SECTION 2
ENVIRONMENTAL & NATURAL RESOURCES

A. Introduction and Statement of Goals

Radnor Township is blessed with an abundance of natural resources: the geology, soils, vegetation, surface water, and biota provide the foundation for the growth and management of all the Township's assets. Agriculture, recreation, business and commerce, residential land – every use of the land is built upon the distinctive environmental conditions contained in Radnor Township. The Township is almost "built-out;" vacant land is nearly obsolete. The extensive development that has proliferated throughout the Township is testament to its general developability, enjoying the good rock foundations and the good soils that exist. With a few exceptions, even the lesser desirable soils and topographic situations tolerate building from a builder's perspective, provided that certain accommodations are made.

1. Goals and Objectives

As remaining natural resources are threatened by encroaching development and redevelopment situations, the Township is taking a proactive approach. Listed below is the overriding goal that has developed out of the comprehensive planning process, followed by the Objectives necessary to fulfill the goal:

Goal

Protect the Township's vital environmental values, including water resources, wetlands, floodplains and riparian areas, woodlands and important habitat areas, balancing the needs of development with environmental values.

Objectives

1. *Direct development to areas of minimum environmental sensitivity; prohibit development in areas of heightened sensitivity and value, such as wetlands, floodplains, riparian zones, and steep slopes.*

2. *Manage water resources, both water quality and water quantity, especially through a program of improved stormwater management.*

3. *Implement watershed-wide planning principles as developed by the Darby Creek River Conservation Plan and other appropriate watershed planning processes.*

4. *Work to preserve remaining natural woodlands in the Township through minimum disturbance/minimum maintenance land development techniques, site conservation, and other practices; reinforce tree protection requirements and promote re-vegetation and re-forestation strategies with native species, compatible with sound landscape ecology principles.*

5. *Work to preserve remaining open spaces in the Township, using all direct means such as acquisition, as well as less direct regulatory programs; prioritize those open spaces, taking into account factors such as proximity to wildlife habitat and forage areas, aesthetic values, water resource values, and other factors relating to landscape ecology management.*

6. *Integrate management of noise, artificial light, and odor into the Township's planning and management program.*

7. *Work to protect air quality through mobile source emission strategies developed in the transportation planning element of the comprehensive plan and through integrating transit oriented development and other auto trip reduction strategies into overall planning.*

B. Earth Resources

1. Geology

Radnor Township is comprised primarily of older rock from the Precambrian era (older than 570 million years) and Lower Paleozoic era (430 to 570 million years ago). Weathering and erosion of these rock types has created the surficial land features including the relatively gently rolling topography of Radnor Township. During much of the Paleozoic era (570 to 245 million years ago), the earth's plate tectonic movements forced the ancient landmasses together several times. One of the most significant of these "collisions" occurred 300 million years ago as the eastern margin of North America collided with South America and Africa. The impact uplifted the North American land area – called Pangaea – and produced the Appalachia mountain range, whose 15,000-foot peaks rival the Alps and Himalayan mountains. After the collision, Pangaea began to break up and rift during the Triassic period (245 to 208 million years ago) to create the modern day Atlantic Ocean. Through the subsequent millions of years of intense geologic activity, the Appalachian range underwent vigorous erosion by wind and water, as well as cycles of uplifting and rifting, to create the present geology and landforms within the Township.

Geologic Formations in the Township

Radnor Township is comprised primarily of ancient crystalline bedrock, along with metamorphic and igneous rocks from the Precambrian period (430 to 570 million years ago). Figure 2-1 depicts the surficial geologic units of the Township and surrounding municipalities. Each rock formation has important properties that influence the local hydrology, topography, soil composition, vegetative association, and landforms found within the Township. Felsic gneiss and Mafic gneiss are metamorphic rock types that cover most of the Township. These formations yield small quantities of water due to the smallness of the cracks, joints, and other openings within the rock. The Wissahickon Formation is a mica schist derived from sandstones and mudstones, and is found in the extreme northern and southern portions of the Township. The Wissahickon Formation is a consolidated rock aquifer and is the highest yielding crystalline aquifer in Delaware County (Balmer and Davis, 1996). Small areas of serpentine rock underlie a small portion of the township. Early in the 19th century, the

surrounding region was famous for its serpentine rock quarries. Serpentine stone was easily extracted from the earth and provided building material for many local structures and homes in earlier periods. Serpentine and the minerals associated with this formation produce a sterile and toxic growing environment for crops and plants, hence the name "serpentine barrens." Serpentine barrens are rare on the east coast and provide habitat for many rare, threatened, and endangered species. Mining and quarrying over the years destroyed much of the serpentine barrens in Radnor and beyond, with continuing sprawling development leading to the consumption of much of the remaining serpentine barrens habitat.

2. Physiography

A *physiographic province* is the expression of bedrock at the surface of the land. As shown in Figure 2-2, Radnor Township lies within the Piedmont Uplands Physiographic Province. The Piedmont is characterized by generally very old and hard upland rocks, which have been deposited from the erosion of the Appalachian Mountains. The Piedmont, meaning "foot of the mountains," is a region of gently rolling hills, fertile valleys, and well-drained soils. Weathering and erosion of the colossal Appalachian range has produced the rolling topography with deeply incised stream valleys traversing the landscape.

As explained above, tectonic forces and shifting crustal plates followed by millions of years of erosion by wind and water, shaped Radnor Township's present day topography. In the rolling valleys of Radnor, elevations range from 150 feet above sea level in the northern and central portion of the Township, to 60 feet above sea level in the southern portion of the Township near the confluence of Ithan Creek and Darby Creek. Although elevations are not great in the Township, change in elevation, and therefore steeply sloped areas, can occur, especially in the deeply incised stream valleys which have been cut over the years. The geological history and variability is often revealed in the attractive rock outcroppings which are exposed in these stream valleys.

Hydrogeology and Watersheds

Groundwater is present in and moves in different degrees through cracks, fractures, and voids within the bedrock material in virtually all rock formations in the Township (see discussion in the Water Resources Section). These cracks, fissures, and voids have been caused by weathering over the millennia and are most common closer to the surface; therefore most of this groundwater can be found relatively close to the earth's surface as well, typically less than 500 feet in depth. As depth increases, rock tends to get "tighter" and weathering and water "opportunities" generally decrease. Although small wells have been developed over the years in Radnor and still exist, none of the geologic formations in the Township yields enough water consistently for large industrial or public supplies because of the inherently low storage capacity of these consolidated rocks (Balmer and Davis, 1996). Streams in the Township generally act as "drains" for the groundwater aquifers, as they are called, with the groundwater continuously discharging by gravity to the surface streams through systems of springs, seeps, wetlands, and other points of discharge (i.e., groundwater creates the stream system).

Figure 2-3 shows the Township in relation to the local and regional Watershed system. About 80 percent of Radnor Township is located in the Darby Creek Watershed, which flows into the Delaware River and includes Little Darby Creek, Ithan Creek, and Meadowbrook Run. The

Little Darby has been residentially developed in lower densities, whereas the Ithan originates in high density Wayne and is buried and channeled in storm sewers down to the vicinity of Meadowbrook and Pembrook Avenues. Meadowbrook Run drains Rosemont/Garrett Hill and a blend of residential, institutional, and other developed uses. To the north, Gulph Creek (about 20 percent of the Township) flows easterly for about three miles through the northern portion of Township and into the Schuylkill River. The watershed divide between the Darby and Gulph/Schuylkill systems roughly follows the alignment of the AMTRAK/Paoli Local between Strafford and Bryn Mawr. These creeks all have cut through the hard rock to form deep Piedmont stream valleys which have considerable planning significance for the Township.

