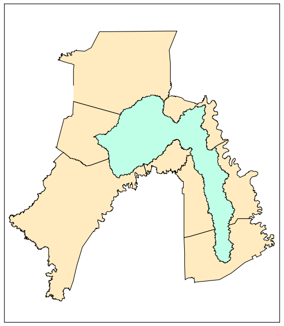
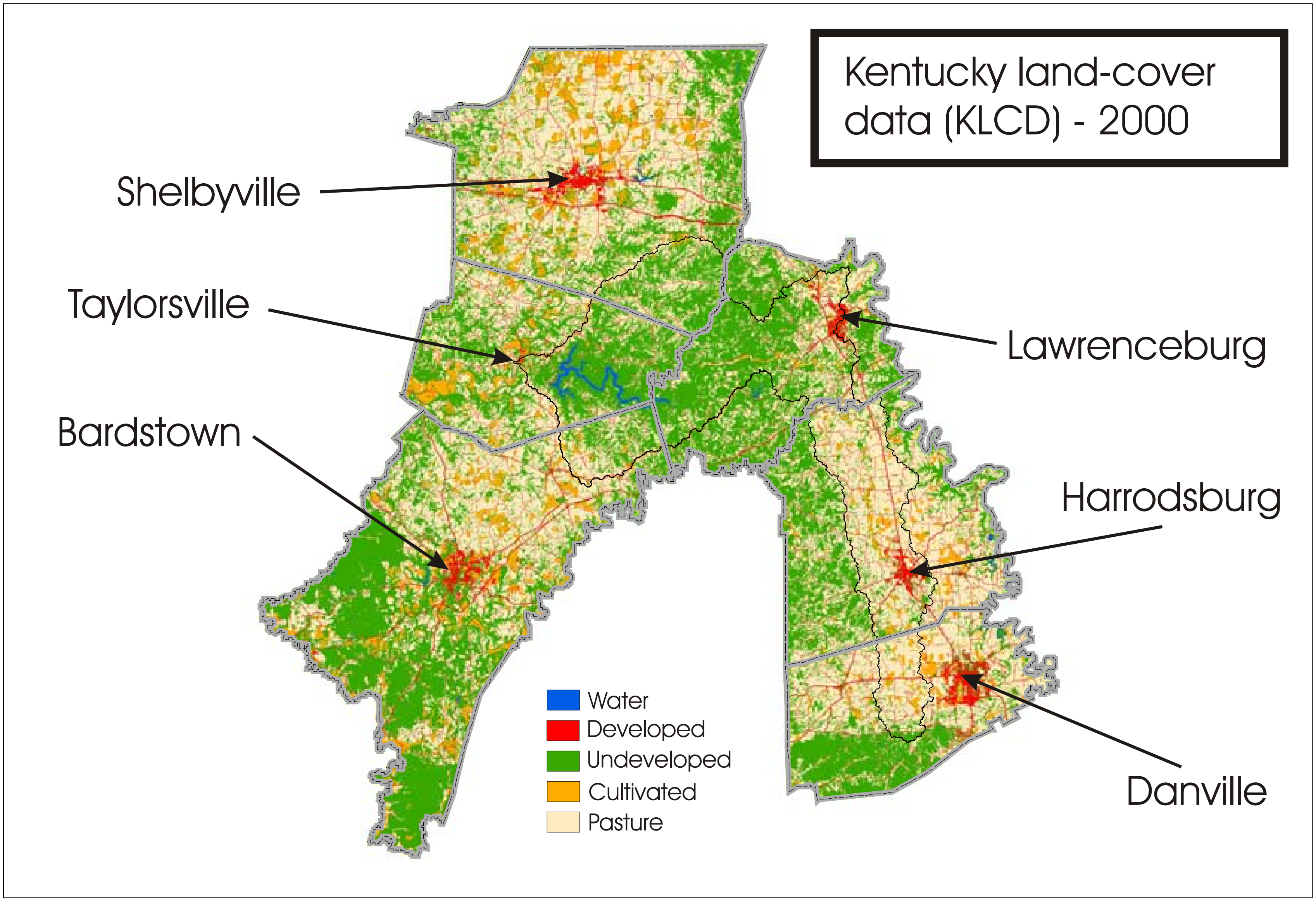
Counties and study area





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National land-cover data - 1992

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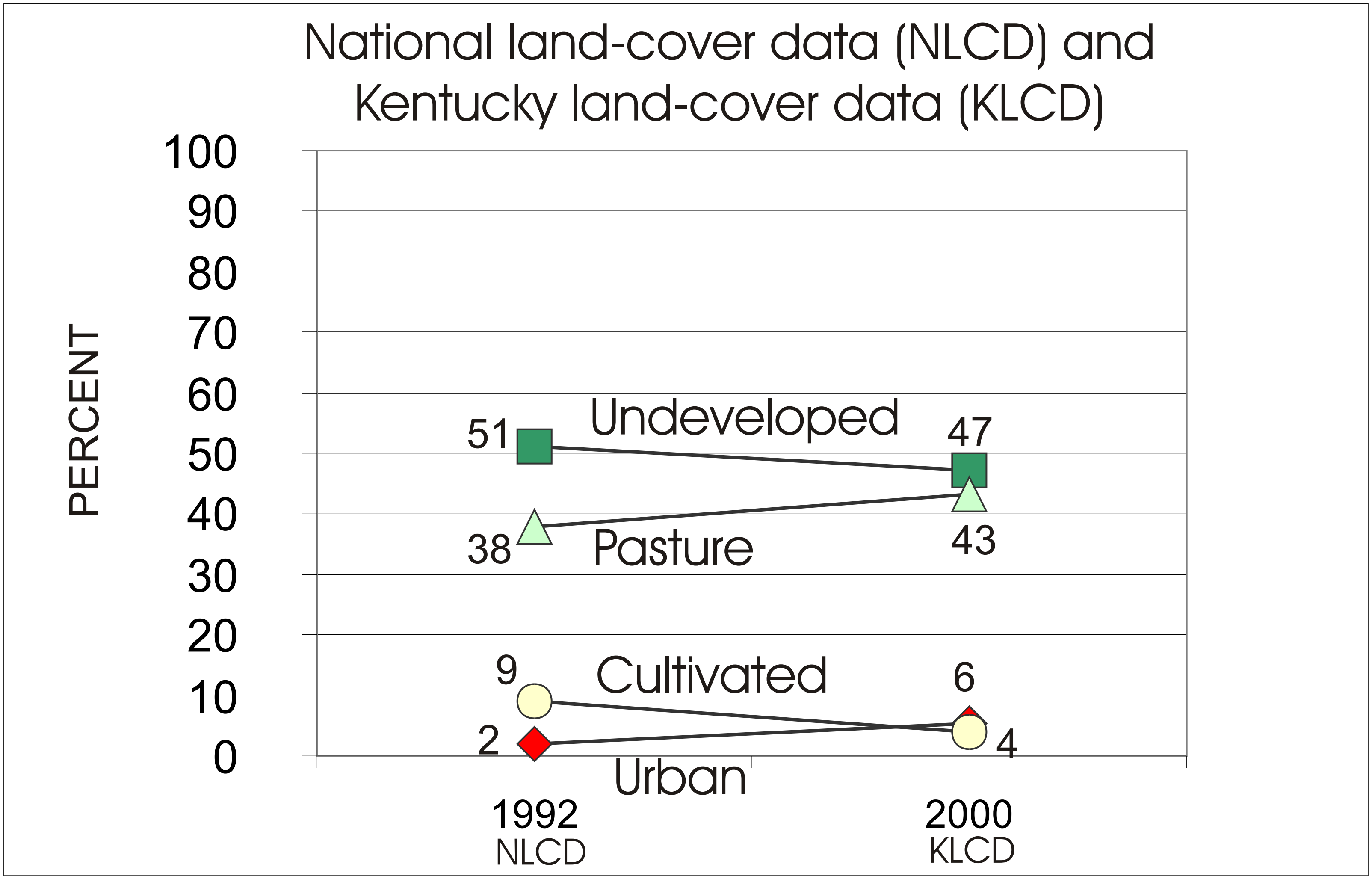
Graph 3



Looking at the trends in land use just within the upper Salt River Basin study area (graph 3, also using the 1992 to 2000 satellite data), pasture land increased by 5 percent, urban land increased by 4 percent, cultivated land declined by 5 percent, and undeveloped land declined by 4 percent. Again, this would indicate that urban and pastureland in the basin is replacing cultivated and undeveloped land.