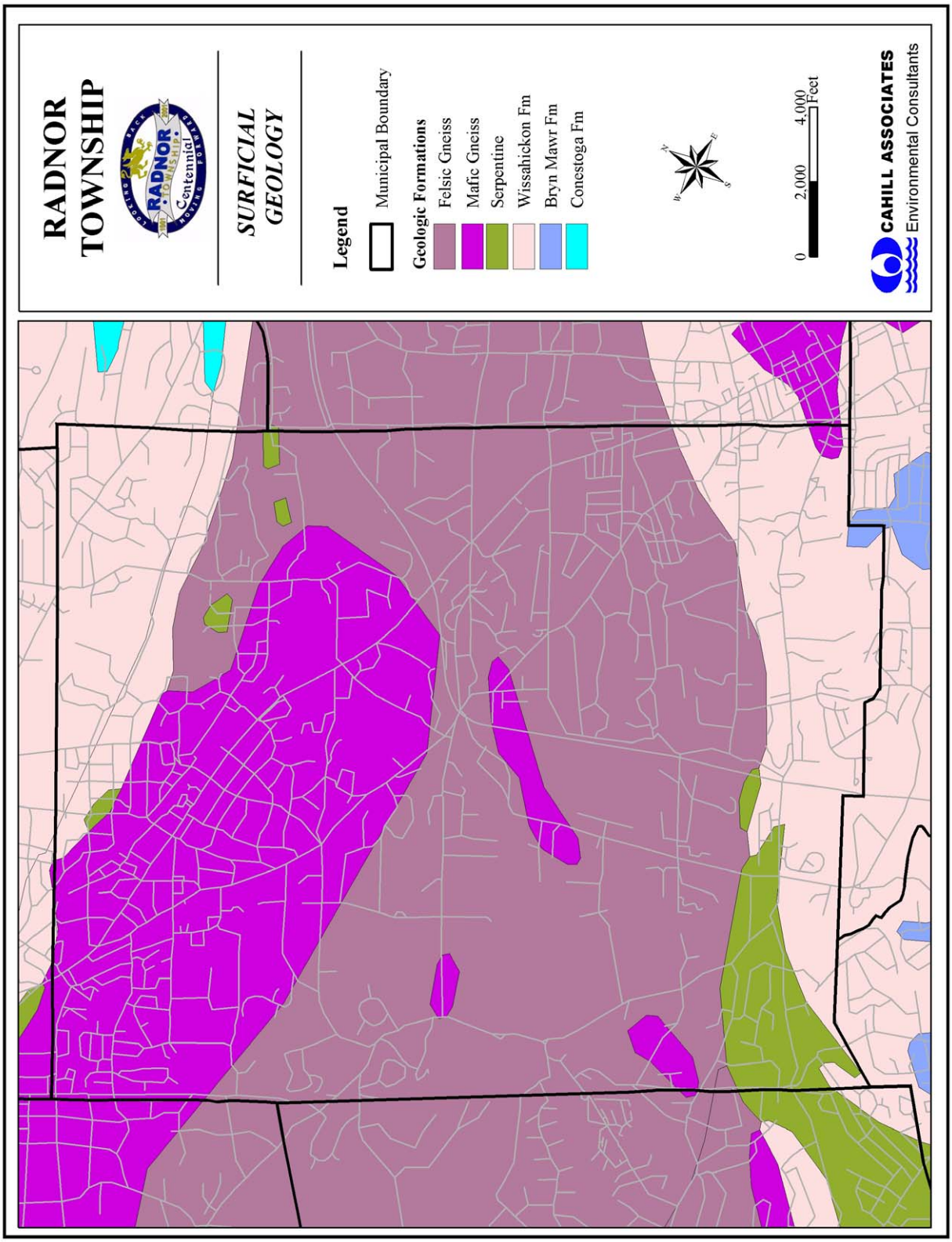

Figure 2-1. USGS Geologic Composition in Radnor Township

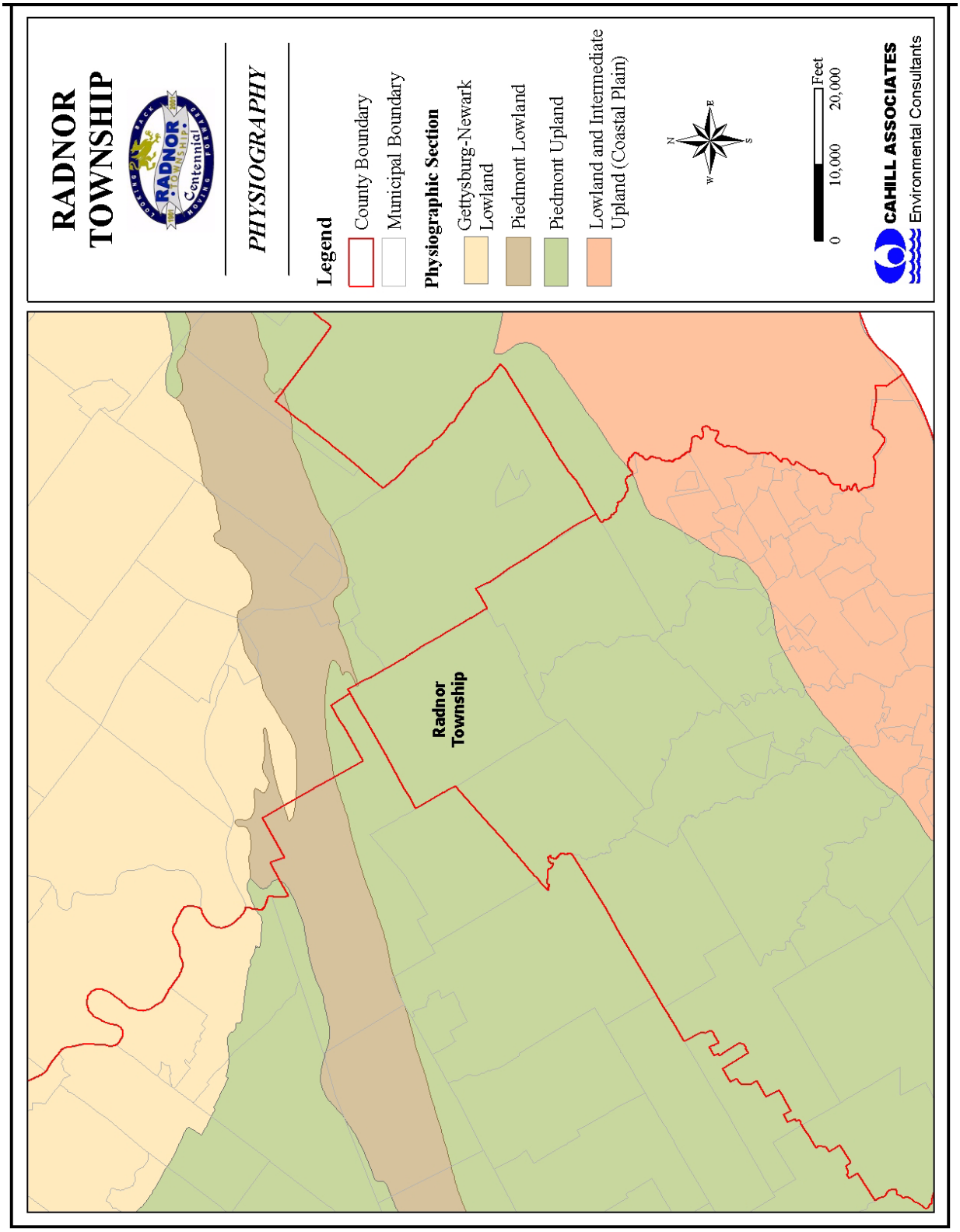

Figure 2-2. Physiographic Provinces for Radnor Township

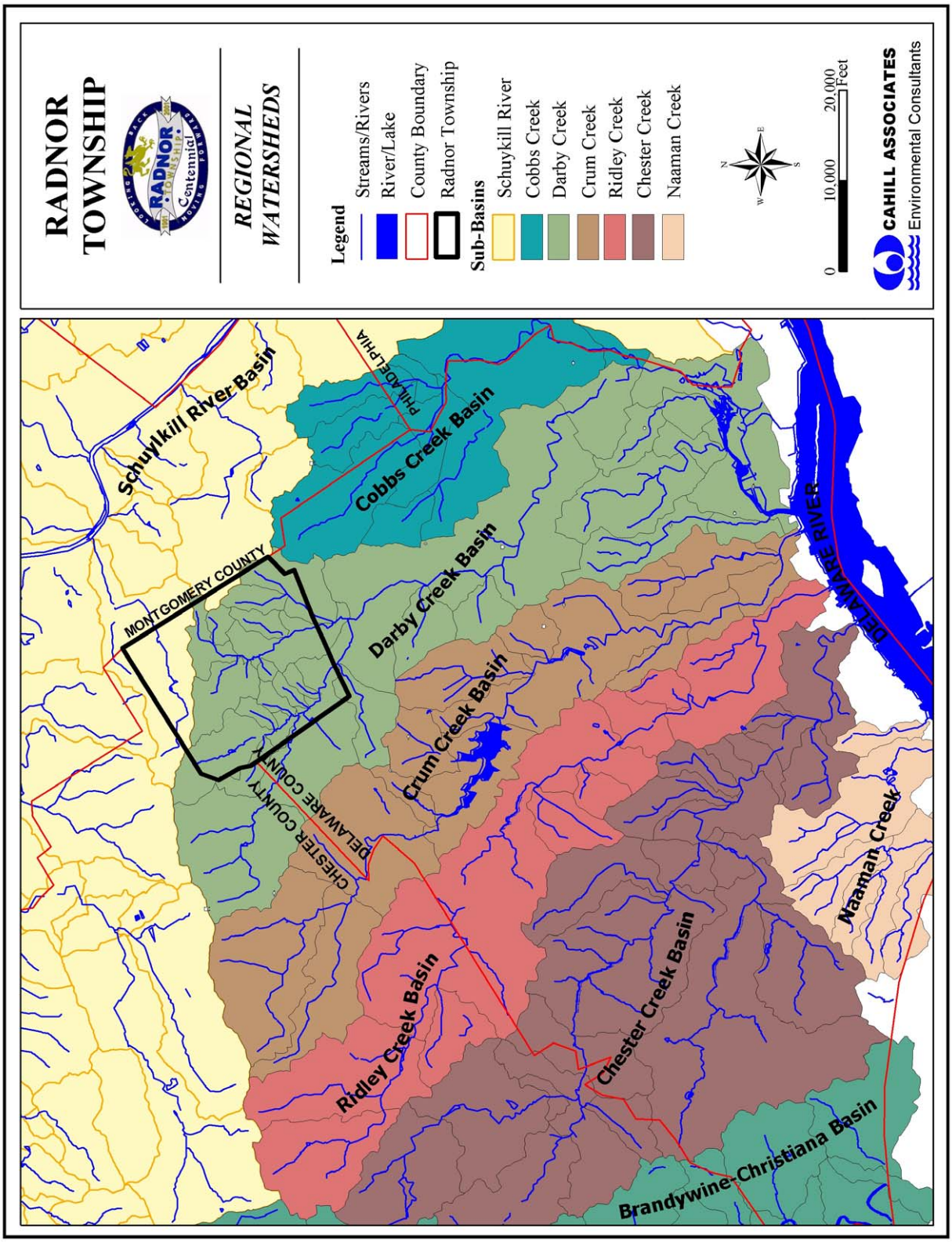

Figure 2-3. Watersheds of Radnor Township and Surrounding Region

3. Soil

The soils in the Township, shown in Figure 2-4, reflect the weathering process of the parent bedrock geology. In this Piedmont region, schist, gneiss, and crystalline rock are the predominant bedrock material. The eroded and weathered underlying bedrock gives way to the well-drained silt loam soils that are the majority of the township, including Glenelg and Manor. Both Glenelg and Manor formed in materials weathered from micaceous schist and support native oak and red maple vegetation. Minor series found in the township include Wehadkee, Worsham, Chewacla, and Congaree soil series are "wet" soils that are moderately to poorly drained, occurring in low-lying areas around floodplains and headwaters of streams. They may be either alluvial soils and/or hydric soils. Alluvial soils are defined as those soils that have been deposited over the years by flooding events; alluvial soils can be used as a "proxy" for more detailed floodplain mapping where floodplain mapping has not been undertaken. Hydric soils are those "wet" soils which support hydrophytic or wetland vegetation and may be closely related to wetlands themselves through depth to water table (typically, not all hydric soils are wetlands, but all wetlands are hydric soils). There is a considerable amount of Made Land (also classified as "Urbana") in the Township, reflecting the significant growth over the years and the substantial cutting and filling, grading, and overall land manipulation and alteration that occurs with traditional development. The areas of Made Land/Urban follow the Route 30 corridor in the northern area of the Township.

Hydrologic Soil Groups

The relationship between water resources and land development impacts is expressed by the Hydrologic Soil Group (HSG) classification of the soil series (USDA, 1979; Figure 2-5). HSGs are given a rating, A through D. These HSG ratings describe the physical drainage properties of each soil series, including texture and permeability, as well as certain physiographic properties, such as depth to bedrock and water table. HSG Group A is well drained and highly permeable, in contrast to HSG Group D which is poorly drained and produces much greater runoff. Sand would be an A; heavy clay would be a C or D. The HSG classification is of importance in determining the feasibility of using infiltration or recharge-oriented Best Management Practices for stormwater management, as well as for determining feasibility of land-based wastewater treatment technologies that recycle wastewater effluent (a permeability of 0.5 inches per hour is often considered adequate for infiltration of stormwater or wastewater).

Radnor Township contains mostly B soils. Lowlands along stream valleys typically consist of HSG Groups C and D soils, reflecting an almost constant saturation and poor drainage condition. The Made Land also tends to have relatively poor permeability, though as with C and D groups, require site specific tests to confirm permeability. It is important to note, that many heavy-clayey C soils with poor permeability are capable of natural infiltration when not disturbed and compacted and when a natural vegetative cover is maintained, owing to the added permeability created by mature dense root systems that can make a C quite permeable.

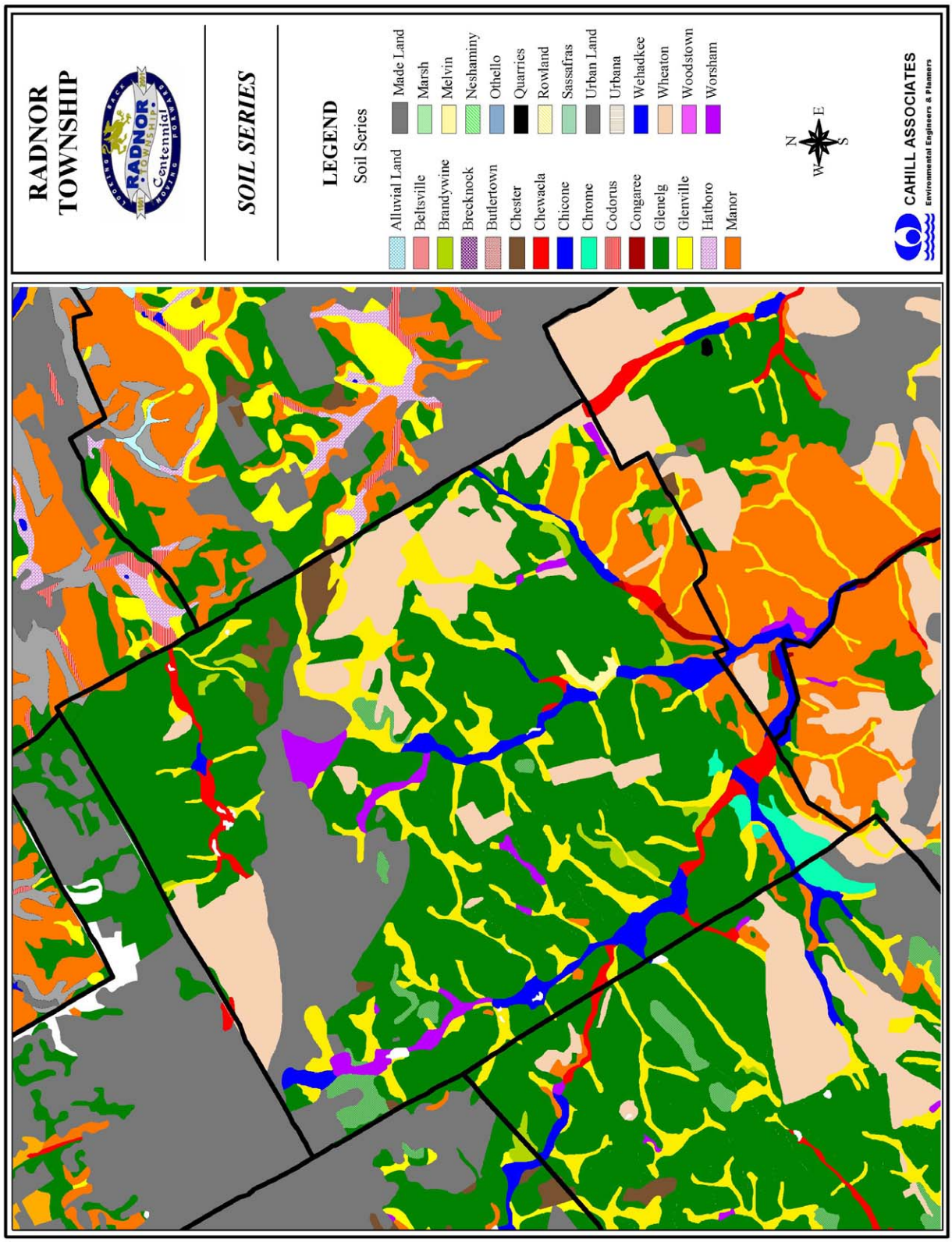

Figure 2-4. Soil Composition within Radnor Township

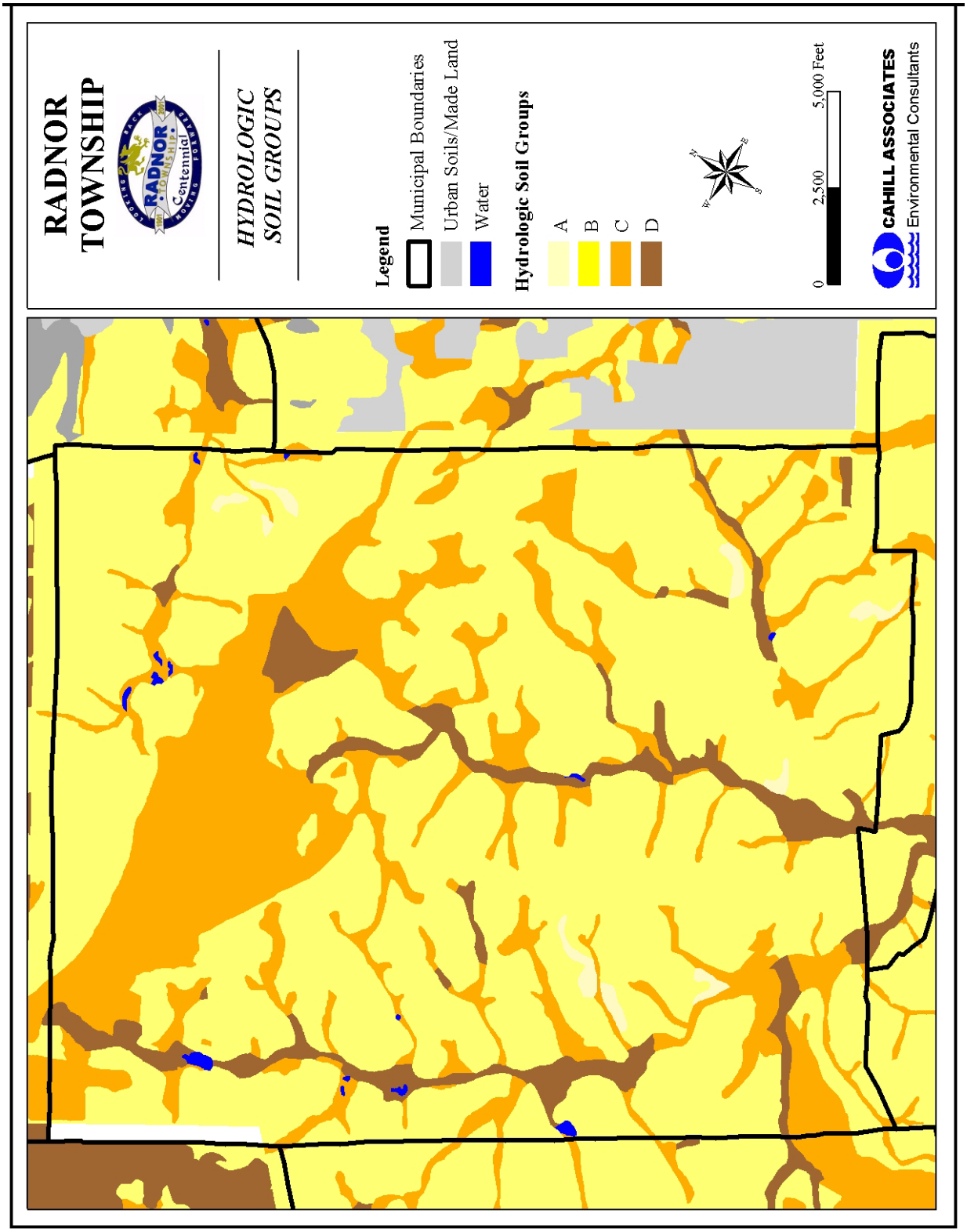

Figure 2-5. Hydrologic Soil Groups within Radnor Township

4. Planning Issues

Radnor Township is blessed with a relative lack of geological and soil-related constraints. The extensive development which has proliferated throughout the Township is testament to its general developability, enjoying the good rock foundations and the good soil which exist. With a few exceptions, even the lesser desirable soils and topographic situations (i.e., steep slopes) tolerate building from a builder's perspective, provided that certain accommodations are made. However, because these areas are more environmentally sensitive, the adverse impacts from their development are much greater than would occur from less sensitive areas. Therefore negative impacts from their development are greater as well. Development on slopes not only eliminates what might have been positive effects of a natural buffer, but increases runoff and erosion and a host of downstream problems. Development in the floodplain, even when properly floodproofed, eliminates all of the positive environmental benefits resulting from naturally vegetated floodplain areas where flood flows are slowed, retained, filtered, infiltrated, and so forth.

At this point, vacant land is a rare commodity in the Township (see Land Use section for further discussion), though parcels or portions of parcels with building constraints, such as wet soils and steep slopes and floodproneness, may still remain. Unfortunately, as development pressures mount, the pressures to development these especially sensitive and highly constrained sites also mount, with developers pressuring local officials to yield to their arguments and approve developments which impact on these most sensitive of resources. Threats to sensitive resources increase. And of course these threats to sensitive lands must be viewed together with the already extensive alterations made to vast areas of the Township, as discussed in the Water Resources and Biotic Resources sections of this Plan. As argued in these sections, the few remaining "islands" of undeveloped land--the very little remaining undisturbed vegetation and soil mantle--are all working double time, triple time and more from a natural resources perspective to counteract the natural system impacts which have already occurred. Their protection is of paramount importance.

C. Water Resources

1. Surface Waters: Streams and Major Tributaries

Radnor Township is fortunate to have a significant amount of surface streams, allowing for many recreation and environmental assets. Figure 2-6 shows a detailed mapping of the existing stream system overlaid with the state-classified sub basins. Comprehensive Plan consultants updated the publicly available GIS stream coverage using the 2000 DVRPC digital aerial orthophotos with a small amount of field reconnaissance. Additional mapping of the surface stream system was necessary for a variety of reasons. First, public stream data is only mapped from US Geological Survey 7.5' quarter quads at a scale of 1" to 200 feet. Accuracy is therefore compromised as many stream segments and tributaries are overlooked. Second, as discussed in detail below, the riparian encroachment analysis required a more accurate stream coverage to assess the impact of a proposed stream buffer ordinance on landowners. Finally, this updated GIS information will be provided to the Township Engineering Department, and through even more accurate GPS field surveys can be updated accordingly for any Township needs.

Table 2-1 lists sub-basin areas and Table 2-2 lists stream lengths by sub-basin. Radnor Township has approximately 35 linear miles of surface streams (data extracted from GIS files). The major streams in the Township include Little Darby Creek, Ithan Creek, Meadowbrook Run, and the Darby Creek itself (all part of the Darby Creek Watershed); Gulph Creek encompasses the northern portion of the Township, flowing into the Schuylkill River. Most (87 percent) of Radnor is in the Darby Creek Watershed, with only 13 percent in the Schuylkill.

Table 2-1. Radnor Township Watershed and Sub-basin Area

Sub-Basin Name	Total Sub-basin Area		Sub-basin Area in Township	
	Acres	Sq. Miles	Acres	Sq. Miles
Abrahams Run	203	0.32	203	0.32
Browns Run	216	0.34	216	0.34
Camp Run	166	0.26	166	0.26
Cobbs Creek	3064	4.79	24	0.04
Darby Creek	10808	16.89	755	1.18
Foxes Creek	961	1.50	167	0.26
Gulph Creek	3825	5.98	1516	2.37
Hardings Run	534	0.83	506	0.79
Ithan Creek North	951	1.49	950	1.49
Ithan Creek South	1087	1.70	996	1.56
Julip Run	414	0.65	63	0.10
Kirks Run	314	0.49	314	0.49
Little Darby Creek	1475	2.30	1092	1.71
Meadowbrook Run	1129	1.76	900	1.41
Miles Run	149	0.23	149	0.23
Mill Creek	4510	7.05	132	0.21
Ramsey Run	96	0.15	96	0.15
Valley Run	383	0.60	383	0.60
Wigwam Run	208	0.32	208	0.32
	30493	47.65	8835	13.81

Table 2-2. Sub-basin Area and Stream length for Radnor Township

Sub-basin Name	Stream Length, Miles
Abrahams Run	0.97
Browns Run	0.98
Camp Run	0.80
Darby Creek	3.49
Foxes Run	0.74
Gulph Creek	5.69
Hardings Run	2.34
Ithan Creek North	2.09
Ithan Creek South	3.00
Julip Run	0.87
Kirks Run	0.95
Little Darby Creek	4.39
Meadowbrook Run	4.83
Miles Run	0.84
Ramsey Run	0.55
Valley Run	1.24
Wigwam Run	0.84
TOTAL	**34.62**

Historic Streams

Figure 2-7 illustrates historical streams, based on a tax map from the mid-19th century (approximately 1870). Quick perusal indicates a substantial reduction in the total stream system extent, with many historical streams (see discussion below) no longer being mapped. Although there may be a variety of explanations for the difference between this historical stream mapping and the current mapping, certainly one explanation is that substantial development has reduced infiltration of precipitation into the groundwater aquifers, thereby lowering the water table and reducing stream baseflow. Reduction in stream baseflow, in turn, means that the smallest first-order streams cease flowing. Therefore, the mapping of perennial streams is reduced.

Buried and Channelized Streams

Though not at all the same issue, another important characteristic of the stream system in the Township is "buried" and channelized streams. An example is shown in Figure 2-8, where the Little Darby Creek flows within a concrete channel. Burial of a stream through piping or other enclosure, though considered to be a viable engineering solution years ago, is now recognized as largely ineffective and environmentally destructive, depriving stream water of essential sunlight, exposure to the atmosphere, and vegetation which transforms, binds up, and neutralizes pollutants. Aquatic habitat, including species feeding and spawning areas, is virtually eliminated. Furthermore, increased runoff velocities and quantities have overtaxed "buried" streams, as has happened in some areas of Radnor Township. Portions of the Ithan Creek have been buried, namely those sections flowing through Wayne (both east and west of Wayne Avenue, both north and south of Lancaster Avenue). Additionally, many portions of streams, including the Ithan, have been channelized, and although the impacts of channelization are not as severe as those of total burial, channelizing also significantly reduces the ecological

functions of the stream. Furthermore, because channelized streams are deprived of streambanks and floodplains where flooding impacts are naturally mitigated, downstream flooding is actually worsened. Stream systems become "flashier" as a result of channelization.

This "out of sight, out of mind" burial, as well as channelization, should be an option of last resort. We should note here that Richard Pinkham's *Daylighting: New Life for Buried Streams* (Rocky Mountain Institute 2000) provides a useful discussion of the problems relating to buried streams and the benefits accruing to their "liberation" through various daylighting techniques. Where feasible, daylighting strategies should be explored in all those areas in Radnor Township where streams have been buried (see discussions below). Similarly, channelization should also be eliminated in the future wherever possible.

Stream Order

Another important characteristic of the stream system relates to the ordering of the stream system. First order streams are especially important to watershed life because they comprise the largest percentage of the total stream system on a lineal percentage basis. Headwaters are the locations of critical ecological functioning where exchange of energy from land to water occurs most directly and is most ecologically vital. Because flows in these small headwaters are especially small, these first order streams are extremely sensitive and are the first streams to dry up when water levels decline. Figure 2-9 is a map of first order streams in Radnor Township. One can imagine that a mapping of first order historical streams would show considerably larger first order stream watersheds, consistent with the scenario of an overall decline in water quality and aquatic biota with increased development.

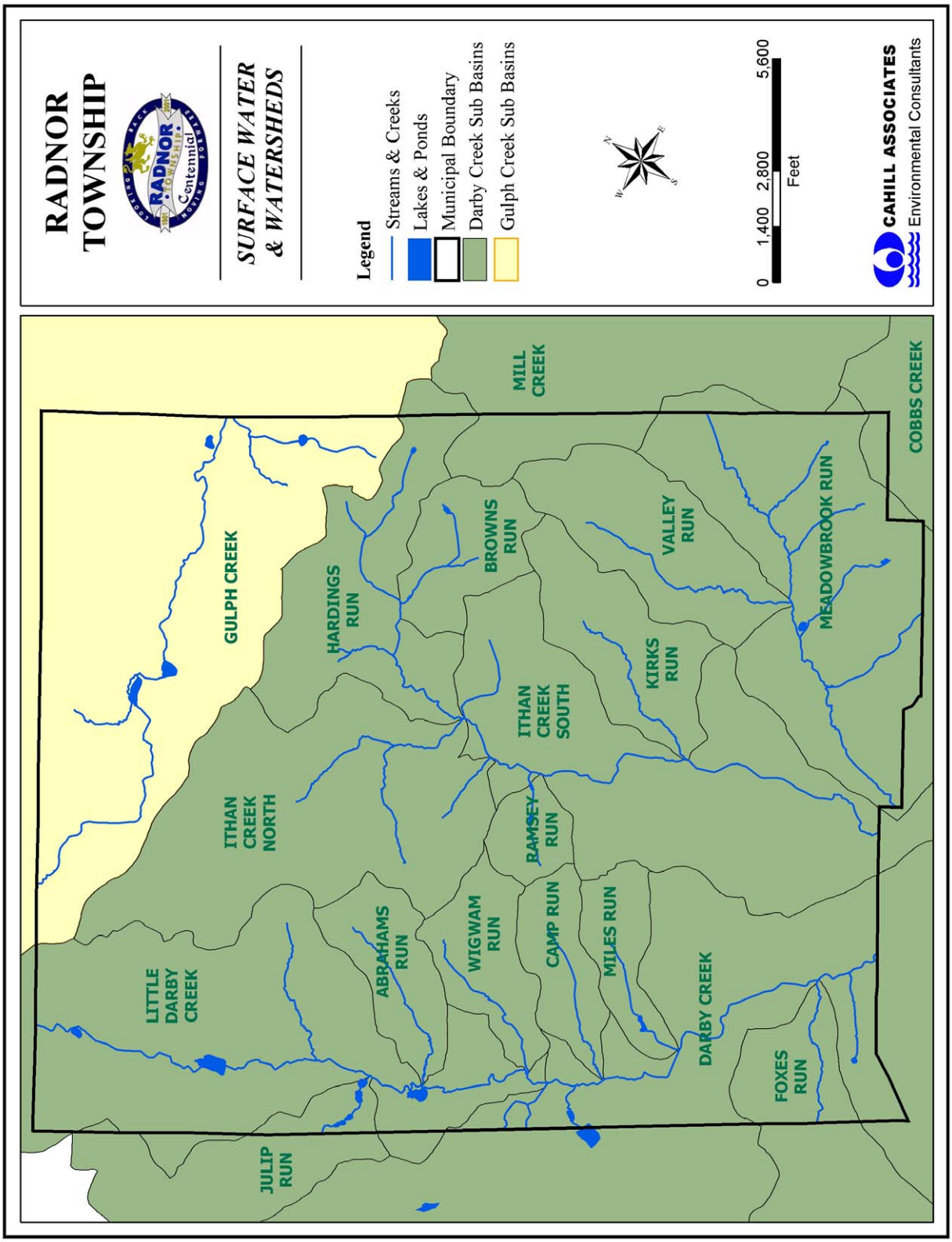

Figure 2-6. Radnor Township Sub Basins, Major Streams, and Tributaries

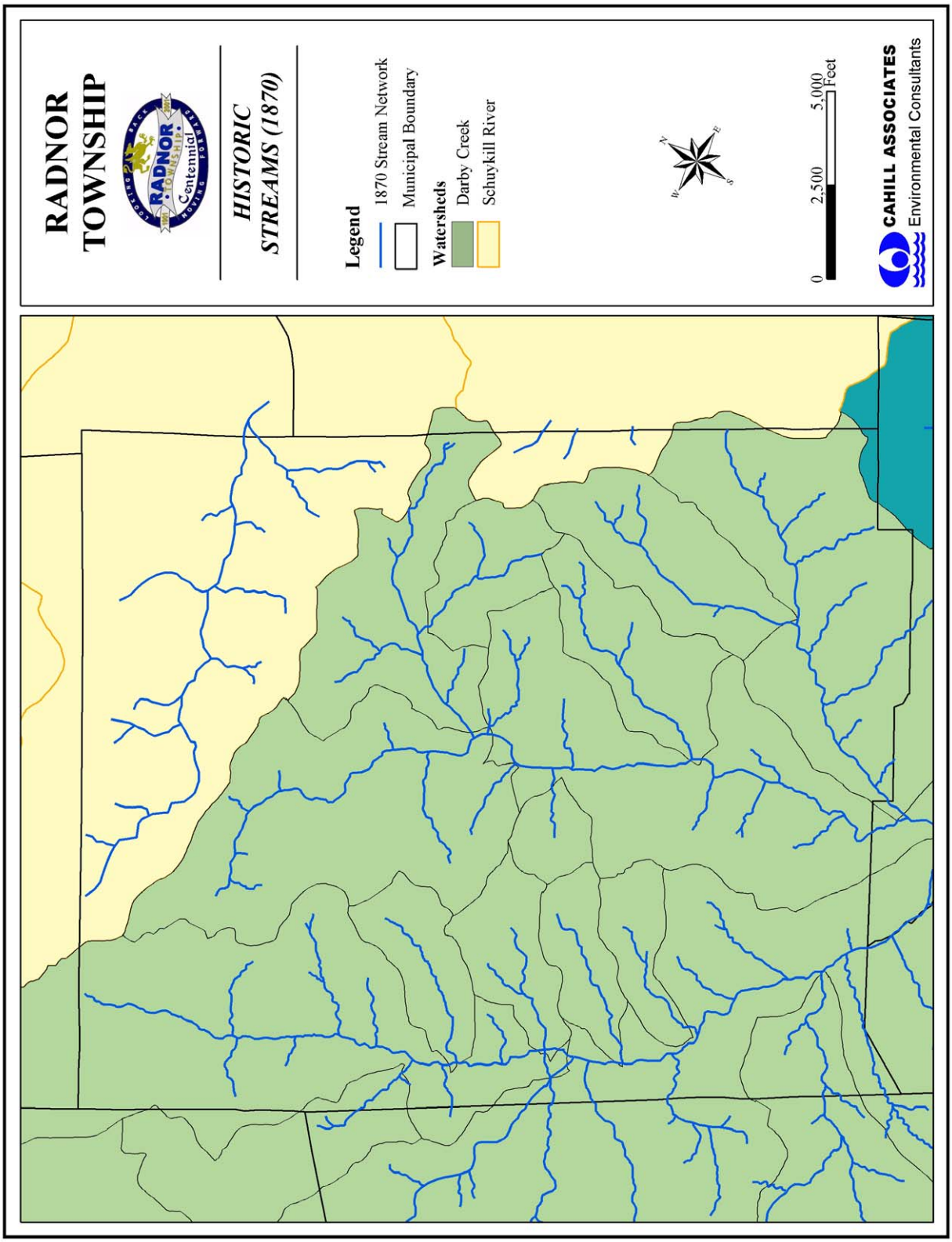

Figure 2-7. Historic Stream Network in Radnor Township based on 1870 mapping

Figure 2-8. Channelization in the headwaters of Little Darby Creek off Sugartown Road