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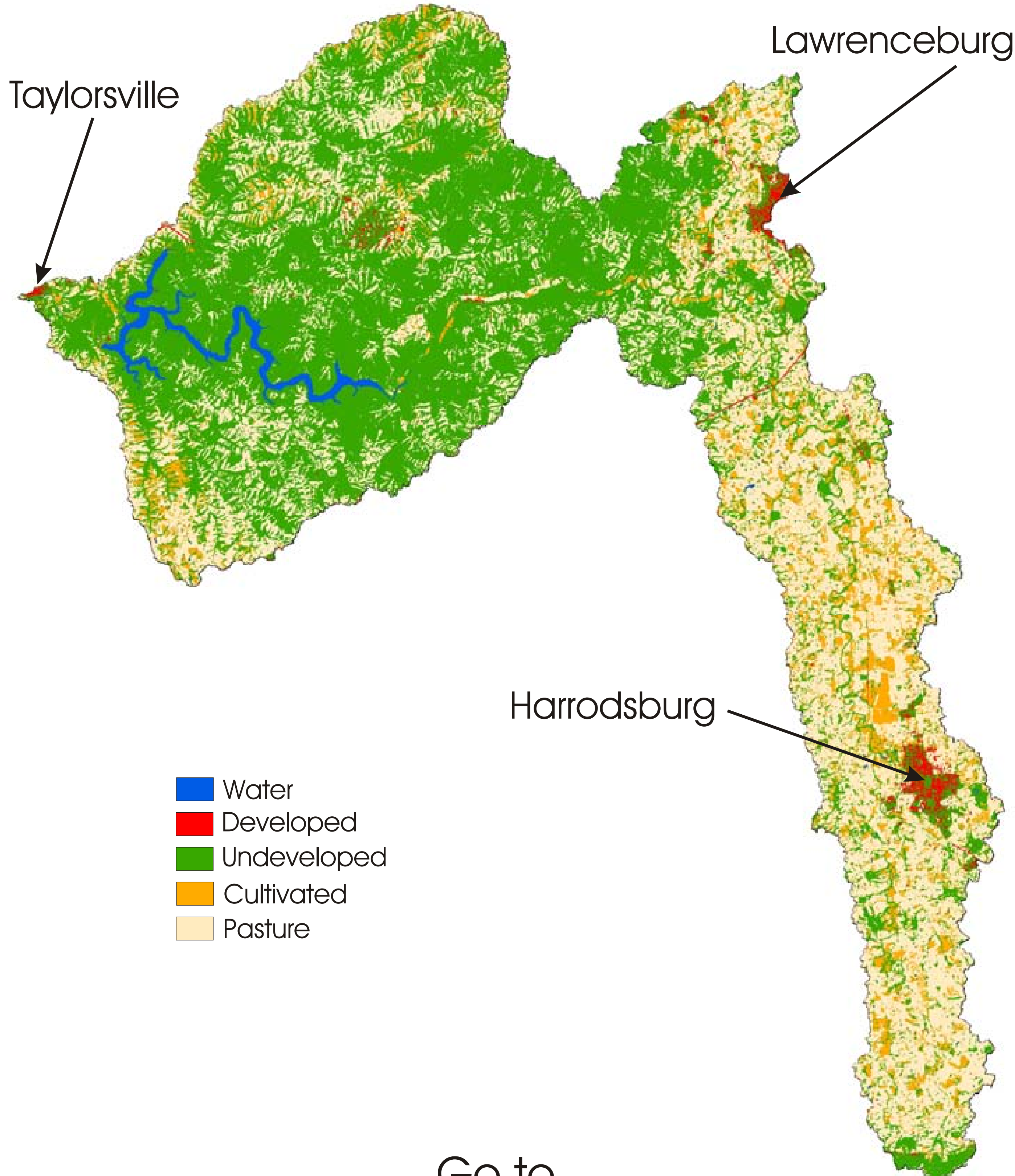
National land-cover data (NLCD) - 1992



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Kentucky-land cover data - 2000

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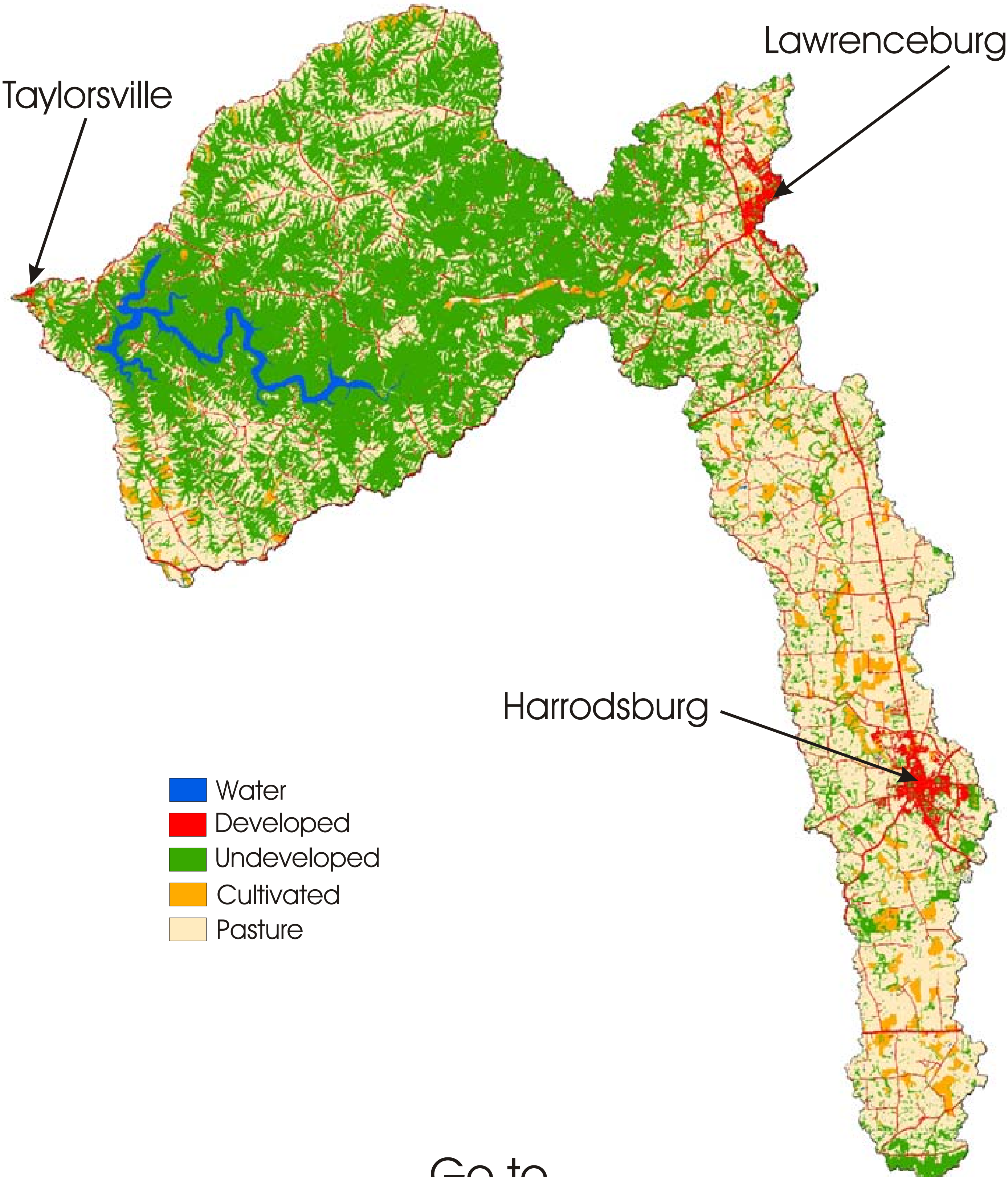
Kentucky land-cover data (NLCD) - 2000



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National-land cover data - 1992

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Water Quality

Water quality is commonly defined by its physical, chemical, biological, and aesthetic (appearance and smell) characteristics. The quality of a body of water affects the way in which communities use the water for activities such as drinking, recreational, or commercial purposes.

How is water quality measured?

The presence of contaminants and the characteristics of water are used to indicate the quality of water. These water-quality indicators can be categorized as

Biological: bacteria, algae

Physical: temperature, turbidity and clarity, color, salinity, suspended solids, dissolved solids

Chemical: pH, dissolved oxygen, biological oxygen demand, nutrients (including nitrogen and phosphorus), organic and inorganic compounds (including toxicants)

Aesthetic: odors, taints, color, floating matter

Radioactive: alpha-, beta-, and gamma-radiation emitters

Measurements of these indicators can be used to determine and monitor changes in water quality as well as to determine whether the quality of the water is suitable for the health of the natural environment and the uses for which the water is required.

Collecting water-quality samples is very expensive and time consuming. One method scientists use to examine water quality when data and resources are limited is to "model" water quality in one location based on data collected at other similar locations. One chemical water-quality indicator is nutrients. The USGS has developed a tool called the "SPAtially Referenced Regressions On Watershed Attributes" (SPARROW) model for modeling nutrients in rivers. The tool estimates the load and yield of specific nutrients in a localized area using data gathered over the entire United States and over a long period of time. The data used for the estimates include national land-cover data, census data, measured water-quality data averaged over a period of years, and data collected at undisturbed sites. This tool is very useful for estimating what is happening with water quality in a watershed when there is limited local data available.

Let's look at nutrients in the upper Salt River Watershed... Next

More links:

Water-quality basics | More about nutrients | Detailed water-quality discussion | NPS and BMPs

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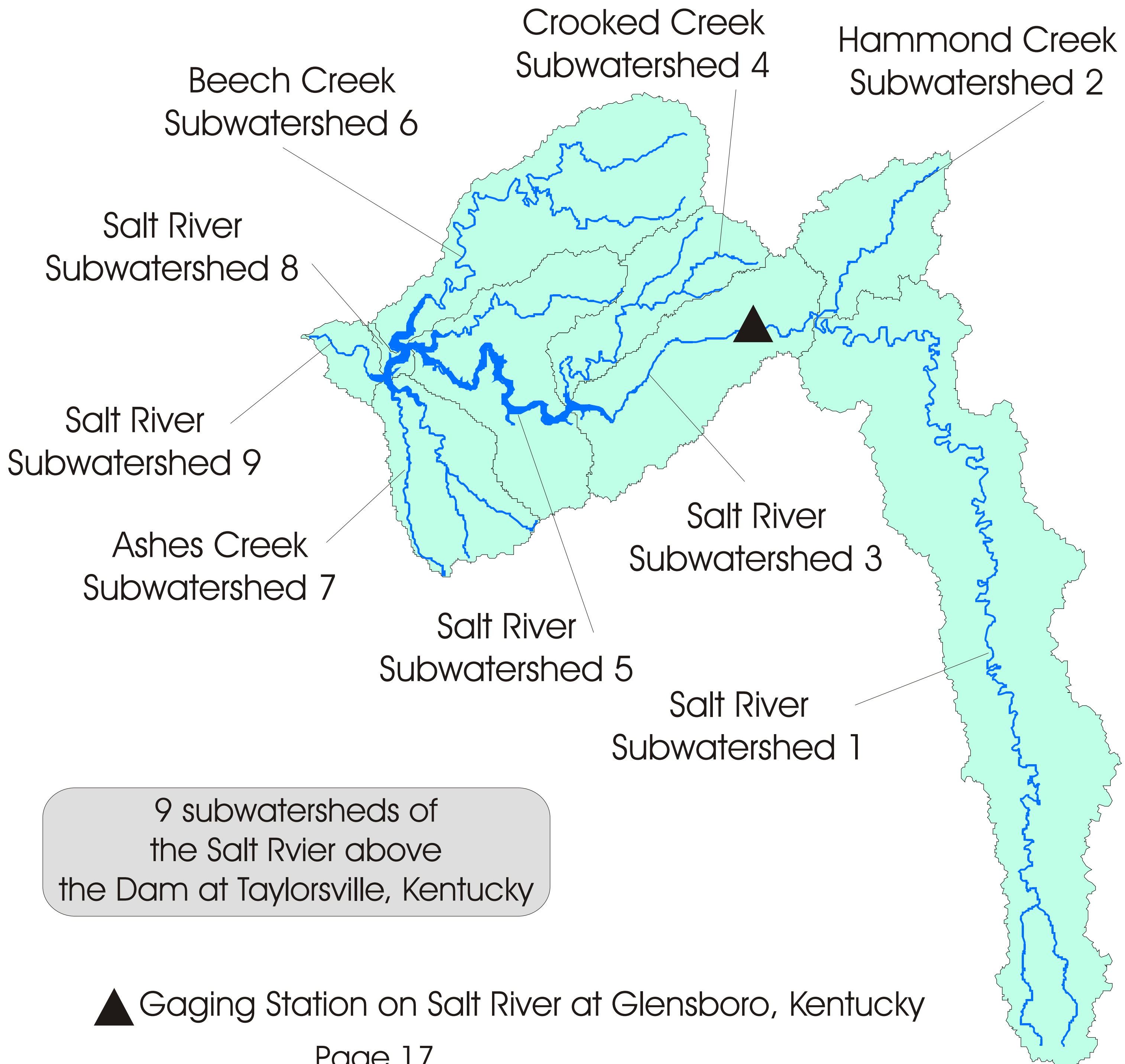
Water Quality

USGS used the SPARROW model to predict annual loads and yields of nitrogen and phosphorus in nine subwatersheds of the upper Salt River above the dam at Taylorsville, Ky. USGS has a discharge gaging station on the Salt River at Glensboro, Ky., that measures how much water is flowing in the Salt River. The KDOW has collected water-quality samples at the Glensboro gage during different seasons over a 9-year period. These data were compared to what the model predicted to see how well the model performed. The model results are comparable to the measured data.



Model Predictions

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[Phosphorus](#)

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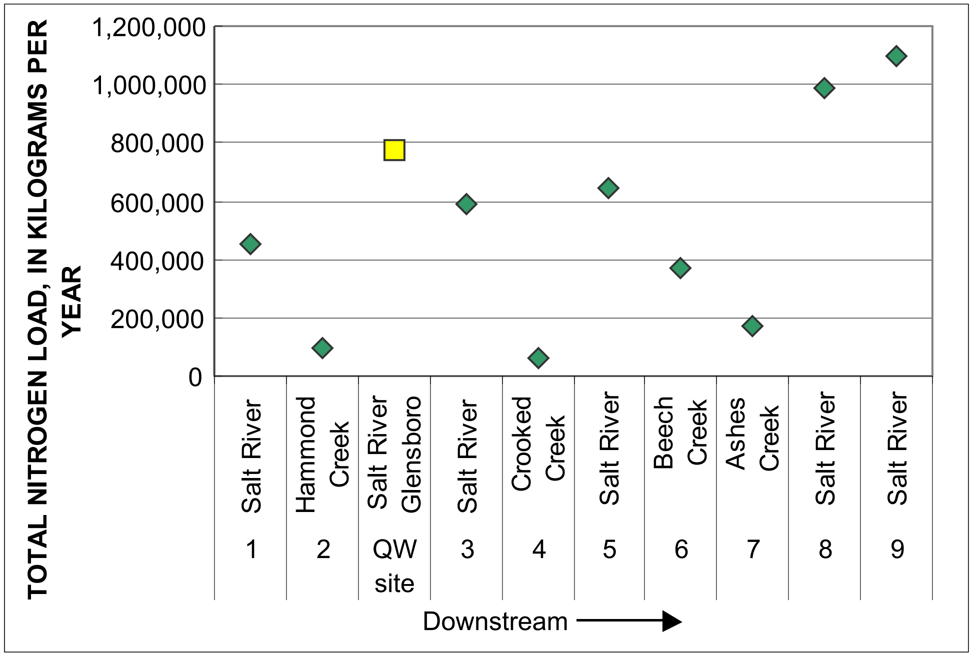
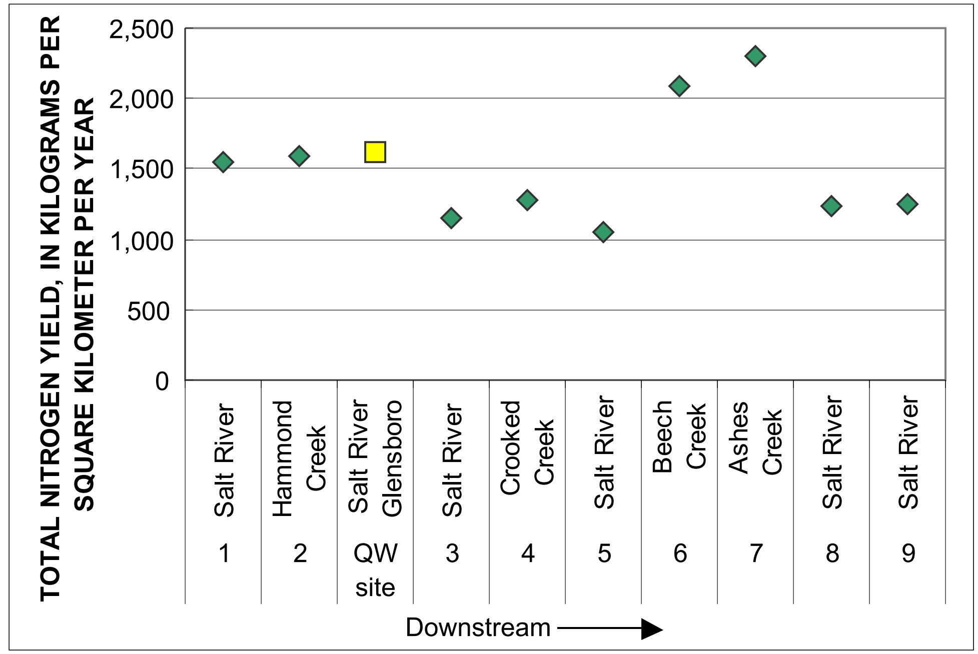
Water Quality

Nitrogen



Graph 4



Graph 5

Transport of nutrients into the upper Salt River Watershed near Harrodsburg, Kentucky, is characterized by the load estimate at subwatershed 1. Transport out of the watershed is characterized by the estimate at the outlet of subwatershed 9. Estimates of the mean annual load for total nitrogen at subwatersheds 1 and 9 were 453,000 kilograms per year (kg/yr) and 1,100,000 kg/yr, respectively (graph 4). This represents a gain of 647,000 kg/yr, on average, across the study area. The Salt River at Glensboro sampling site, which represents drainage from the uppermost subwatershed on the main stem of Salt River (subwatershed 1) and drainage from the tributary, Hammond Creek (subwatershed 2), had an estimated mean annual load of total nitrogen of 720,000 kg/yr for 1988-92. This number is comparable to the sum of the mean annual load of total nitrogen from subwatersheds 1 and 2, which was 546,500 kg/yr for the same period.

Estimates of the yield for total nitrogen in subwatersheds 1 and 9 were 1,554 kilograms per square kilometer per year (kg/km^2/yr) and 1,251 kg/km^2/yr, respectively (graph 5). This represents a decrease of 303 kg/km^2/yr, on average, across the study area. The Salt River at Glensboro sampling site had an estimated yield of total nitrogen of 1,622 kg/km^2/yr for 1988-92. This number is comparable to the weighted-average yields of total nitrogen from subwatersheds 1 and 2, which was 1,559 kg/yr for the same period. Of the major tributaries of the upper main stem of the Salt River, Ashes Creek (subwatershed 7) had the highest estimated yield of total nitrogen (2,300 mg/L) for 1988-92. Crooked Creek (subwatershed 4) had the lowest estimated yield of total nitrogen (1,277 mg/L).

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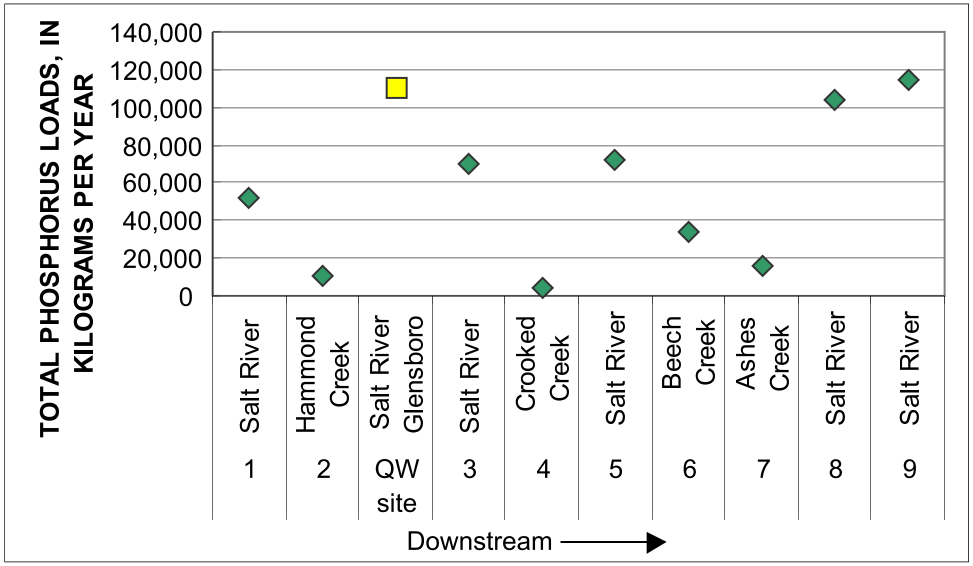
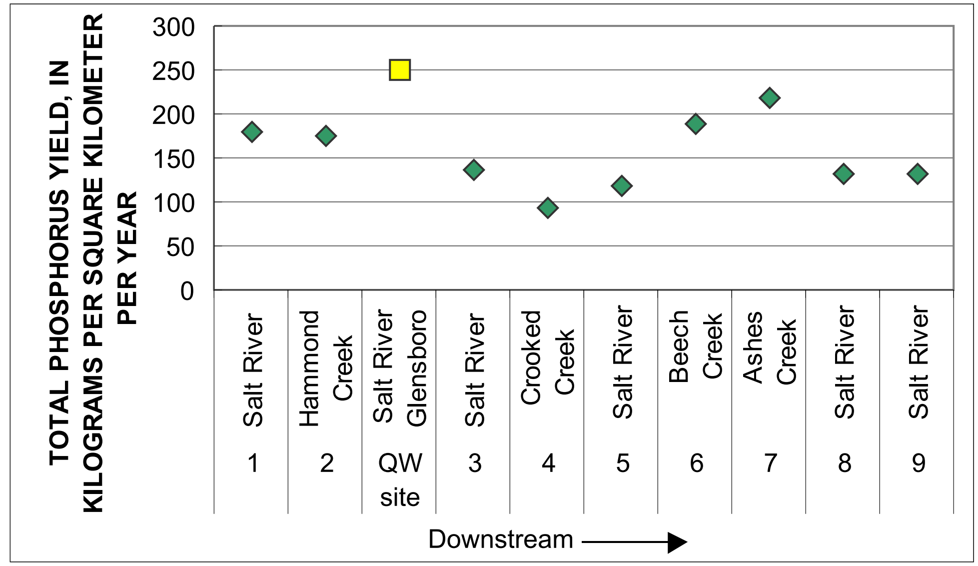
Water Quality