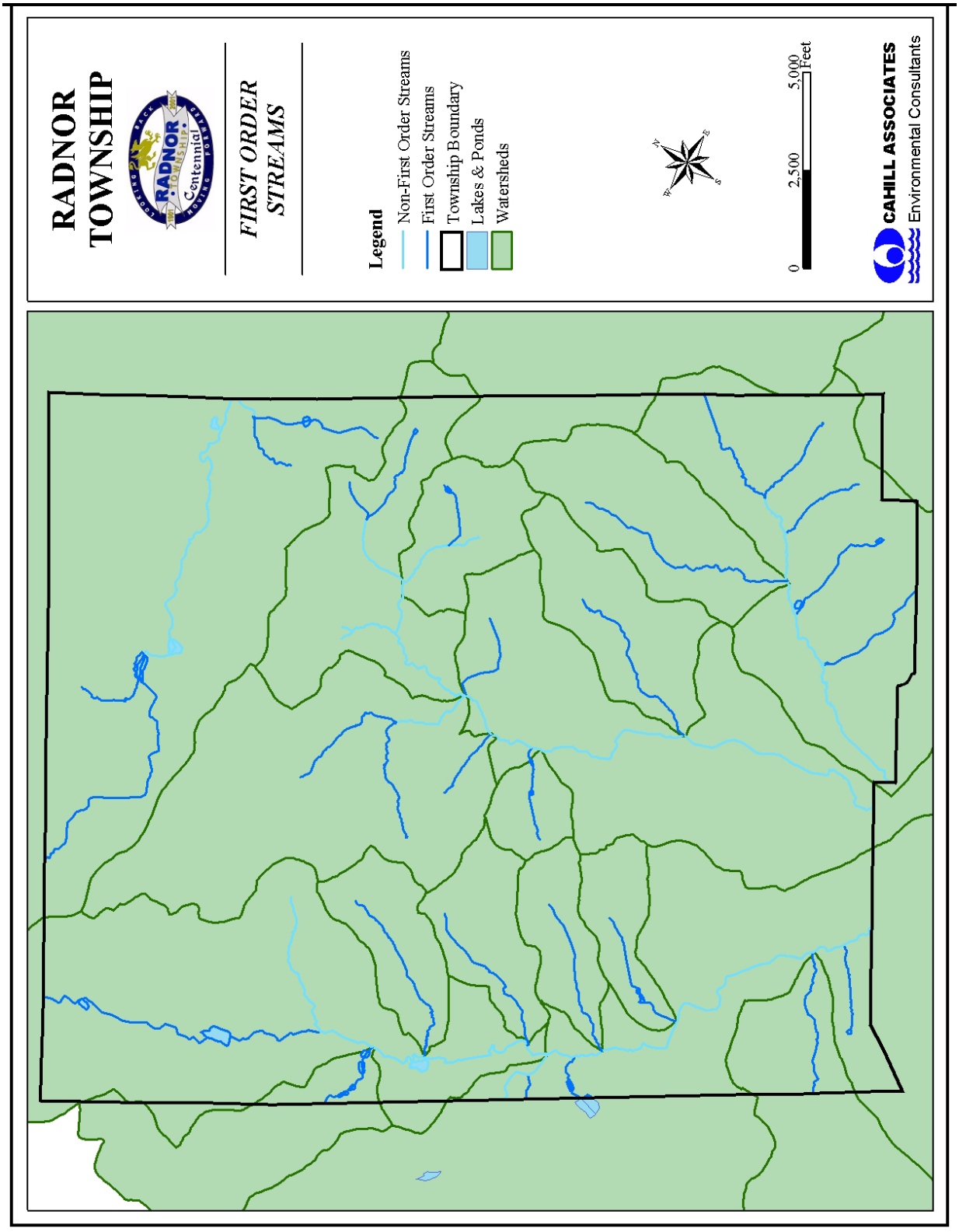

Figure 2-9. First Order Streams in Radnor Township

2. Floodplains, Riparian Zones, Riparian Buffers

Floodplains and the riparian areas buffering streams, rivers, lakes, and other waterbodies are especially sensitive watershed zones. In their naturally vegetated and undisturbed state, floodplains and riparian areas provide critical stormwater management and flood control functions, both in terms of water quantity and water quality. For example, floodplains and riparian areas intercept and reduce unmanaged sheet flow runoff and absorb out of bank flows as storms increase in intensity. Flood flows are slowed, infiltrated into the vegetated floodplain zone, and actually "stored" when the entire watershed system is taken into account. Substantial physical filtering of nonpoint pollutants, especially particulates, occurs as stormwater and flood flows move across and through the vegetated floodplain, and a host of chemical and biological actions are at work both on the surface and in the sub-surface to reduce and convert nonpoint source pollutant loadings. The naturally vegetated floodplain and riparian zone typically provides substantial stream shading through the tree and shrub canopy; overheating of waters is reduced in the summer which is so important for sensitive aquatic species. The vegetation also provides a balanced level of detrital matter such as leaves and twigs which serves as an important food source for aquatic biota. Floodplain and riparian zone vegetation anchors the stream bank and prevents scouring, undercutting, and overall erosion, important to maintain the stream's morphology, its system of meanders and riffles, and resulting aquatic habitat. Floodplains and riparian areas, when conserved, provide an effective system of greenways linking larger open space masses to support habitat for humans and non-human species. In short, undisturbed floodplains and riparian areas are absolutely essential watershed elements.

It should be noted that although these positive floodplain functions are closely interrelated to the positive functions of the riparian area buffer and in many cases floodplains and riparian areas may physically coincide, they are not necessarily the same area. In many cases, assuming a riparian buffer width of at least 50 to 100 feet or more, the designated floodplain may extend beyond the riparian buffer limit and vice versa, depending upon the upstream-to-downstream watershed location and a host of other factors. In this discussion, floodplain and riparian buffer functions and benefits are treated as one, with the strong recommendation being made that floodplains and riparian areas should be kept in a natural and undisturbed condition without structures and other improvements and without disturbance of the soil mantle and natural vegetation.

Floodplains are shown in Figure 2-10. If we hypothesize an average floodplain/riparian zone width of 75 feet (extending 75 feet on both sides of the stream) and apply this to the entire stream system of Radnor Township, floodplains/riparian zones potentially comprise 595 acres within Radnor (about 7 percent of total Township area). Over the years, development has encroached substantially into floodplains in many places in the Township. Sometimes, as discussed above, this development has resulted in total stream enclosure/burial with virtual elimination of any semblance of the floodplain. Elsewhere, streams have been substantially channelized with structures built into and onto the floodplain. Or substantial fill has been placed within floodplain areas to accommodate parking, roads, and other development elements, resulting in a broad array of floodplain functional impacts. Even the relatively inoffensive clearing of floodplain areas with replacement as lawn and other landscaped areas takes its toll on the important water quality and water quantity functions of the natural floodplain.

Furthermore, although this point has not been well-documented, the substantial alteration in natural hydrology of Radnor's watersheds including the Darby as the result of so much historical development which has increased runoff volumes and decreased infiltration volumes has translated into lower low flows and higher high flows (i.e., worsened flooding), such that the same size rainfall now produces a significantly different stream reaction with worsened flooding downstream. This means that, all else being equal, floodplains are actually expanding in their areal extent, aggravated by all the factors mentioned above as well.

Floodplain/Riparian Zone Encroached Area Analysis: Although detailed field inventory and analysis of the existing floodplain and riparian zone has not been undertaken during this comprehensive planning, approximate evaluation of the floodplain and riparian zone condition has been developed by combining the land use data file with the mapping of the Township stream system (Figure 2-11). Existing land use categories that encompass a 75' zone from the stream center, including Recreation, Agriculture, Conservation Easement, and Vacant, were assumed to be natural or relatively natural (a very forgiving and generous assumption; in truth, significant portions of these land use categories also could have been altered from their natural riparian condition). In addition, these uses were assumed to have some sort of existing riparian buffer and/or undeveloped floodplain condition. All other land use categories were assumed to constitute some sort of floodplain/riparian zone encroachment condition. Based on this combination of data layers, the resultant statistics indicate that 348 acres of the Township's total 595 acres of riparian area (about 58 percent) have experienced encroachment by development and are likely to have substantially reduced floodplain and riparian zone functions (again, this could well be a substantial undercount). In sum, substantial portions of the most sensitive and critical riparian zones in the Township have been adversely impacted by development. Clearly, restoration of these areas already impacted is important, and better management of the floodplain and riparian zones should be an important goal for the Township in the future.

Floodplain management in an undeveloped watershed is important, but effective management is especially important in developed watersheds where the benefits of the floodplain and riparian zone take on heightened importance. One problem, as the data indicate, is that much of Radnor Township has been developed before the emergence of either any stormwater management or floodplain regulations, most notably the Federal Emergency Management Agency (FEMA) set of minimum floodplain regulations. Radnor Township has incorporated minimum FEMA standards into its code and ordinances (Radnor like most municipalities has not gone beyond FEMA minimum requirements, although municipalities are constitutionally enabled to enact more rigorous floodplain and riparian zone controls). As a result, any new development project or redevelopment project which involves "substantial improvement" (defined as 50% or more of the market value) must comply with these minimum floodplain standards.

However, two important points need to be made here regarding these minimum FEMA requirements. The minimum FEMA standards themselves are inadequate and allow for substantial floodplain and riparian zone impacts to continue to occur. FEMA standards focus primarily on the protection of life, limb, and property. Although standards have improved in recent years, FEMA standards are not intended statutorily to be a program of floodplain

protection and watershed management. Filling and even structural construction may occur even within the highest risk floodway zone, provided that impacts are not substantial and the lowest habitable floor areas are properly flood-proofed. Furthermore, massive vegetative clearing, soil disturbance, paving, and so forth may occur in the floodplain under the FEMA program. Even more extensive filling is possible in the "flood fringe" portion of the floodplain. These very generous allowances in the existing FEMA regulations explain why development projects continue to be approved within the floodplain and riparian zone in so many areas and why impacts especially in terms of flooding have grown more serious.

Township action over and above FEMA requirements is critical. As challenging and difficult as this might be, rigorous floodplain and riparian zone protection is cost effective and ultimately the wisest course of action in the long run. Development and redevelopment projects must avoid floodplains and riparian zones totally. Rigorous regulations must be enacted so that natural floodplain/riparian zone functions are restored. Though this restoration will take many years, given the current level of impact, benefits will begin to accrue to all Township, not to mention downstream, residents who will also benefit in so many other ways from this floodplain and riparian zone restoration. The Township's recent efforts to adopt riparian buffer regulations should be reinforced and led to a successful conclusion, using a buffer definition that is both reasonable and sensitive to property rights as well as environmentally rigorous.