Phosphorus



Graph 6



Graph 7

Estimates of the mean annual loads of total phosphorus at subwatersheds 1 and 9 were 52,300 and 115,000 kg/yr, respectively, representing a gain of 62,700 kg/yr (Graph 6). Salt River at Glensboro, which represents drainage from subwatersheds 1 and 2 had an estimated mean annual load of total phosphorus of 110,000 kg/yr for1988-94. This number is comparable to the sum of the mean annual load of total phosphorus from subwatersheds 1 and 2, which was 62,600 kg/yr fror 1988-92. The number at the Salt River at Glensboro sampling site cannot be closely compared with the gain throughout the study area, because the sampling site area is about 13 percent of the total area; however, a general comparison indicates that the main stem of the upper Salt River and its tributaries function in removing total phosphorus from the water through absorption and deposition.

The estimated yields of total phosphorus in subwatersheds 1 and 9 were 179 and 131 kg/km^2/yr, respectively, representing a decrease of 48 kg/km^2/yr for the entire study area (graph 7). A possible explanation for this decrease is the presence of the Taylorsville Lake dam. As water enters Taylorsville Lake, it slows, and the sediment particles are deposited. Phosphorus also is deposited, because phosphorus is bound to sediment particles. The Salt River at Glensboro sampling site had an estimated yield of total phosphorus of 249 kg/km^2/yr for 1989-94. This number is comparable to the weighted-average yields of total phosphorus from subwatersheds 1 and 2, which was 178 kg/yr for 1988-92. The tributaries, Ashes Creek and Crooked Creek, had the highest yield of total phosphorus (218 kg/km^2/yr) and lowest yield of total phosphorus (93 kg/km^2/yr), respectively.

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CONCENTRATIONS OF NITROGEN, PHOSPHORUS, AND TOTAL SUSPENDED SOLIDS (TSS)

Occurrence of Concentrations of Nitrogen

The dominant form of nitrogen sampled at the Salt River at Glensboro sampling site was dissolved nitrite plus nitrate. About 62 percent of the median concentration of total dissolved nitrogen was in the form of nitrite plus nitrate. Concentrations of total Kjeldahl nitrogen (total organic nitrogen plus ammonia) ranged from less than 0.05 to 2.72 mg/L, with a median concentration of 0.56 mg/L. Concentrations of nitrite plus nitrate ranged from less than 0.005 to 5.33 mg/L, with a median concentration of 1.31 mg/L. Concentrations of nitrate in samples collected from the Salt River at Glensboro sampling site never were higher than the USEPA MCL for drinking water: 10 mg/L for nitrate as nitrogen. Concentrations of nitrate greater than 10 mg/L in drinking water can have adverse human-health effects, especially to infants whose digestive systems convert nitrate to nitrite thereby reducing the oxygen-carrying capacity of blood and resulting in blue-baby syndrome. (U.S. Environmental Protection Agency, 1999). Concentrations of total nitrogen ranged from 0.09 to 5.74 mg/L, with a median concentration of 2.13 mg/L.

Occurrence of Concentrations of Phosphorus and TSS

Concentrations of total phosphorus ranged from 0.06 to 1.78 mg/L, with a median concentration of 0.27 mg/L. All concentrations of total phosphorus in samples collected from the Salt River at Glensboro sampling site were higher than the recommended goal of 0.10 mg/L of total phosphorus in flowing surface water (U.S. Environmental Protection Agency, 1986). Concentrations of TSS ranged from 1 to 610 mg/L, with a median concentration of 10 mg/L.

Relation of Concentrations of Nitrogen, Phosphorus, and TSS to Season

Streamflow varied at the Salt River at Glensboro sampling site with varying rainfall Graphs 8a & 8b . Graph 9 shows the historical streamflows for 1989-2002 for the Salt River at Glensboro sampling site. The long-term annual mean streamflow at Salt River at Glensboro is 247 cubic feet per second (ft^3/s). A similar pattern of rainfall and streamflow was observed in this part of the study area. The timing of rainfall-runoff events and location of runoff events affects the concentrations and transport of constituents.

Interpreting the relation of concentrations of nutrients and TSS to season and streamflow is difficult because season and streamflow variables generally are not independent of one another. For example, a seasonal pattern in concentrations of nutrients may be caused by the correlation between concentration and streamflow rather than directly by seasonal changes in water-quality processes.

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Concentrations of nutrients vary seasonally. This seasonal variation is commonly attributed to uptake by algae and aquatic plants. Other possible causes include seasonal fertilizer application and variation in seasonal streamflow. The median concentrations of nitrite plus nitrate at the Salt River at Glensboro sampling site tend to be highest during late autumn through spring and lowest during summer and early autumn Graph 10. During November through March, plants in the study area are dormant and not using much of the available nutrients; therefore, nutrients build up in the soil. The excess soluble nutrients, such as nitrate, are flushed to streams from the surrounding soils during rainfall events. In late spring and early summer, nitrogen fertilizers are applied to cornfields, which extend the availability of nutrients through early summer. As rainfall becomes less frequent in late summer and early autumn, use of available nutrients by plants diminishes and concentrations of nitrate in streams decline. The relation for total nitrogen (sum of total organic nitrogen plus ammonia and nitrite plus nitrate) at Glensboro is similar to those for nitrite plus nitrate because dissolved nitrite plus nitrate constitutes most of the total nitrogen Graph 11. In contrast, the median concentrations of organic nitrogen plus ammonia are highest in late summer and early autumn and lowest in late autumn through spring.

Seasonal variation in concentrations of total phosphorus was minimal for water samples collected on the Salt River at Glensboro Graph 12. High concentrations of total phosphorus are associated more with runoff events than with seasonal variation because total phosphorus is transported to streams mainly by runoff. Most of the high concentrations of total phosphorus were observed in samples collected during runoff events.

TSS include both suspended sediment and organic material collected with the water sample. TSS can cause problems for fish by clogging gills and for aquatic plants by reducing light penetration and, thus, limiting growth. In addition, TSS provide a medium for the accumulation and transport of other constituents such as phosphorus and bacteria. Median concentrations of total suspended solids at the Salt River at Glensboro sampling site tend to be highest during summer (June-August) and lowest during other seasons Graph 13.

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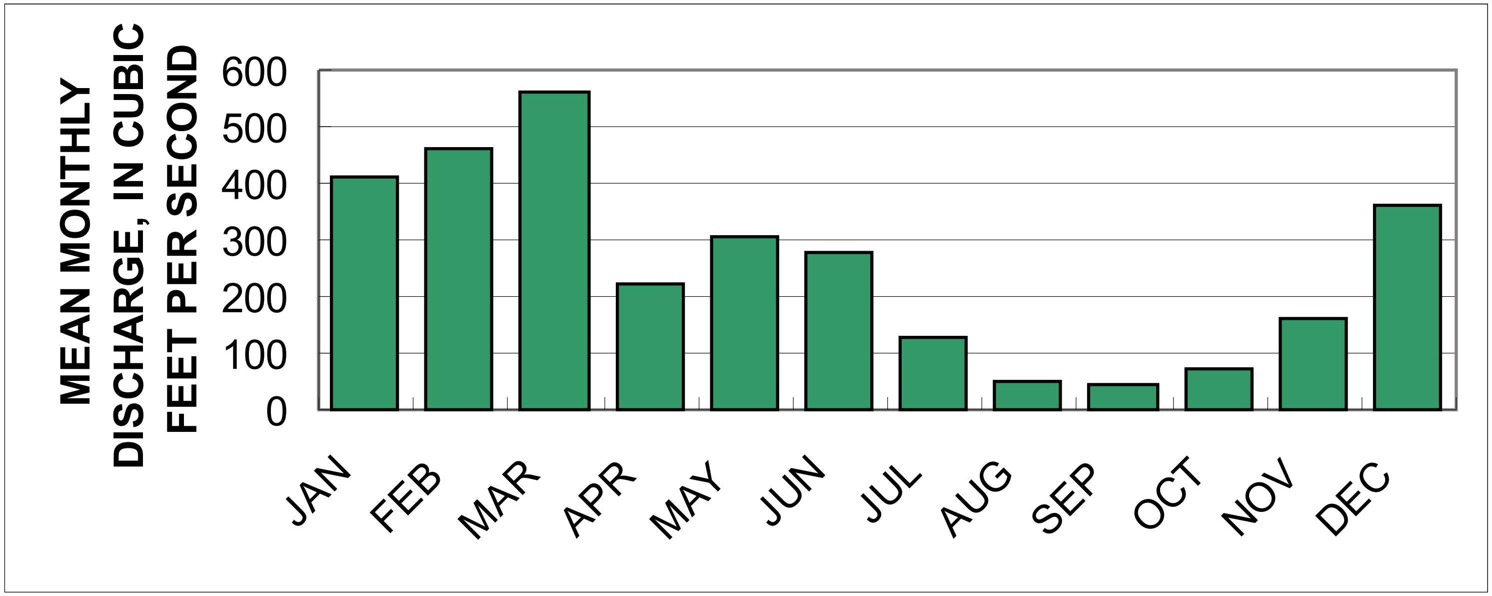
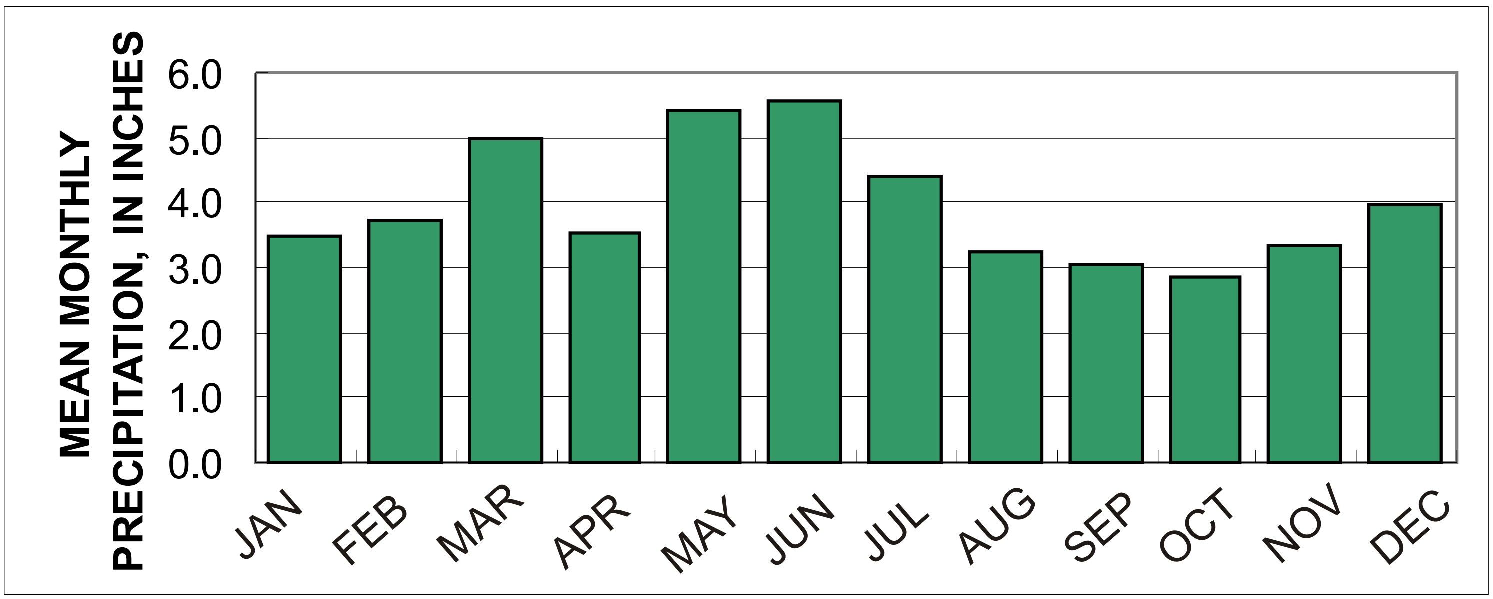


Graph 8a



Graph 8b

Streamflow variations at the Salt River at Glensboro sampling site corresponded to variations in rainfall.

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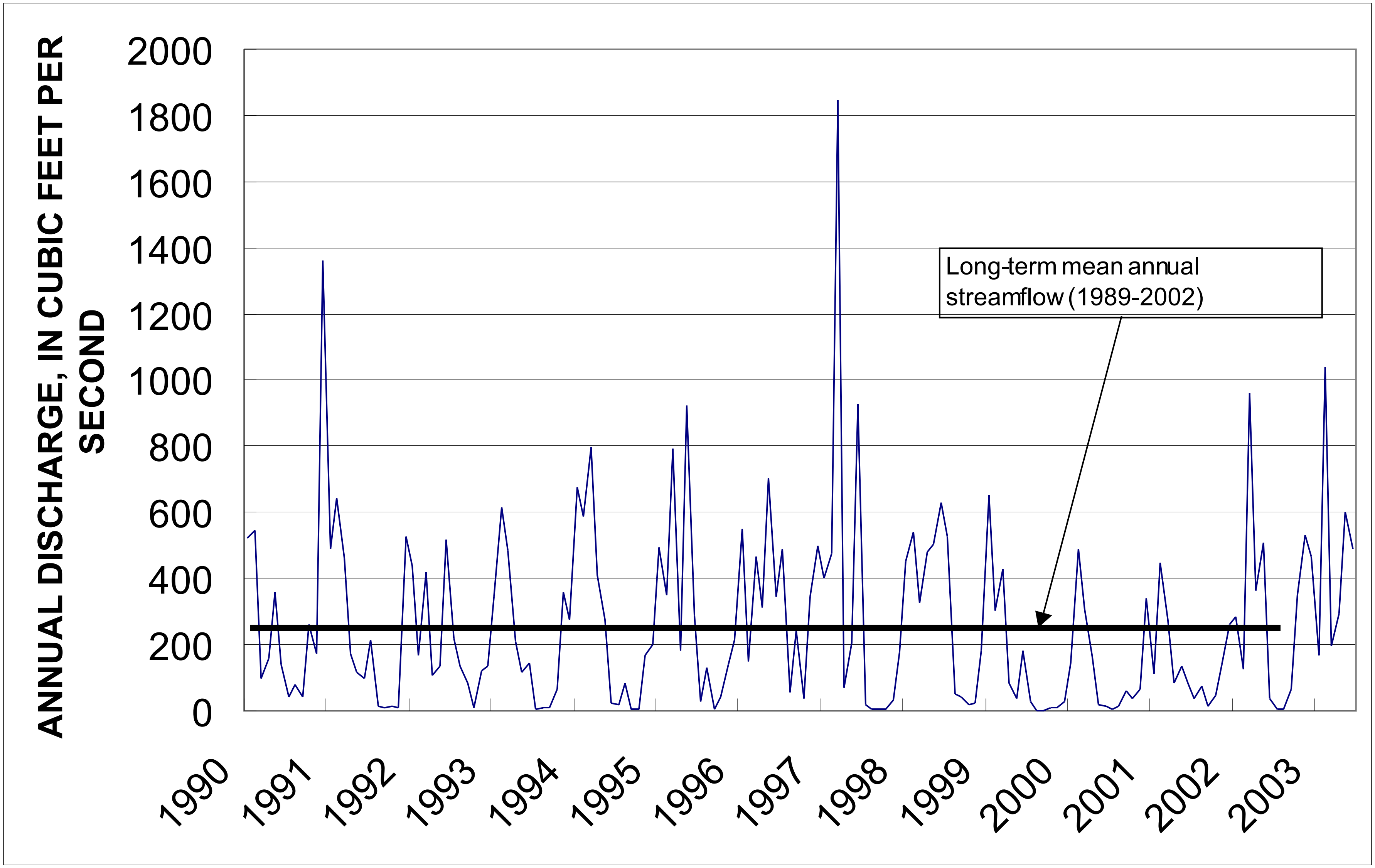

Graph 9

Historical streamflows for 1989-2002 for the Salt River at Glensboro site.

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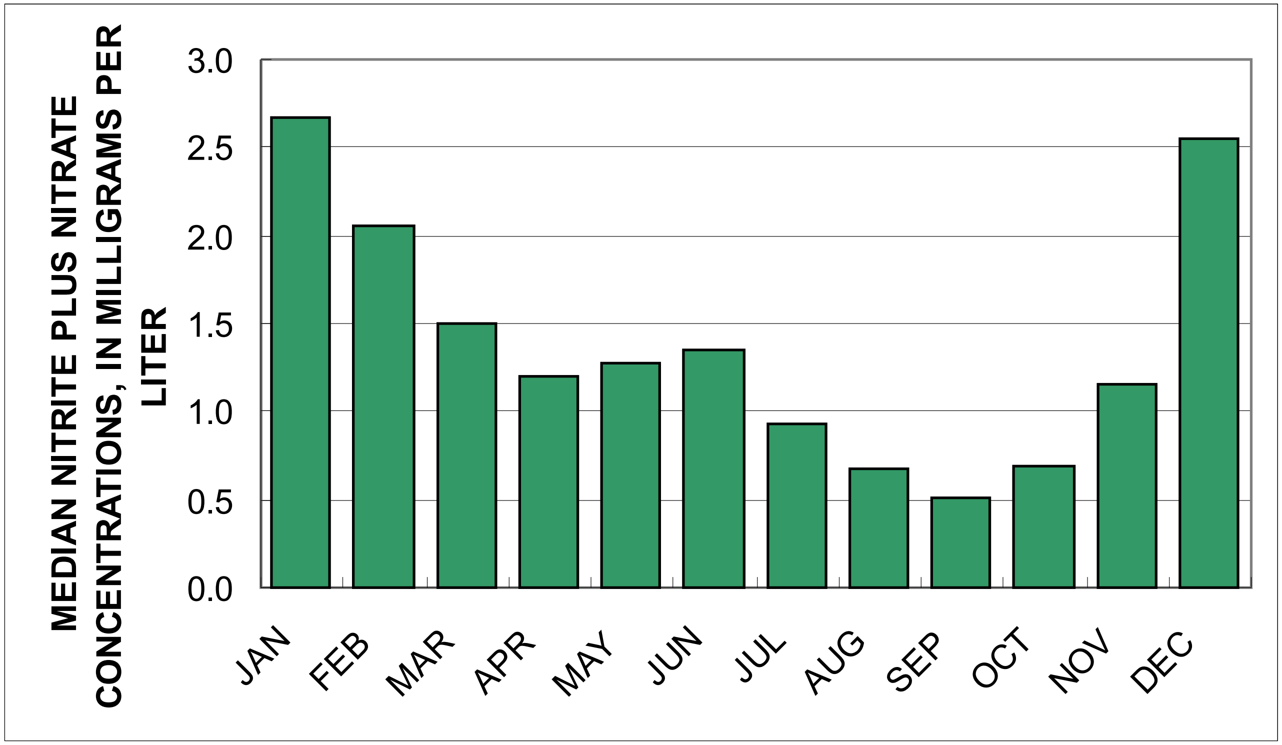

Graph 10

The median concentrations of nitrite plus nitrate at the Salt River at Glensboro sampling site tend to be highest during late autumn through spring and lowest during summer and early autumn.