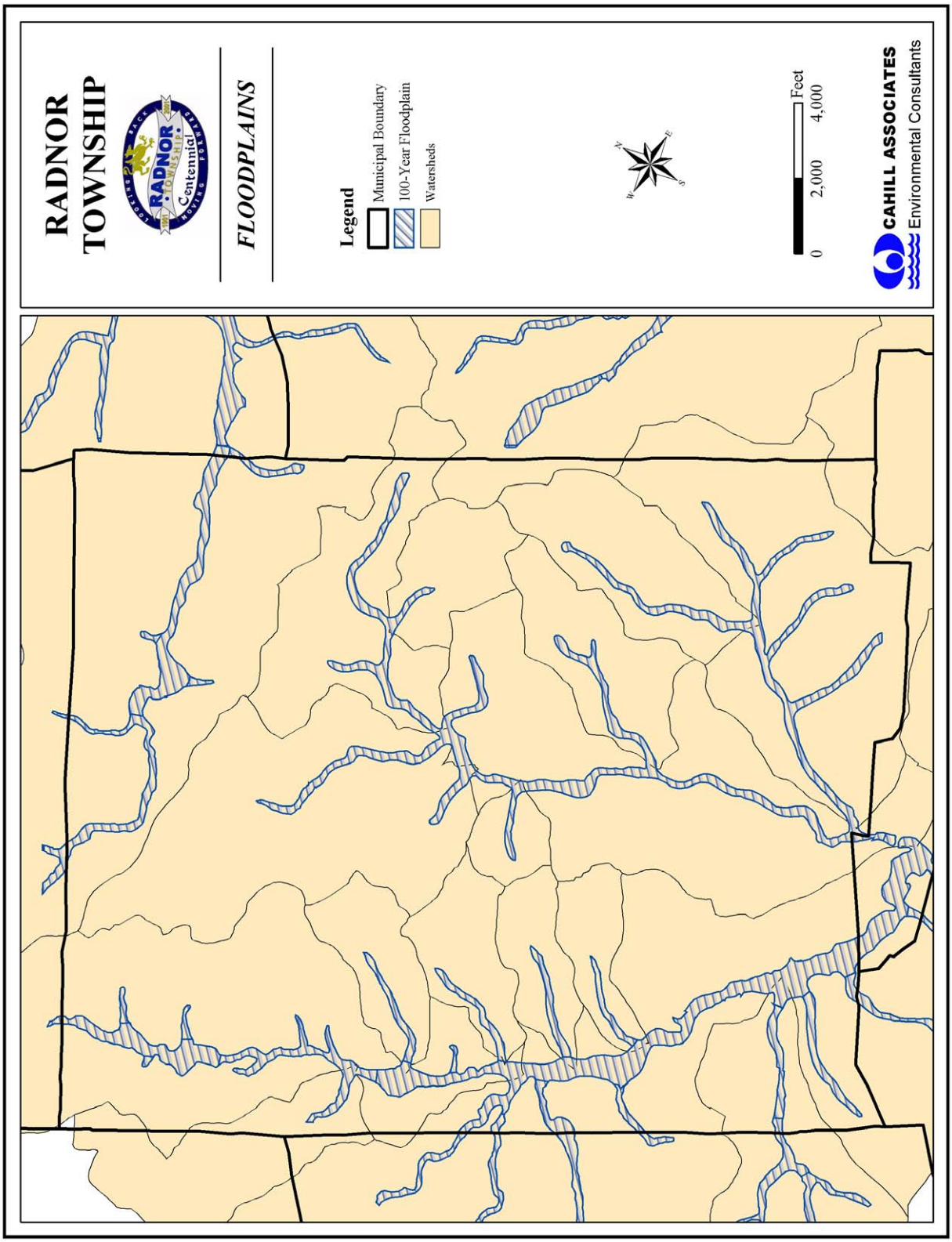

Figure 2-10. Floodplain Areas in Radnor Township

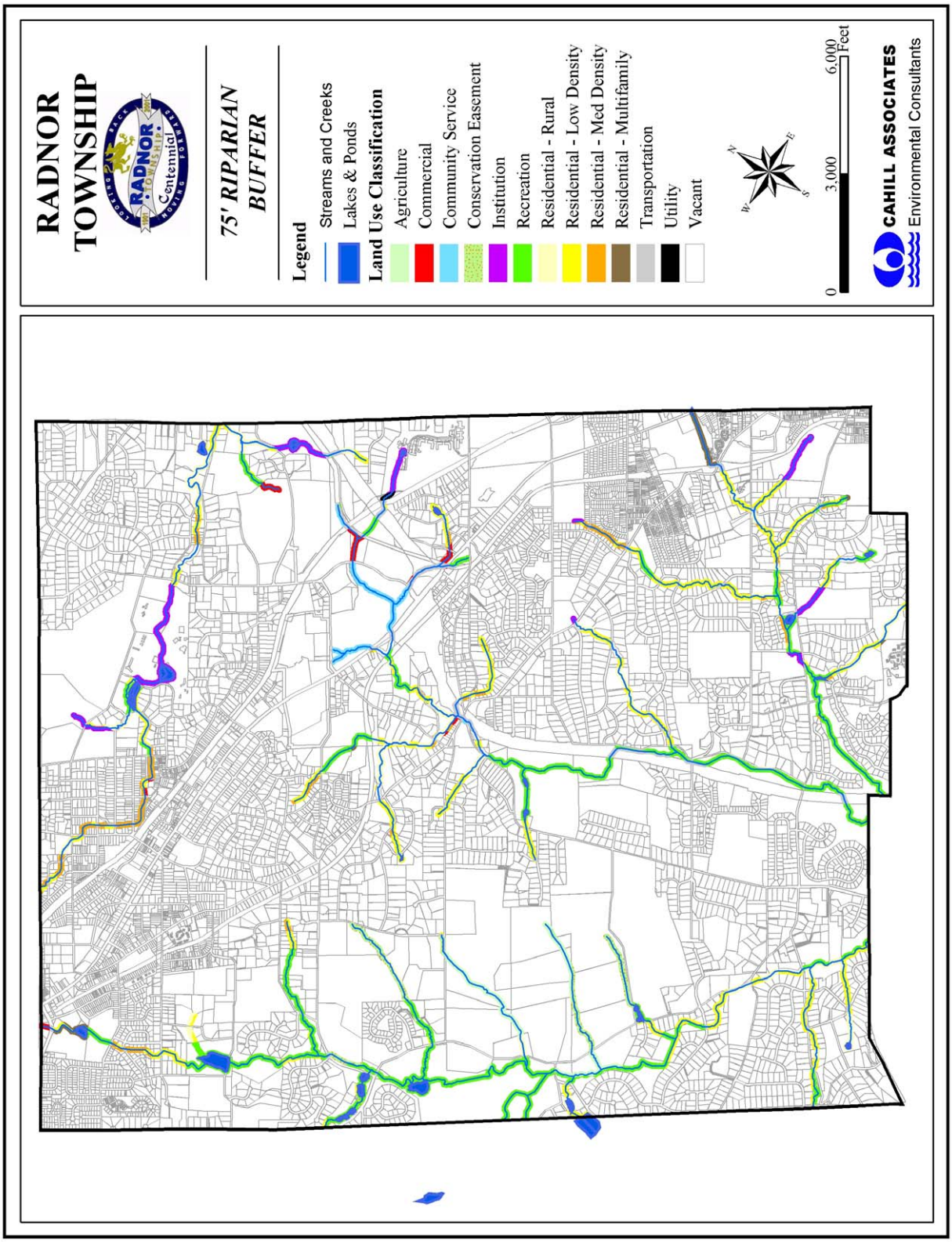

Figure 2-11. Riparian Area Encroachment Analysis in Radnor Township

3. Wetlands

Wetlands are transitional lands between terrestrial and aquatic environments and include lands commonly known as swamps, marshes, and bogs; wetlands can also include areas which may not always have standing water and hydric soils are a strong indicator of wetlands. Wetlands are unique environments which provide critical ecological and overall environmental functions which ultimately have natural, economic, and even social benefits. These functions include water storage, flood water abatement, water quality improvement, provision of vital plant and wildlife habitat (including an inordinate proportion of Pennsylvania's rare, threatened, and endangered species), and groundwater recharge in some cases (in most cases wetlands are zones of groundwater discharge). In terms of Radnor Township, all of these benefits are of importance, though given the existing problems of both water quality and stormwater flooding in the Township, these wetland benefits undoubtedly top the list. Because an unknown quantity of wetlands have been lost to development (i.e., filled) over the years in the Township (it can be surmised that a considerable quantity of wetlands located adjacent to streams and tributaries have been filled as development has encroached across the floodplain and overall riparian zone), those wetlands which remain are of particular importance and are deserving of special protection.

Wetlands within the Township have been identified and mapped (Figure 2-12) based on National Wetland Inventory (NWI) data. The NWI wetland classification system is hierarchal, with habitats divided among five major systems at the broadest level. Only 1 percent of the Township is classified Palustrine (marsh or swamp), while the remaining land – almost 99 percent – is classified as Uplands (non-wetland classification). The NWI data source provides an approximate mapping of wetlands and is appropriate for use in this Plan. Wetland delineation is based on interpretation of high altitude aerial photography and should not be used for regulatory purposes. Some small wetlands (any less than 5 acres) typically are omitted from NWI mapping.

Few natural lakes exist in the Township. Several ponds such as at The Willows have been artificially created. These small bodies of water often have been created as part of landscape master planning for older estates and have varying though usually limited functional benefit for the overall aquatic life and water resources of the Township. As a matter of fact, many of these small constructed impoundments suffer from water quality problems; for example, the ponds at the Willows suffer from an abundant goose population with excessive goose droppings loaded with nutrient and other bacterial loadings.

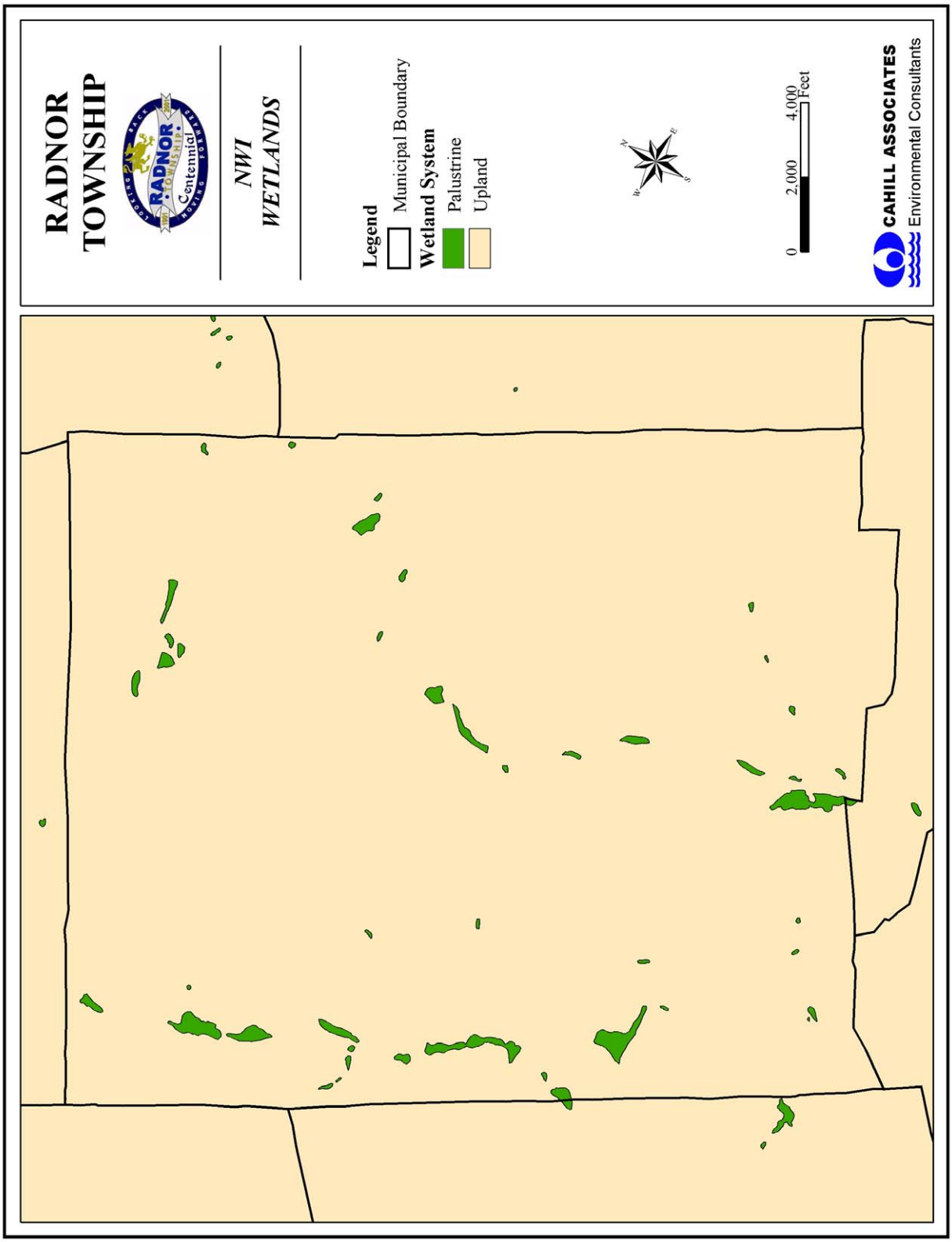

Figure 2-12. Wetland Systems in Radnor Township

4. Water Quantity

Understanding the water cycle and how human development actions have affected this cycle is especially important in order to understand the natural resources of Radnor Township. Presented below is a brief summary of the water quantity issues; Appendix A discusses water resources in significant detail, comparing pre-development hydrologic conditions to post-development hydrologic conditions, and the effects of traditional stormwater management on the lost resource of stormwater. All environmental Appendices are available in hard copy only at the Radnor Township Building.

The natural hydrologic cycle is measured via precipitation gages and stream flow gages, and here in Radnor Township, as well as the greater Piedmont region, we typically see on average 45 inches of precipitation annually, with 15 inches of that 45 compromising stream baseflow (the water flowing in the stream in periods of little precipitation). Land development typically means a significant change in the natural landscape, including creation of impervious surfaces (roads, parking, roofs, other). When we pave over and make impervious surfaces, we increase surface runoff and decrease infiltration into the groundwater. Traditional stormwater management programs focus on managing stormwater peak rates, though much of Radnor's development occurred before any stormwater management regulations. Consequently, in areas like Wayne, stormwater runoff is directed into the nearest stream without any type of peak rate control, volume control, or water quality control. Presently, peak rate management for new development occurs through use of a detention basin, and current regulations do not provide for peak volume management. The result is an increase in downstream flooding as stormwater flushes first through the basin, then through the outlet structure into the nearest stream.

It is important here to appreciate that the water cycle system itself is a closed loop. What goes in must come out. Impacts on one part of the cycle by definition create comparable impacts elsewhere in the cycle. Through traditional stormwater management, stormwater is a lost resource. Innovative engineering and planning solutions must be instituted (and are presently being instituted in Radnor Township) in new development and redevelopment projects so that stream baseflows are maintained, downstream flooding effects are decreased, and valuable stream ecology is preserved.

Impervious Cover Analysis: Through the use of GIS files and literature-supported data, plan preparers analyzed the effects of existing land uses in terms of total impervious cover and its effects on stormwater runoff/loss of infiltration. Using the existing parcel-based land use coverage as a base, Cahill Associates has applied appropriate impervious cover assumptions to these land use categories.

Figure 2-13 illustrates the mapping of percent impervious cover in Radnor Township. Table 2-3 sums these statistics by the land use groupings and demonstrates, first, that the total impervious area for the Township itself is a moderately high 23 percent. Table 2-4 then translates this imperviousness into a water reality, indicating the loss or reduction in natural infiltration into the ground, again created by impervious surfaces in the Township land use sub-areas (calculations are based solely on imperviousness and not on reduced permeabilties which also been significant). The loss in infiltration is many millions of gallons each year. In sum, development has had a tremendous adverse impact on the water cycle in Radnor Township.

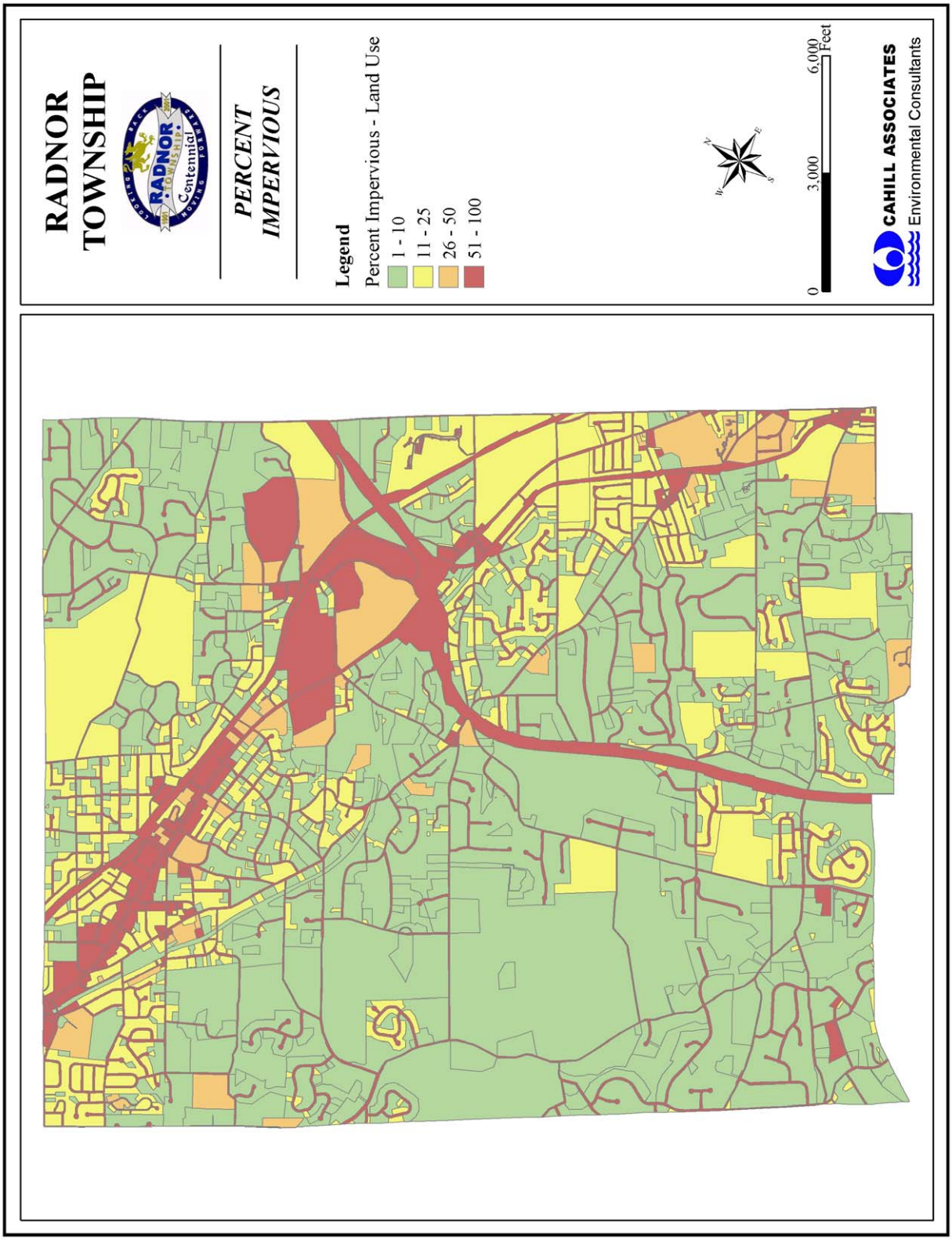

Figure 2-13. Impervious Area Percentages based on Existing Land Uses

Table 2-3. Impervious Areas within Radnor Township (Cahill Associates, 2002)

Existing Land Use Category	Area of Land Use within Township, (acres)	Percent Impervious Factor (based on Land Use)	Impervious Area within Township, (acres)
Residential - Low Density	2,657	10%	266
Recreation	1,097	5%	55
Utility	10	80%	8
Transportation	1,009	80%	807
Residential - Med Density	1,006	20%	201
Residential - Rural	801	5%	40
Institution	793	25%	198
Commercial	365	70%	255
Agriculture	310	2%	6
Conservation Easement	287	2%	6
Community Service	222	50%	111
Residential - Multifamily	213	30%	64
Vacant	61	1%	1
TOTAL	**8,831**	**n/a**	**2,018**

Percent Impervious Area = 2018/8831 = **23%**

Table 2-4. Average Annual "Lost" Infiltration in Radnor Twp. (Cahill Associates, 2002)

Existing Land Use Category	Area of Land Use within Township, (acres)	Percent Impervious Factor (based on Land Use)	Impervious Area within Township, (acres)	Rate of Baseflow Reduction (Baseflow reduction = 15 in/yr)	
				(acre-in/yr)	(gal/year)
Residential - Low Density	2,657	10%	266	3,986	108,239,134
Recreation	1,097	5%	55	823	22,334,455
Utility	10	80%	8	120	3,270,246
Transportation	1,009	80%	807	12,107	328,762,079
Residential - Med Density	1,006	20%	201	3,017	81,926,756
Residential - Rural	801	5%	40	601	16,321,645
Institution	793	25%	198	2,973	80,726,704
Commercial	365	70%	255	3,830	104,003,508
Agriculture	310	2%	6	93	2,523,716
Conservation Easement	287	2%	6	86	2,336,313
Community Service	222	50%	111	1,669	45,311,993
Residential - Multifamily	213	30%	64	957	25,998,859
Vacant	61	1%	1	9	250,412
TOTAL	**8,831**	**n/a**	**2,018**	**30,272**	**822,005,821**

5. Water Quality

The importance of water quantity issues notwithstanding, important points need to be made regarding water quality. In fact, water quality and water quantity are inseparable and unrelated; both aspects of water management are inextricably linked. Management strategies that effectively address water quantity will in many cases address quality as well. Runoff from newly paved surfaces – both the increased volume and rate of runoff – means that pollutants are scoured, suspended, and swept away. Strategies that reduce this impervious surface and/or immediately redirect runoff into natural swales directly reduce the source of stormwater and indirectly reduce the agent that transports stormwater-linked pollutants. If runoff is quantitatively eliminated, erosion by definition will be eliminated.