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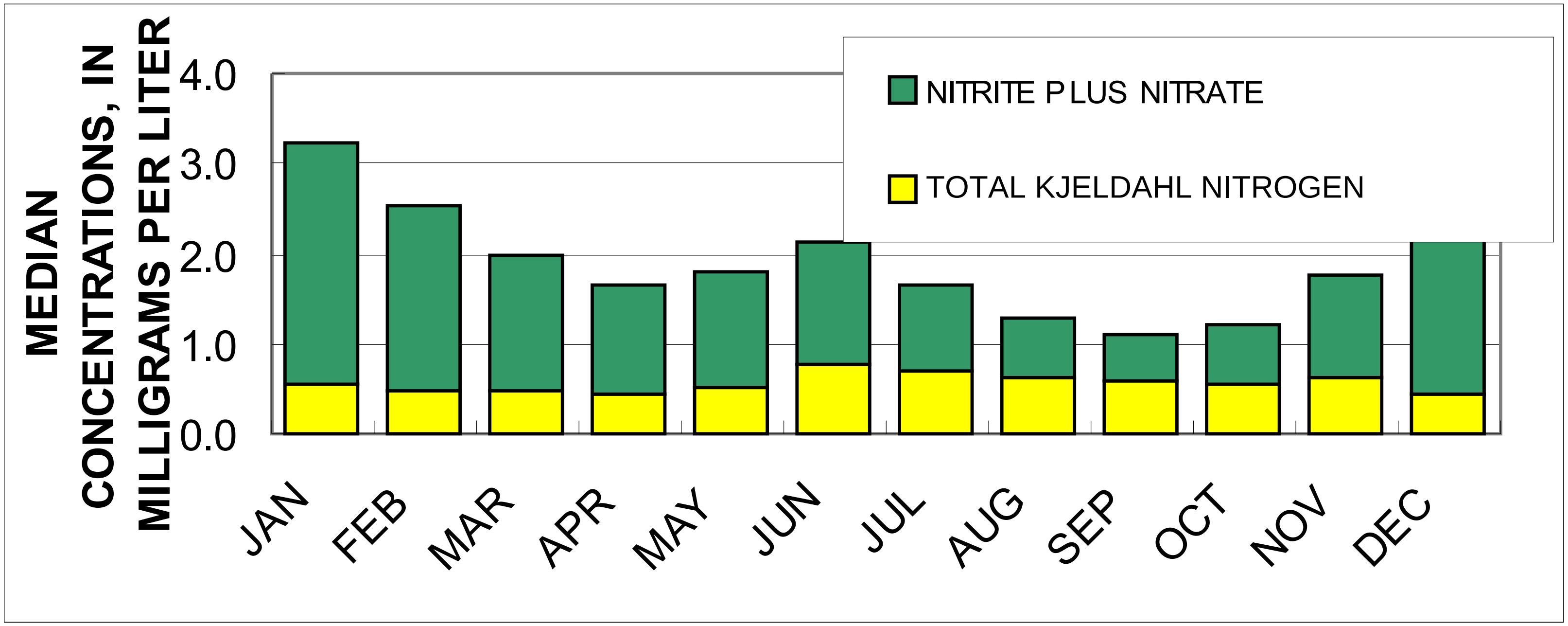

Graph 11

The relation for total nitrogen (sum of total organic nitrogen plus ammonia and nitrite plus nitrate) at Glensboro is similar to those for nitrite plus nitrate because dissolved nitrite plus nitrate constitutes most of the total nitrogen. The median concentrations of organic nitrogen plus ammonia are highest in late summer and early autumn and lowest in late autumn through spring.

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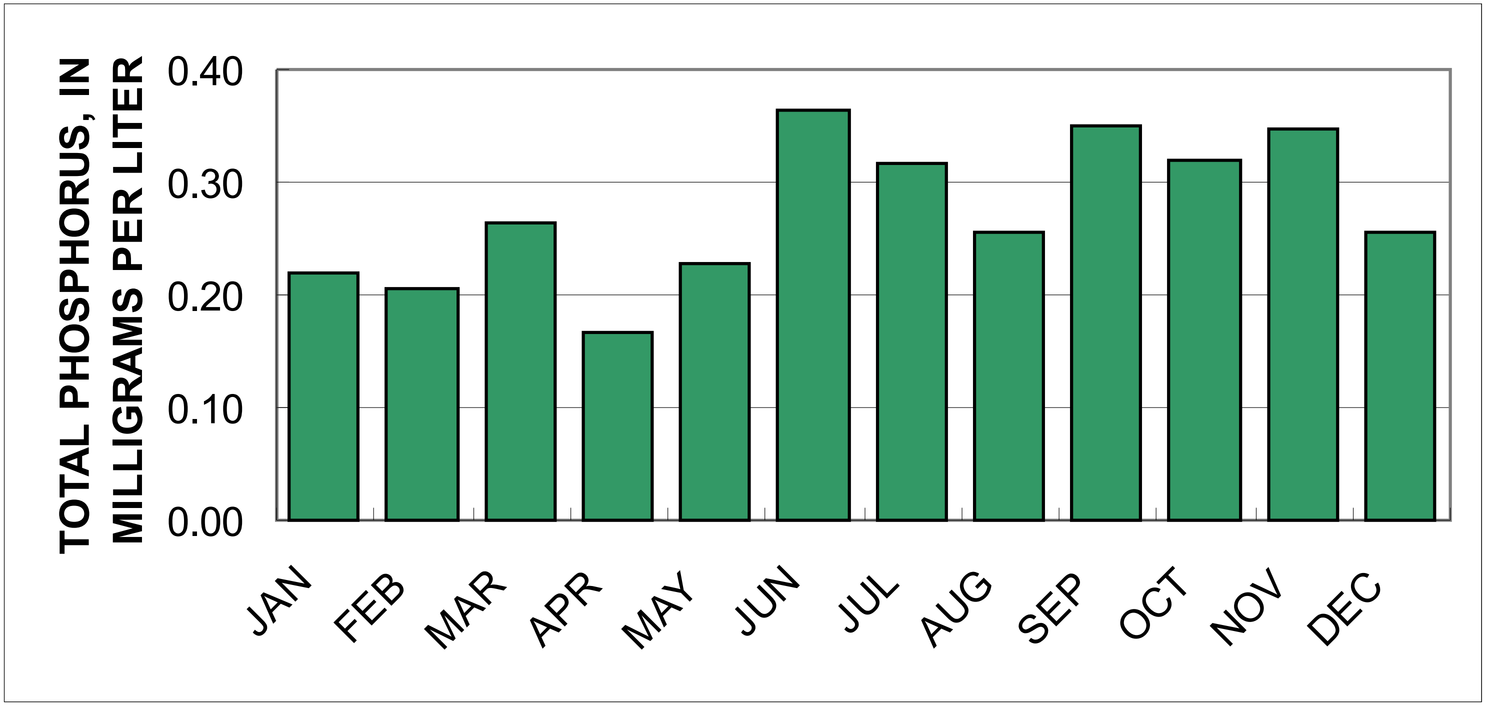

Graph 12

Seasonal variation in concentrations of total phosphorus was minimal for water samples collected on the Salt River at Glensboro. High concentrations of total phosphorus are associated more with runoff events than with seasonal variation because total phosphorus is transported to streams mainly by runoff. Most of the high concentrations of total phosphorus were observed in samples collected during runoff events.

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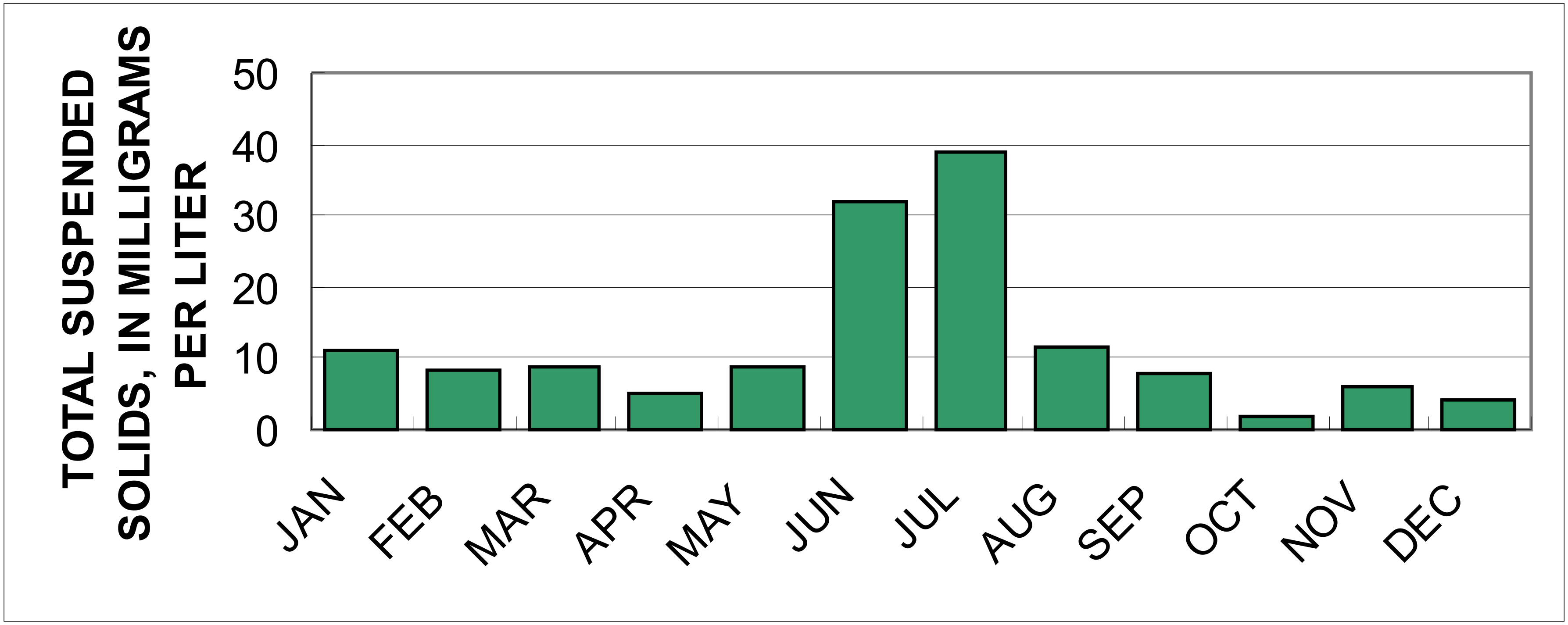

Graph 13

Median concentrations of TSS at the Salt River at Glensboro sampling site tend to be highest during summer (June-August) and lowest during other seasons.