Once in the stream, increased volumes and rates of runoff mean streambank erosion, undercutting, flattening and straightening of the channel, re-suspension of sediment, all of which become serious quality problems. Even if flooding is not worst case, full or near full bank flooding has serious water quality ramifications. Therefore, although the focus of this discussion thus far has been on water quantity and the water cycle, both quantity and quality are very much at issue.

Even so, not all quality pollutant loads can be eliminated through quantity reduction techniques. Some roads and highways are necessary which will generate vehicle use and pollutant generation by definition (i.e., there is some proportion of these pollutant loads which are not variable and will be generated even if maximum reduction in quantity can be made to happen). At the other end of the quantity spectrum – reductions in stream baseflow – water quality and water quantity issues emerge as well. To the extent that any fixed or constant source of pollution – for example, point source discharges or malfunctioning onsite septic systems – continue to generate pollution – loads as infiltration and stream baseflow decline, this reduced stream baseflow translates into increased concentrations of instream pollutants with pollution-related problems growing more severe. Fortunately, Radnor Township has few "point sources" or wastewater treatment plants discharging wastewater effluent into its streams and waterways (the Sun Oil Company PA0056839 is the only listed point source discharger according to the PADEP inventory of NPDES permitted sources; Sun is permitted by PADEP for releases of benzene, ethlybenzene, toluene, total BTEX, total xylenes, and pH at levels which PADEP has determined will not prevent the stream from achieving State water quality standards).

Water quality aspects of stormwater management, or nonpoint sources, have become a major concern nationwide. In fact, stormwater-linked nonpoint source pollution – the mix of pollutants that is washed off the earth's surface with each precipitation event – is often cited as the primary water quality problem in the nation today. As a result, numerous manuals such as the new *Pennsylvania Handbook of Best Management Practices for Developing Areas* have been produced setting forth management programs designed to minimize stormwater-linked water quality problems. This is an important issue for Radnor, given the extensive development that exists in the Township.

Stormwater-linked pollutants vary with type of land use and intensity of land use and have been shown to include bacteria, suspended solids, nutrients, hydrocarbons, metals, herbicides and pesticides, other toxics, organic matter, and others. Pollutant loads are generated both from

impervious areas ("hot spots" such as gas stations, fast food parking lots, and heavily traveled roadways are primary culprits and which are common in Radnor), as well as from pervious zones, such as the chemically maintained lawns and landscaped areas where chemical maintenance can be considerable, also in great abundance in Radnor. Some nonpoint pollutants are even air-borne, deposited onto the land surface and then are washed into receiving waterbodies. Sources of this pollution include:

- Vehicles
- Vegetative decay (leaves, grass, etc.)
- Direct atmospheric deposition
- General litter, including pet litter
- Soil erosion
- Road surface applications (salt, sand, etc.)
- Fertilizers
- Pesticides/herbicides

There also appears to be serious problems of inflow and infiltration, or "I/I" as it is commonly called, throughout many portions of the Township which are sewered. As discussed in more detail in Appendix A, elevated pollutant loadings in both wet weather and dry weather in those stream reaches where large sanitary collection and conveyance systems parallel the stream suggest that these sewers are leaking their sanitary wastes directly into the streams during both wet and dry times. Also, although this issue has not been well documented, there is clearly a water quality problem in Radnor related to the increased Canadian geese population all too happily residing on both the extensive public and private lawn areas adjacent to water features which have been created in the Township. Pollutants of concern include bacteria and nutrients as well as special pollutants of concern such cryptosporidium. Given that the overall regional population of geese is increasing, management actions should focus on elimination or minimization of habitat which is creating the problem in the first place.

In such a highly developed watershed, point source wastewater treatment plants would be expected to be a pollutant source, but are not significant pollutant sources in the Darby Creek Watershed, given the export of wastewater to Philadelphia's Southwest Treatment Plant.

State Stream Classifications

As part of the water quality standards program, PADEP conducts stream use designation evaluations on an ongoing basis, pursuant to Chapter 93 of the Department's Rules and Regulations. All Commonwealth waters are protected for a designated aquatic life use as well as a number of water supply and recreational uses. The use designation shown in the water quality standards is the aquatic life use. These uses are Warm Water Fishes (WWF), Trout Stocking (TSF), Cold Water Fishes (CWF), and Migratory Fishes (MF). In addition, streams with excellent water quality may be designated High Quality Waters (HQ) or Exceptional Value Waters (EV).

Figure 2-14 indicates the DEP designated stream classifications for streams in Radnor Township. There are no Special Protection Waters designated in Radnor, either High Quality or Exceptional Value streams. Gulph Creek is classified as a Warm Water Fish; however, the Darby system is classified as either Cold Water or Warm Water Fish, all with a Migratory designation.

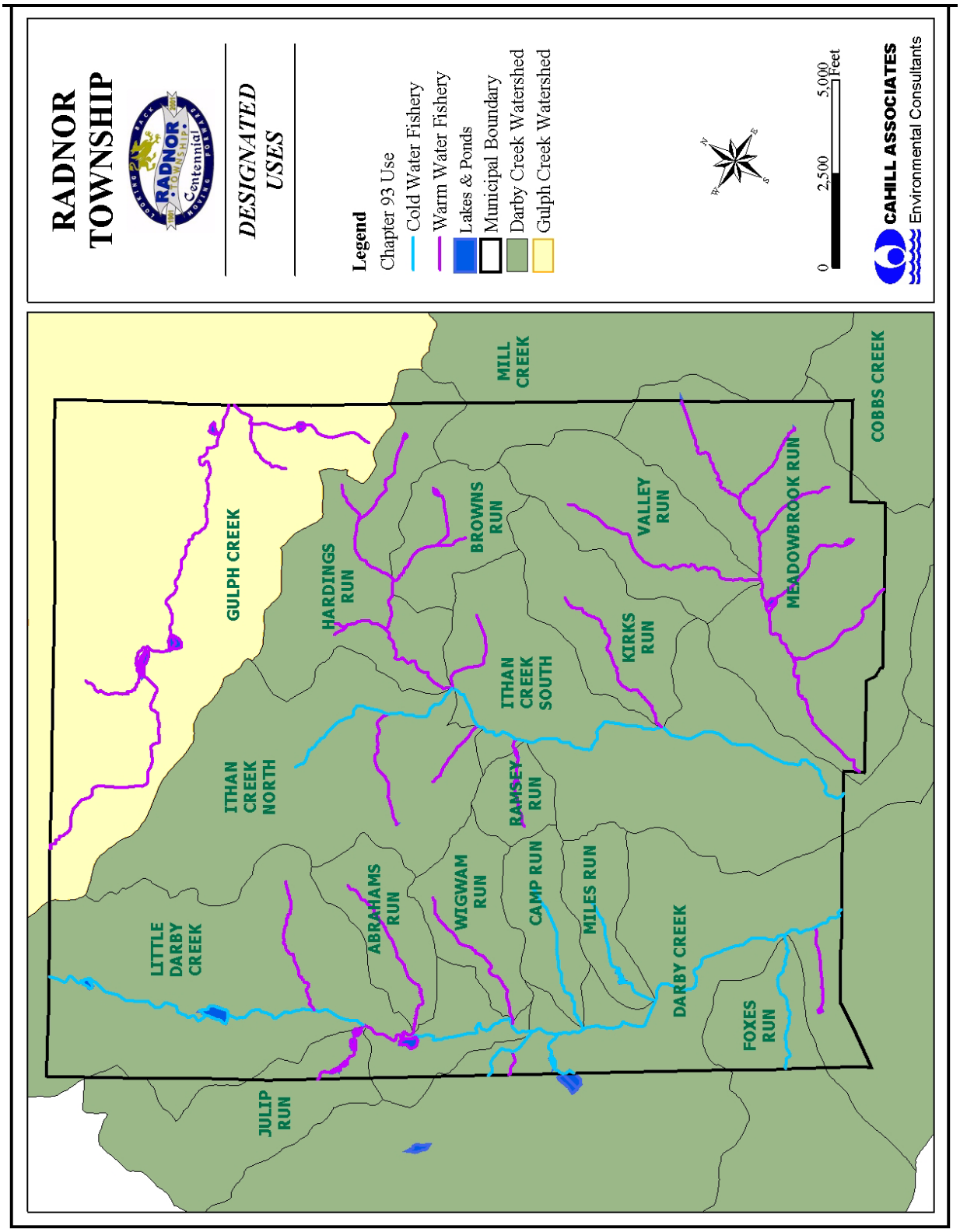

Figure 2-14. Pennsylvania Stream Designations for Radnor Township

D. Biological Resources

1. Aquatic Biota

As the natural flow patterns of Radnor's watersheds have undergone change, water quality and the aquatic biota present in the stream system typically have changed as well. Usually these changes have not been for the best. The considerable urbanization which has occurred in the Township's sub-basins has translated into encroachment into the floodplain and directly into the stream channel itself (in the most extreme, completely burying the stream underground in some cases). Changes in the natural hydrology – in the patterns of infiltration and runoff – have resulted in stream channelization, creating a system which is not in dynamic equilibrium. Time to peak has been decreased, sometimes dramatically; peak flow rates are increased equally dramatically. Smaller rainfall events produce more and more bankfull and out-of bank flooding, unable to be accommodated by the existing stream channels, floodplains, and wetlands, all of which have been diminished by development over time. More erosion has occurred; more sediment has been deposited. Increased flood flows scour stream banks, fill pools and cover riffles with sediment. A more short-lived, homogeneous, and unstable species system is created with increased sediment deposition and decreased habitat diversity. The aquatic ecosystem has lost much of its critical energy linkage in first order streams and wetlands, as these valuable areas are disturbed and often reduced and their ecological functions destroyed.

Benthic macroinvertebrates—the bottom dwellers of the stream—are critical links in the food chain and are critical for the support of the higher order fish community. Unfortunately, the impacts of urbanization have hit the benthic macroinvertebrate community especially hard. Because the benthic macros rely heavily on the stream's system of natural riffles as primary habitat for most of their life cycle activities, the increased flows plus sediment deposition and scouring that have resulted in the stream system have adversely impacted the reproductive and feeding activities of many macroinvertebrates. Eggs are either scoured downstream or covered with sediment. Many species have been eliminated; others tremendously reduced in terms of richness and abundance. Organisms adapted to hydrologic extremes proliferate.

Fish follow suit. Like the benthic macroinvertebrates, habitat change means fish species change. Those species reliant on riffles, rocks and vegetation for egg depositing, or those where egg nests located in larger constant pools are guarded by parents, are seriously impacted. Sudden changes in flow regimes physically destroy eggs which have been deposited and kill the fry. At the other end of the spectrum, sudden stream flow reductions and reduced stream baseflows means that biotic life in pools can be killed off quickly as these pools literally dry up.

Further, stormwater outfalls and combined sewer overflows worsen the overall stream condition for the aquatic community by increasing flood flows, increasing sedimentation and erosion, and then reducing water quality (e.g., fecal coliform releases ultimately result in increased biological oxygen demand with reduced dissolved oxygen levels as flows decrease, ultimately depriving fish life of oxygen).

Aquatic Biota Sampling

The abundance and diversity of the aquatic biota, of course, are excellent indicators of water quality. In 1995 and 1996, Pennsylvania Department of Environmental Protection performed special investigations of the Darby Creek Watershed extending into Radnor, sampling for water quality, fish, and benthic invertebrates at a variety of stations. As reported in PWD's Technical Memorandum No. 1, the benthic was rated as "fair" at Station 2 with both benthic and fish rated as "very good" and "good" respectively farther downstream at Stations 3 and 4 in Radnor Township and as "poor" and "fair at Station 5 in Radnor, and "good" and "fair" at Station 6 in Radnor. Ratings declined to "poor" and "fair" for benthic and fish immediately downstream, from Radnor down through Springfield Township. Based on this information, it would appear that pollution and pollution impacts on the aquatic biota are quite variable, though definitely do exist in portions of the Township, at least in the Darby Creek Watershed.

Finally, and perhaps most significantly, PADEP has performed biological assessment of the Darby Creek system in 1998 as part of the PADEP Unassessed Waters Program, including 28 stations using EPA's Rapid Bio-Assessment Protocol and habitat assessment methods. The purpose of this special study was to determine stream impairment, based on quality and quantity of habitat and the macroinvertebrate community data. This work also was to be used as the basis for the 303(d) list that PADEP is required to develop under the Federal Clean Water Act. Figure 2-15 indicates the 1998 findings based on this sampling. A portion of the Darby Creek system is classified as "impaired," specifically a portion of the Little Darby Creek. (Technical Memorandum No. 1, November 16, 1999)

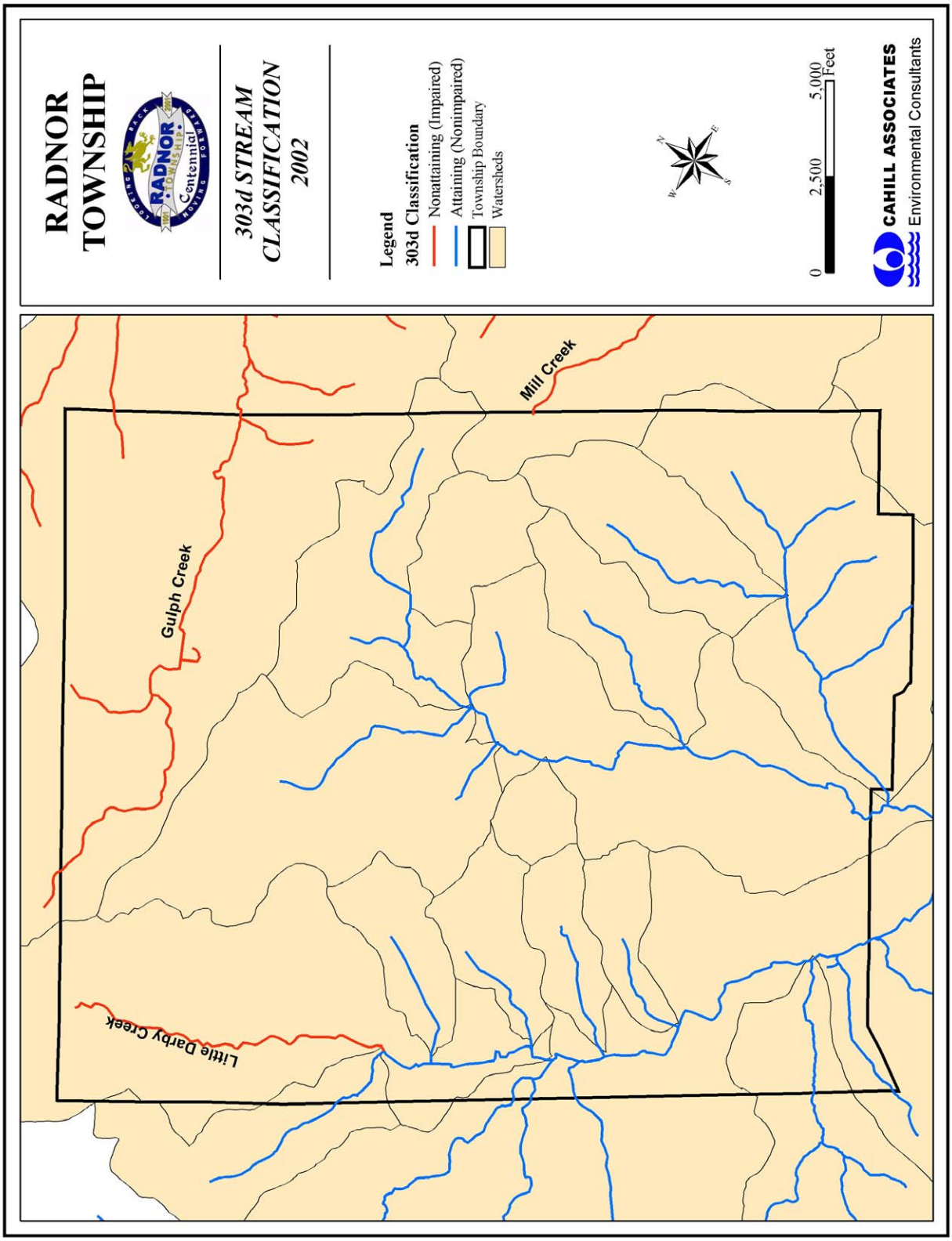

Figure 2-15. EPA Assessed Streams within Radnor Township

2. Terrestrial Biota

"*The soil is good, air serene and sweet from the cedar, pine and sassafras, with wild myrtle of great fragrance"* wrote Penn in an early description of Penn's Woods. Pennsylvania was heavily forested upon Penn's arrival, and he recommended, "*…care to be taken to leave one acre of trees for every five acres cleared*." As discussed in other sections, the natural characteristics of Radnor Township had much to do with shaping its development. Radnor's geographic location, natural resources, and soil and climate influenced the development of industry and commerce. This same development impacted and diminished much of the original natural landscape.

Undeveloped uses of the Township (Agriculture, Conservation Easement, Recreation, and Vacant) total a mere 20 percent of the total land area, with all other "developed" uses comprising 80 percent of the land area (Figure 2-16). These figures are based on the Townships existing land uses as classified from aerial interpretation of 2000 Digital Orthophotos (Figure 10-2).

When we use the Delaware Valley Regional Planning Commission's 1995 Land Use data, which includes a Wooded category, we see that the naturally Wooded area that remains tends to follow stream valleys. The stream valley greenway that currently exists becomes the primary natural resource feature in this substantially developed Township, though the greenway remains a fragmented, disconnected resource. Such a fragmented natural habitat has serious implications for the natural biological systems including reduced species diversity, increased rates of species extinction, and establishment of invasive species. The existing greenway should be supplemented and reinforced with more and more "green" islands, in order to connect and expand the environmental natural features.

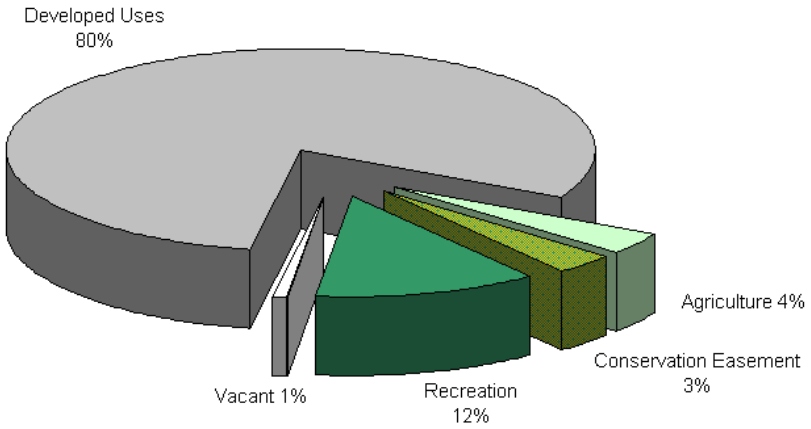

Figure 2-16. Developed vs. Undeveloped Land Uses in Radnor Township

3. Pennsylvania Natural Diversity Inventory (PNDI)

The Pennsylvania Natural Diversity Inventory (http://www.dcnr.state.pa.us/forestry/pndi/pndiweb.htm) was established in 1980 as a cooperative project with the PADCNR's Bureau of Forestry, The Nature Conservancy (TNC), and the Western Pennsylvania Conservancy. PNDI partners collect biological data and conduct inventories to describe and identify Pennsylvania's threatened and endangered and otherwise rare species ("special concern" species), storing this information in a computerized data management system. In addition to species, PNDI identifies the most outstanding examples of Pennsylvania's natural communities and geologic features ("critical sites" or "priority areas"). After surveying the ecological resources of a county and identifying the outstanding species and areas, each site is ranked from 1 to 5 (1 being the highest priority) in order to prioritize conservation of these areas. The goal of the PNDI program is "…to provide accurate and accessible ecological information needed for conservation, development planning, and natural resource management." Consonant with these goals, some countywide reports have been prepared and published, documenting results of PNDI inventory work. Delaware County has a 1992 (Updated 1999) PNDI report available.

Pulling from the County listing, TNC provided plan preparers a list of 'species of concern' found in Delaware County (Table 2-5) and GIS datasets to map the PNDI priority sites in the Township (Figure 2-18). The species list and the priority sites map characterize the current ecological information as monitored by PNDI. Radnor Township should work with PNDI partners to use the information as a guide for its comprehensive planning, zoning, and land development, as well as an input to future municipal open space planning.

- **Ithan Creek Wetland**: Bordered by the Blue Route, Bryn Mawr Avenue, Ithan Creek and a residential neighborhood, offers wildlife habitat and local landscape diversity. "Somewhat weedy wetlands with good representation of common, native wetland plants; adds to diversity of local landscape; provides some wildlife habitat and has educational value; protect from encroachment."

- **Radnor Woods:** "Moderately mature beech/oak forest on rocky slopes and floodplain along little Darby Creek; creek channel heavily eroded by high storm flows; fragment of original forest provides refuge for native flora and fauna and green space for humans; maintain closed canopy."

- **Skunk Hollow**: "Poor population of Pennsylvania Rare wildflower in moderately mature beech forest along Darby Creek; exotic species such as privet pose main threat; area protected in Skunk Hollow Park."

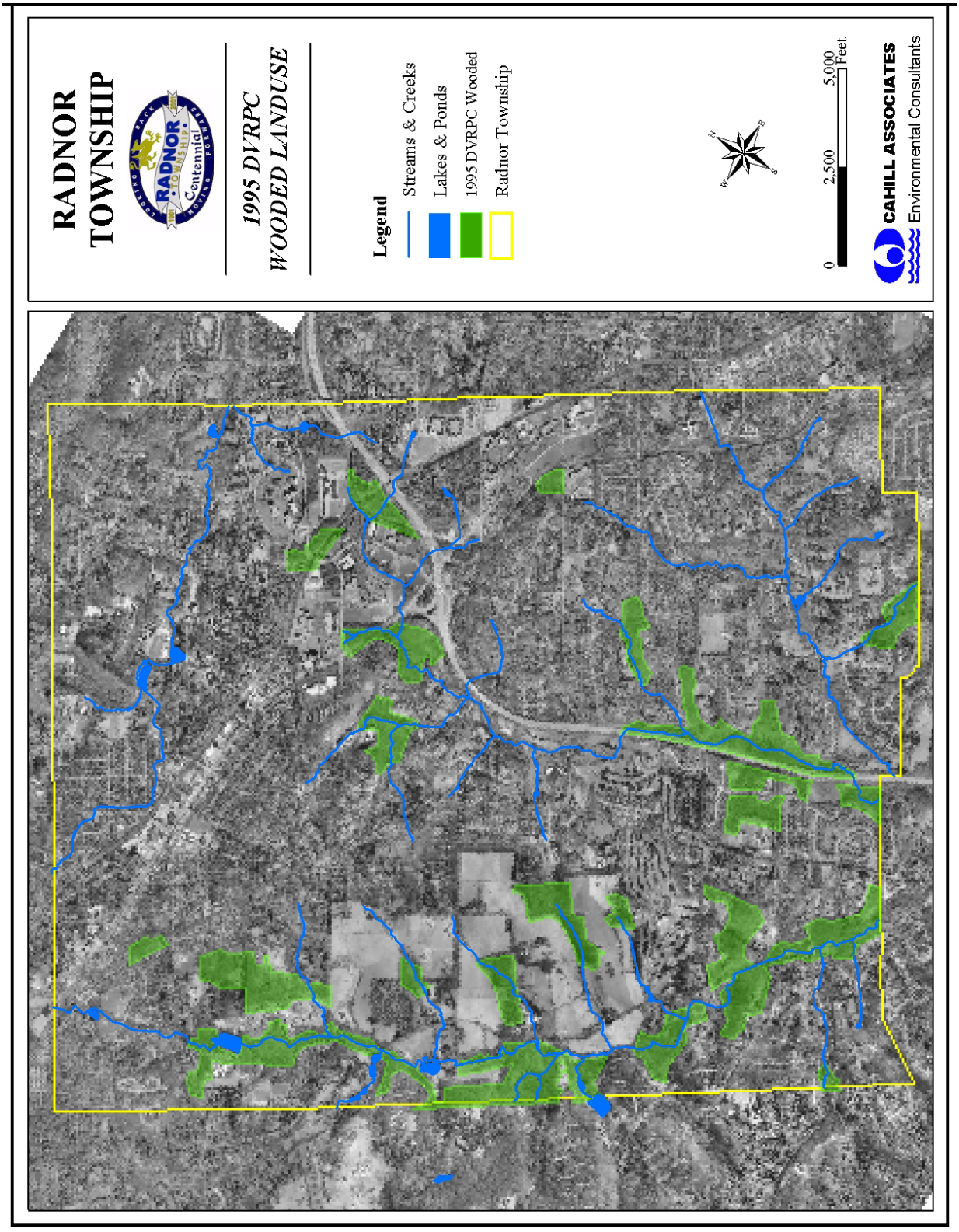

Figure 2-17. Wooded areas in Radnor Township according to 1995 DVRPC Land Use

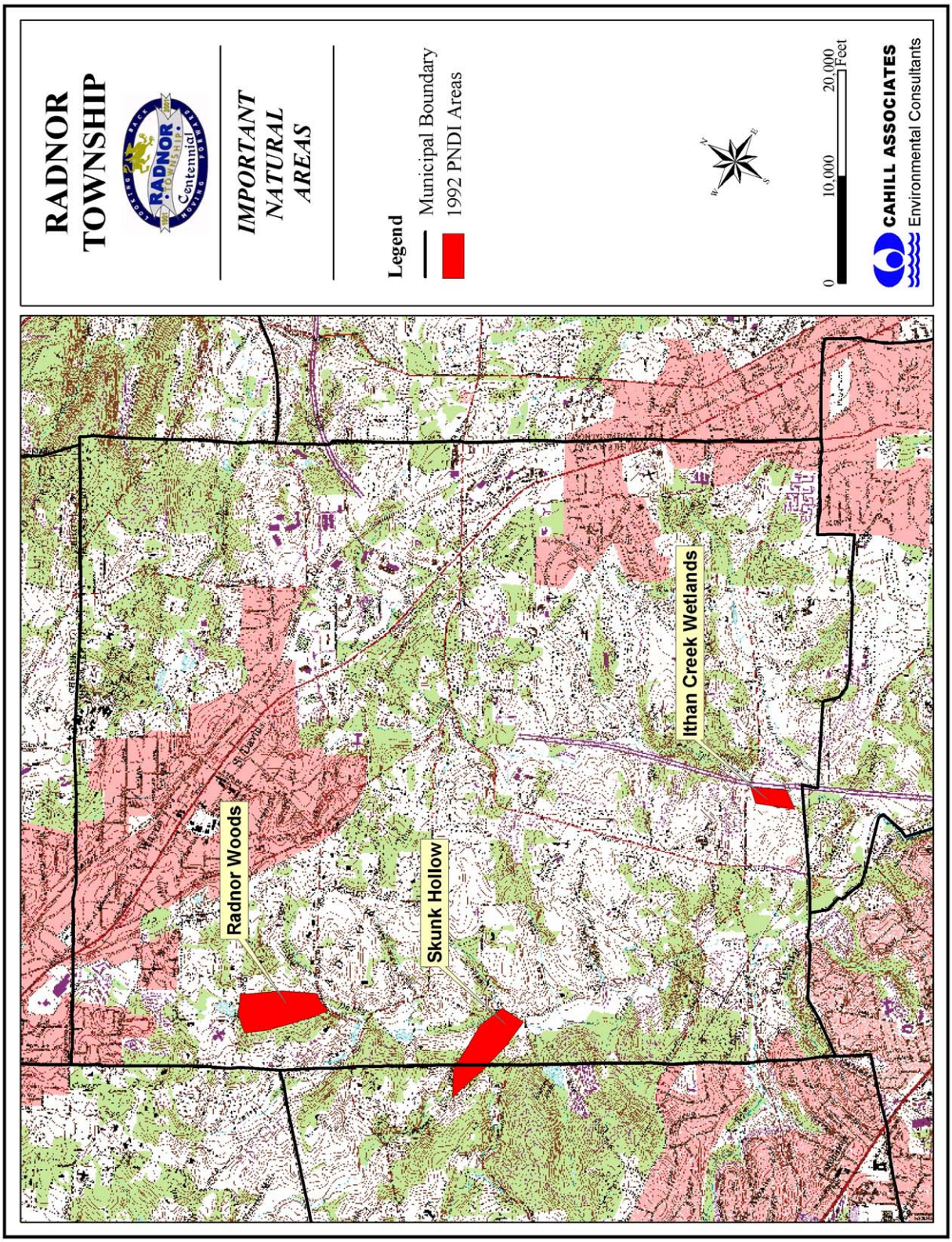

Figure 2-18. TNC/PNDI Areas of Concern in Radnor Township (1992)