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Data used in the study

NLCD 1992

http://landcover.usgs.gov/natllandcover.asp

Derived from the early to mid-1990s Landsat Thematic Mapper satellite data, the NLCD is a 21-class land-cover classification scheme applied consistently across the United States. Both leaves-off and leaves-on data sets were analyzed. The resulting clusters were then labeled using aerial photography and ground observations. Clusters that represented more than one land-cover category also were identified and, using various ancillary data sets, models were developed to split the confused clusters into the correct land-cover categories.

KLCD 2000 Provisional. This data set is currently under review.

http://klc.ky.gov/

http://kls.ky.gov/

The Kentucky Landscape Snapshot is a National Aeronautic and Space Administration (NASA) funded project to update the NLCD, develop a detailed forest-type map, and create a stratified forest inventory for the Commonwealth of Kentucky. The project also will develop urban land-use maps for selected counties and toolsets to make the data and products functional. The project will provide very useful data for decision making in Kentucky.

NRI

http://www.ky.nrcs.usda.gov/programs/NRI/what.html

The NRI is a statistical survey of land-use and natural resource conditions and trends on United States non-Federal lands. The NRI is conducted by the USDA-NRCS, in cooperation with Iowa State University's Center for Survey Statistics and Methodology.

The NRI program serves as the Federal Government's principal source of information on the status, condition, and trends of soil, water, and related resources in the United States.

SPARROW Provisional. This data set is currently under review.

http://water.usgs.gov/nawqa/sparrow/

SPARROW relates in-stream water-quality measurements to spatially referenced characteristics of watersheds, including contaminant sources and factors affecting over-land and stream transport. The model estimates the origin and fate of contaminants in streams and quantifies uncertainties in these estimates based on model-coefficient error and unexplained variability in the observed data.

STREAMFLOW, PRECIPITATION, AND WATER-QUALITY DATA

Daily streamflow data (January 1989-June 2003) were available from the Salt River at Glensboro gaging station (03295400). The USGS, in cooperation with the USCOE-Louisville District and the Environmental and Public Protection Cabinet, operates this gaging station.

Monthly precipitation data were obtained from the University of Kentucky Agricultural Weather Center. The weather site at Lexington was the source of the precipitation data.

Water-quality data for the Salt River at Glensboro sampling site were collected and analyzed by the KDOW. Samples were collected from February 1989 to June 2003.

The load for total nitrogen was estimated for 1988-92 at the Salt River at Glensboro sampling site using the FLUX computer program (Walker, 1987). The load for total phosphorus was estimated for 1988-94 at the same site using the ESTIMATOR computer program (Cohn and others, 1989). The reported load estimates for total nitrogen and total phosphorus for the nine subwatersheds within the upper Salt River Watershed are based on the use of the SPARROW watershed model (Smith and others, 1997; Alexander and others, 2000). For this project, only total nitrogen and total phosphorus are reported because they represent total loads for the main nutrient compounds of concern.

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Partners

Kentucky Department of Fish and Wildlife Resources	http://fw.ky.gov/
Kentucky Division of Conservation	http://www.conservation.ky.gov/
Spencer County Conservation District	http://www.geocities.com/sccdconservation/
Anderson and Shelby County Conservation Districts	http://www.conservation.ky.gov/condistricts/
Kentucky Division of Forestry	http://www.forestry.ky.gov/
Kentucky Division of Water	http://www.water.ky.gov/
Salt River Basin Team	http://www.watersheds.ky.gov/basins/salt/
Salt River Watershed Watch	http://kywater.org/watch/salt1
U.S. Army Corps of Engineers-Louisville District-Taylorsville Lake	http://www.lrl.usace.army.mil/tay
USDA-Natural Resources Conservation Service-Kentucky	http://www.ky.nrcs.usda.gov/
U.S. Geological Survey-Kentucky District	http://ky.water.usgs.gov/index.htm

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Web links

KDOW-Nonpoint Source Pollution	http://www.water.ky.gov/sw/nps/
KDOW-Watershed Framework	http://www.water.ky.gov/watersheds/
Kentucky Landscape Census-KLCD	http://klc.ky.gov/
U.S. Census Bureau	http://www.census.gov/
USDA-National Agricultural Statistics Service	http://www.usda.gov/nass/
USDA-NRCS-NRI	http://www.ky.nrcs.usda.gov/programs/NRI/what.html
USDA-NRCS-Soils	http://soils.usda.gov/
USGS-NLCD	http://landcover.usgs.gov/natllandcover.asp
USGS-SPARROW	http://water.usgs.gov/nawqa/sparrow/

References Cited

Alexander, R.B., Smith, R.A., and Schwarz, G.E., 2000, Effect of stream channel size on the delivery of nitrogen to the Gulf of Mexico: Nature, v. 403, p. 758-761.

Cohn, T.A., DeLong, L.L., Gilroy, E.J., Hirsch, R.M., and Wells, D.K., 1989, Estimating compound loads: Water Resources Research, v. 25, no. 5, p. 937-942.

Kentucky Natural Resources and Environmental Protection Cabinet, 2000, Upper Salt River/Taylorsville Reservoir Watershed Non-point Source Demonstration Project Final Report: Frankfort, Ky., Division of Water, Water Quality Branch, Technical Report No. 4, April 2000, p 106-109.

Smith, R.A., Schwarz, G.E., and Alexander, R.B., 1997, The regional interpretation of stream water-quality monitoring data: Water Resources Research, v. 33, p. 2,781-2,798.

U.S. Census Bureau, 2000, Population Statistics 1990-1999: Washington, D.C., On-line at < http://www.census.gov/main/www/cen2000.html> accessed April 12, 2004.

U.S. Environmental Protection Agency, 1986, Quality criteria for water 1986: Washington D.C., Report 440/5-86-001, p. 453.

-- 1999, Children and drinking water standards: Washington, D.C., Office of Water, EPA 815-K-99-001, December 1999, p. 15.

Walker, W. W., Jr., 1987, Empirical methods for predicting eutrophication in impoundments Report 4, Phase III Applications Manual: Vicksburg, Miss., U.S. Army Corps of Engineer Waterways Experimental Station, Technical Report [variously paged].

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Source: http://www.epa.nsw.gov.au/envirom/waterqual.htm

What is water quality?

Water is essential to human life and to the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (river and lakes) and ground-water environments, across coastal and inland areas. Water has two dimensions that are closely linked - quantity and quality. **Water quality is commonly defined by its physical, chemical, biological, and aesthetic (appearance and smell) characteristics.** The quality of a body of water affects the way in which communities use the water for activities such as drinking, swimming, or commercial purposes.

Why is water quality important?

Our water resources are of major environmental, social, and economic value and if water quality becomes degraded this resource will lose its value. Water quality is important not only to protect public health, but also for ecosystem habitats, farming, fishing, recreation, and tourism. If water quality is not maintained, it is not just the environment that will suffer - the commercial and recreational value of our water resources also will diminish.

What affects the quality of our water?

Water quality is closely linked to the surrounding environment and land use. Other than in its vapor form, water is never pure and is affected by community uses such as agriculture, urban and industrial use, and recreation. The modification of natural streamflows by dams and weirs also can affect water quality. The weather too can have a major effect on water quality.

How is water quality measured?

The presence of contaminants and the characteristics of water are used to indicate the quality of water. These water-quality indicators can be categorized as:

- **Biological:** bacteria, algae
- **Physical:** temperature, turbidity and clarity, color, salinity, suspended solids, dissolved solids
- **Chemical:** pH, dissolved oxygen, biological oxygen demand, nutrients (including nitrogen and phosphorus), organic and inorganic compounds (including toxicants)
- **Aesthetic:** odors, taints, color, floating matter
- **Radioactive:** alpha-, beta-, and gamma-radiation emitters

Measurements of these indicators can be used to determine, and monitor changes in, water quality and determine whether the quality of the water is suitable for the health of the natural environment and the uses for which the water is required.

What is a watershed?

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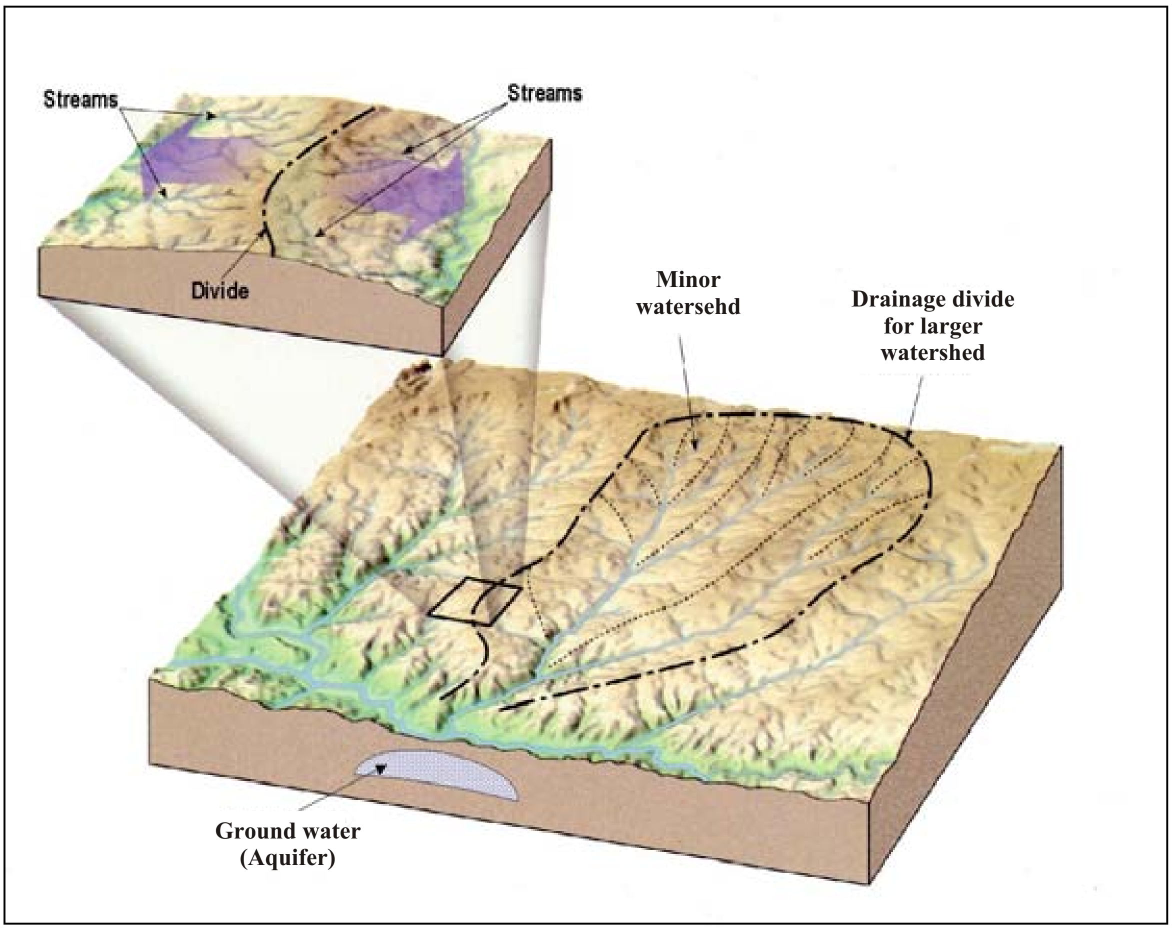
What is a watershed?

No matter where you live, work, or play, you are in a watershed. A watershed, also called a drainage basin, is a geographic area where all rainwater running off the land drains to a specific location. This location may be a stream, river, lake, wetland, or ocean. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often along a ridge. Large watersheds, like the area that drains into the Mississippi River, contain thousands of smaller watersheds.



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More about nutrients

Nitrogen occurs in natural waters as nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), and organically bound nitrogen. As aquatic plants and animals die, bacteria break down large protein molecules containing nitrogen into ammonia. Ammonia is then oxidized by specialized bacteria to form nitrites and nitrates. Sources of nitrogen include sewage, fertilizers, and animal wastes. Excessive nitrates stimulate growth of algae and other plants, which later decay and increase biochemical oxygen demand as they decompose.

Phosphorus is usually present in natural water as phosphates (orthophosphates, polyphosphates, and organically bound phosphates). Phosphorus is a plant nutrient needed for growth and a fundamental element in the metabolic reactions of plants and animals (hence its use in fertilizers). Sources of phosphorus include human and animal wastes (i.e., sewage), industrial wastes, soil erosion, and fertilizers. Excess phosphorus causes extensive algal growth called "blooms," which lead to decreased oxygen levels in water.

Nutrient yields for river basins are often estimated to evaluate the effectiveness of water-quality-management programs. A comparison of nutrient yields among river basins can be useful to water-resource managers in understanding and taking measures to improve water quality. For this project, yields were estimated in order to make meaningful comparisons of estimated loads of total nitrogen and total phosphorus for the nine subwatersheds within the upper Salt River above the Dam at Taylorsville. The load of a water-quality constituent in a stream (the weight of material transported during a specific time period) is determined by multiplying the concentration of the constituent by the stream discharge. A yield equals the load divided by the drainage area of the watersehd.

Source: http://www.water.ky.gov/sw/nps/About.htm

KY Division of Water

About Nonpoint Source Pollution

Last Updated on12/28/2003

Nonpoint source (NPS) pollution is also known as runoff or diffuse pollution. Unlike pollution from industrial and sewage treatment plants, NPS pollution is caused by rainfall or snowmelt moving over and through the ground. NPS pollution is the number one contributor to water pollution in Kentucky; it accounts for approximately two-thirds of the water quality impairments in Kentucky's streams and lakes. As the runoff moves, it picks up and carries pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and even underground aquifers. For example, these pollutants include:

- Excess fertilizers, herbicides and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff;
- Sediment from improperly managed construction sites, crops, forestlands and eroding streambanks;
- Acid drainage from abandoned coal mines;
- Bacteria and nutrients from livestock, pet wastes and faulty septic systems;

While the bulk of water quality data is presented in terms of surface water, nonpoint source pollution affects all water resources: rivers, streams, lakes, wetlands and groundwater. Groundwater and surface water are often difficult, and sometimes impossible, to separate. From sinking streams to springs to large karst rivers, groundwater and surface water are intimately linked in Kentucky.

The Kentucky Nonpoint Source Pollution Control Program is currently authorized under §319 of the Clean Water Act (CWA) amendments of 1987. The CWA amendments of 1987 deal with a wide variety of pollutants that enter the water by sources other than a point source discharge. Conflicts over the use of public waters are inevitable and likely to increase as population and demands for water increase. It is clear, however, that management strategies are critical in reconciling varied but equally important uses. Protection of water quality to support designated uses are the key components of management strategies, whether for point or nonpoint sources of pollution.

NPS Pollution Control

Nonpoint source pollution is controlled primarily through the adoption of practical and cost-effective land management practices that are known as Best Management Practices (BMPs). BMPs allow for everyday activities while reducing or preventing nonpoint source pollution. The use of BMPs protects water quality while maintaining the economic value of Kentucky's land resources.

Kentucky's approach to controlling NPS pollution includes both focused watershed projects and statewide initiatives. Watershed projects are important for reducing NPS pollution; they are designed to improve or maintain water quality conditions in watersheds through aggressive BMP implementation. Watershed projects address diverse NPS concerns, utilize a variety of funding sources for BMP implementation and include water quality monitoring as a measure of success. Statewide programs are an integral part of Kentucky's strategy to reduce NPS pollution. Statewide programs help to raise public awareness about runoff pollution, provide technical information on BMPs and develop and implement regulatory programs. Kentucky's NPS Pollution Control Program uses both regulatory and non-regulatory mechanisms to achieve BMP implementation in watershed projects and statewide initiatives.

Like many states, Kentucky does not have sufficient resources to implement BMPs for all existing or potential NPS pollution problems. In order to maximize NPS pollution control efforts, technical and financial assistance from other federal, state and local sources are cooperatively targeted to NPS priority watersheds. Grant funds authorized by Section 319(h) of the Clean Water Act assist states with implementing nonpoint source pollution control projects.

For More Information Contact:
Kentucky Division of Water
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Fax: (502) 564-0111
Email: water@ky.gov

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GLOSSARY

Aquifer--A geologic formation(s) that is water bearing. A geological formation or structure that stores and (or) transmits water, such as to wells and springs. Use of the term is usually restricted to those water-bearing formations capable of yielding water in sufficient quantity to constitute a usable supply for people's uses.

Base flow--Streamflow coming from ground-water seepage into a stream.

Concentration--The amount or mass of a substance present in a given volume or mass of ample. Commonly expressed as milligrams per liter in water samples.

Constituent--A chemical or biological substance in water, sediment, or biota that can be measured by an analytical method.

Cubic foot per second (ft^3/s). --Rate of water discharge (streamflow) representing a volume of 1 cubic foot passing a given point during 1 second, equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute.

Discharge--The volume of water that passes a given location within a given period of time. Usually expressed in cubic feet per second.

Drainage basin--Land area where precipitation runs off into streams, rivers, lakes, and reservoirs. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge. Large drainage basins, like the area that drains into the Mississippi River contain thousands of smaller drainage basins. Also called a "watershed."

Erosion--The process in which a material is worn away by a stream of liquid (water) or air, often caused by the presence of abrasive particles in the stream.

Gaging station--A site on a stream, lake, reservoir or other body of water where observations and hydrologic data are obtained. The U.S. Geological Survey measures stream discharge at gaging stations.

Headwater(s)--(1) The source and upper reaches of a stream; also the upper reaches of a reservoir. (2) The water upstream from a structure or point on a stream. (3) The small streams that come together to form a river. Also may be thought of as any and all parts of a watershed except the mainstream river and main tributaries.

Next

Load--General term that refers to a material or constituent in solution, in suspension, or in transport; usually expressed in terms of mass or volume.

Maximum contaminant level (MCL)--Maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCLs are enforceable standards established by the U.S. Environmental Protection Agency.

Mean--The average of a set of observations, unless otherwise specified.

Mean discharge--The arithmetic average of individual daily average discharges during a specific period, usually daily, monthly, or annually.

Median--The middle or central value in a distribution of data ranked in order of magnitude. The median also is known as the 50^{th} percentile.

Milligrams per liter (mg/L)--A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million.

Nitrate--An ion consisting of nitrogen and oxygen (NO_3). Nitrate is a plant nutrient and is very mobile in soils.

Nonpoint source (NPS) pollution--Pollution discharged over a wide land area, not from one specific location. These are forms of diffuse pollution are caused by sediment, nutrients, organic, and toxic substances originating from land-use activities, which are carried to lakes and streams by surface runoff. Nonpoint source pollution is contamination that occurs when rainwater, snowmelt, or irrigation washes off plowed fields, city streets, or suburban backyards. As this runoff moves across the land surface, it picks up soil particles and pollutants, such as nutrients and pesticides.

Nutrient--Element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Pathogen--A disease-producing agent; usually applied to a living organism. Generally, any viruses, bacteria, or fungi that cause disease.

Phosphorus-- A nutrient essential for growth that can play a key role in stimulating aquatic growth in lakes and streams.

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Point-source pollution--Water pollution coming from a single point, such as a sewage-outflow pipe.

Total Kjeldahl nitrogen (TKN)--The sum of the organic plus ammonia nitrogen in water samples.

Total suspended solids (TSS)--A measure of the suspended organic and inorganic solids in water.

Water quality--A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Watershed--A watershed is the area of land that drains to a common point. Also called a drainage basin.

Yield--A mass of material or constituent transported by a river in a specified period of time divided by the drainage area of the watershed.

Abbreviations

Agencies

Kentucky Department of Natural Resources-Division of Conservation (KDOC)
Kentucky Division of Water (KDOW)
National Aeronautic and Space Administration (NASA)
Natural Resources Conservation Service (NRCS)
U.S. Army Corps of Engineers (USACE)
U.S. Department of Agriculture (USDA)
U.S. Environmental Protection Agency (USEPA)
U.S. Geological Survey (USGS)

Miscellaneous

Best-management practices (BMPs)
Geographic information system (GIS)
Kentucky land-cover data (KLCD)
Maximum contaminant level (MCL)
National land-cover data (NLCD)
National Resources Inventory (NRI)
Nonpoint source (NPS)
SPAtially Referenced Regressions On Watershed Attributes (SPARROW)
Total suspended solids (TSS)

Units of measure

cubic feet per second (ft^3/s)
kilograms per square kilometer per year ($kg/km^2/yr$)
kilograms per year (kg/yr)
milligrams per liter (mg/L)

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