Table 2-5. TNC/PNDI Sites and Species of Concern within Delaware County, (2001)

Species and Ecological Communities Tracked by PNDI within the Darby Creek Watershed			
SCIENTIFIC NAME	COMMON NAME	STATE RANK	STATE STATUS
FRESHWATER INTERTIDAL MARSH	FRESHWATER INTERTIDAL MARSH	S1	
POANES VIATOR ZIZANIAE	BROAD-WINGED SKIPPER	S1	
INCISALIA IRUS	FROSTED ELFIN	S2	
LYCAENA HYLLUS	BRONZE COPPER	S2	
CISTOTHORUS PALUSTRIS	MARSH WREN	S2S3B	
NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON	S2S3B	
EUPHYES CONSPICUUS	BLACK DASH	S3	
RALLUS LIMICOLA	VIRGINIA RAIL	S3B	
TYTO ALBA	BARN-OWL	S3B,S3N	
CIRCUS CYANEUS	NORTHERN HARRIER	S3B,S4N	
PONTIA PROTODICE	CHECKERED WHITE	SH	
KINOSTERNON SUBRUBRUM	EASTERN MUD TURTLE	SH	
PANOQUINA PANOQUIN	SALT-MARSH SKIPPER	SH	
ATRYTONE AROGOS AROGOS	AROGOS SKIPPER	SX	
DRYOPTERIS CLINTONIANA	CLINTON'S WOOD FERN	S2	N
HETERANTHERA MULTIFLORA	MULTIFLOWERED MUD-PLANTAIN	S1	PE
ECHINOCHLOA WALTERI	WALTER'S BARNYARD-GRASS	S1	PE
ELEOCHARIS PARVULA	LITTLE-SPIKE SPIKE-RUSH	S1	PE
ELEPHANTOPUS CAROLINIANUS	ELEPHANT'S FOOT	S1	PE
LYONIA MARIANA	STAGGER-BUSH	S1	PE
QUERCUS FALCATA	SOUTHERN RED OAK	S1	PE
VERNONIA GLAUCA	TAWNY IRONWEED	S1	PE
ELEOCHARIS OBTUSA VAR PEASEI	WRIGHTS SPIKE RUSH	S1	PE
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	S1B	PE
RALLUS ELEGANS	KING RAIL	S1B	PE
CASMERODIUS ALBUS	GREAT EGRET	S1B	PE
IXOBRYCHUS EXILIS	LEAST BITTERN	S1B	PE
NYCTANASSA VIOLACEA	YELLOW-CROWNED NIGHT-HERON	S1B	PE
ASIO FLAMMEUS	SHORT-EARED OWL	S1B,S3N	PE
QUERCUS PHELLOS	WILLOW OAK	S2	PE
RANA SPHENOCEPHALA	COASTAL PLAIN LEOPARD FROG	S2	PE
SAGITTARIA SUBULATA	SUBULATE ARROWHEAD	S3	PR
AMARANTHUS CANNABINUS	WATERHEMP RAGWEED	S3	PR
SCHOENOPLECTUS FLUVIATILIS	RIVER BULLRUSH	S3	PR
ZIZANIA AQUATICA	INDIAN WILD RICE	S3	PR
BIDENS BIDENTOIDES	SWAMP BEGGAR-TICKS	S1	PT
ELLISIA NYCTELEA	ELLISIA	S2	PT
PSEUDEMYS RUBRIVENTRIS	REDBELLY TURTLE	S2	PT
SPIRANTHES TUBEROSA	LITTLE LADIES'-TRESSES	S1	TU
TRADESCANTIA OHIENSIS	OHIO SPIDERWORT	S1	TU
EUPATORIUM ROTUNDIFOLIUM	A EUPATORIUM	S3	TU

4. Significant Habitat Areas in Radnor Township: Landscape Ecology and Conservation Biology Principles

The "natural landscape" of Radnor Township (Penn's Woods) has been significantly altered and with it the habitats that that landscape supports. Without delving into the science in great detail, the dilemma confronting developing regions is to minimize the loss of species diversity by minimizing the loss of habitat. An important objective here is to minimize the impacts of habitat fragmentation and negative edge effects, which occur so frequently in developing suburban areas where small, isolated, unconnected and unplanned patches of natural habitat may be preserved, but with minimal habitat benefit if habitat is interrupted with frequent intrusions and interruptions. In order to maximize the important natural ecological functions (or "services"), the science of landscape ecology has demonstrated that the most beneficial or efficient way to optimize ecological functions provided by landscape is through a system of interconnected networks, linking core reserve areas with natural corridors. Such a system if properly planned can provide critical mating variety, food supply, shelter opportunities, and overall support to foster greater species diversity. Core reserve areas may be thought of as undisturbed islands or patches of natural habitat area; these areas must have depth, must have interior area where any number of "non-natural" development-related influences and effects are minimized if not eliminated. These areas are less vulnerable to invasion by alien plant species resulting from wind blown seed distribution or from vines and other invasives; these areas are most protected by existing tree canopy. Minimum distances or radii to define these "patches" will vary with habitat area and the species naturally supported by that habitat area. For the sake of this comprehensive plan, we are defining this critical interior depth at a distance of approximately 300 feet (i.e., masses of "core reserves" with an interior of at least 300 feet) linked together by corridors. Figure 2-19 illustrates all those remaining natural (i.e., wooded) areas in Radnor which satisfy this criterion, without taking into account parcel boundaries.

Figure 2-19 indicates mapping of wooded areas, in overlay with 2000 aerials; the map itself suggests a system of "core reserves," heavily focused in the western half of the Township, with existing connections or the potential for linkage in many locations. The Comprehensive Plan strongly recommends that this map be used as the basis for a Township program which protects and preserves these existing natural areas to the maximum extent (this should be done in a variety of ways through the zoning and subdivision/land development regulations, as well as other Township-backed actions). This protection effort should be reinforced by a program which promotes the re-forestation of areas both within and adjacent to these "core reserve" areas, in order to reinforce and increase their positive ecological functions and "services." Some of this effort could occur on publicly owned lands; some of this could occur on privately owned lands.

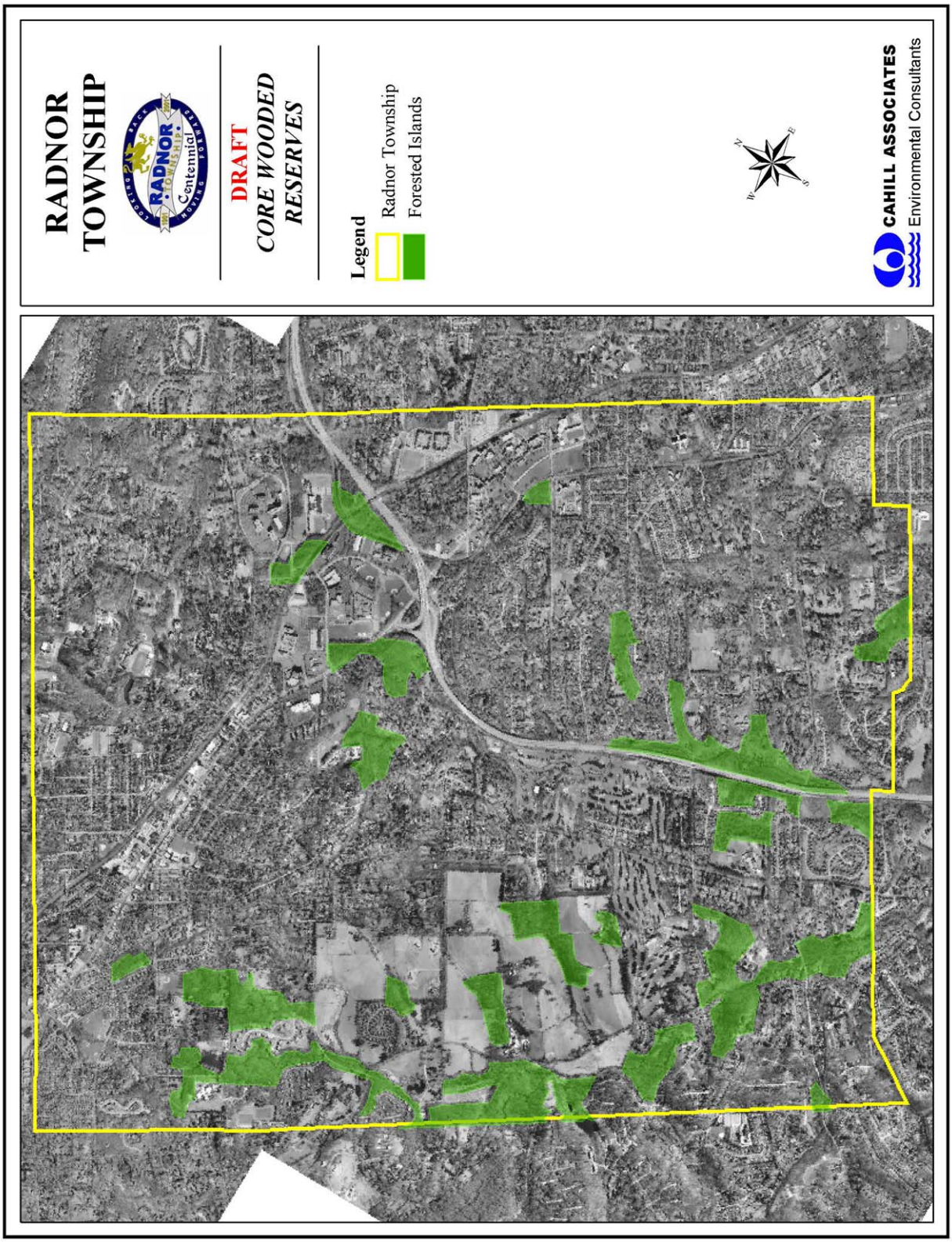

Figure 2-19. Core Reserve Wooded Areas in Radnor Township according to 1995 DVRPC Land Use

E. Air Quality

Amidst the "greene countrie" of Radnor, air quality is often dismissed as a secondary consideration. Furthermore, in terms of Radnor Township comprehensive planning, air quality issues tend to be the prerogative of Federal and State agencies, not really open to local initiative. At the same time, no other natural resource is more basic to life, to quality of life. Air quality is essential therefore to the quality of life in Radnor for all of its residents, its businesses and employees, its schools and colleges and other institutions, the successful utilization of all of its parks and recreational open spaces. Furthermore, mounting scientific evidence is demonstrating that human life is vulnerable to more subtleties in air quality than previously recognized.

Appendix A describes in great detail the regulatory framework under the Clean Air Act, sources of air pollution in our region and the health effects with specific pollutants, and data for air quality in Pennsylvania and the Radnor Township area.

F. Recommended Actions

Repeated below is the overriding goal and the objectives for the environmental resources of the Township. Listed beneath each Objective are the *Recommended Actions* for the Township.

Additionally, the Delaware County Planning Department (DCPD), in cooperation with adjoining counties (Chester, Montgomery, and Philadelphia), is preparing an Act 167 Stormwater Management Plan for the Darby Creek Watershed, funded largely through a PADEP grant. Preparation of this watershed-level study involves a complex planning process, with detailed inventorying and complex hydrologic modeling. The 167 Plan will identify stormwater problems and include development of new regulatory requirements which Watershed municipalities such as Radnor will be required to adopt. Although these new requirements cannot be determined at this time, the recommendations in this Plan should be compatible with those contained within this Act 167 planning effort. It also should be noted that Act 167 plans are designed to address future stormwater impacts from new development, not correct problems resulting from existing development. Therefore, given the mostly developed status of the Darby Creek Watershed in Radnor, effectiveness of the Act 167 plan will be limited to its ability to control runoff from future development. Although Act 167 plans have historically focused only on water quantity issues, recent re-interpretation of the Act now requires water quality considerations to be taken into account when managing future runoff.

Another important program development affecting stormwater and overall environmental resource management in Radnor relates to the National Pollution Discharge Elimination System (NPDES) Phase II stormwater plan and permit program which targets Municipal Separate Storm Sewer Systems or MS4 communities. Radnor has been designated an MS4 municipality. All MS4 municipalities, defined as over a certain population and/or with a certain threshold population density, must be permitted under the requirements of this new program; in order to obtain these permits, detailed Phase II permit applications will have to be prepared and submitted by each affected municipality by Spring 2003 with the actual programs developed thereafter. These permit requirements are being phased in the future under the administration of both PADEP and the US Environmental Protection Agency. NPDES Phase II permit program requirements have been drafted by PADEP and are currently in various stages of final review. PADEP has drafted a model stormwater ordinance which is to be incorporated by MS4 municipalities (note that these NPDES Phase II ordinance requirements will have to be incorporated into the Act 167 stormwater management planning for the Darby Creek Watersheds and the model ordinance, as discussed above). Because the NPDES Phase II permit program has so many facets, a detailed description has not been provided in this Comprehensive Plan.

Goal

Protect the Township's vital environmental values, including water resources, wetlands, floodplains and riparian areas, woodlands and important habitat areas, balancing the needs of development with environmental values.

Objectives

1. *Direct development to areas of minimum environmental sensitivity; prohibit development in areas of heightened sensitivity and value, such as wetlands, floodplains, riparian zones, and steep slopes.*

    - **Tighten existing natural resource regulations.**

    - **Evaluate existing natural resource regulations in the Township for rigor; compare with regulatory programs being recommended by the Brandywine Conservancy, the Green Valleys Association, and other environmental organizations for a "tough but fair" test (e.g., carefully scrutinize exactly what is allowed to happen in the floodplain, look at what is happening under current regulations). A sub-committee of the PC, buttressed with volunteers, could do this and report back to the PC.**

    - **Promote use of private tools such as conservation easements to permanently protect sensitive areas. Radnor could continue to rely on the Brandywine and other conservancies, but if other municipalities can support their own local land trusts, should Radnor start its own land trust as well?**

2. *Manage water resources, both water quality and water quantity, especially through a program of improved stormwater management.*

    - **Modify the existing stormwater regulations to require comprehensive (peak rate, total, volume, water quality) management, encouraging low impact development/conservation design applications where feasible.**

    - **Pursue comprehensive stormwater management at all Township projects; promote this approach at all School District and other public sites. This recommendation includes Meadow Management/Reforestation Pilot Projects, undertaken by the Township on Township-controlled parcels (e.g., The Willows) where water quality is so critical.**

    - **Undertake special retrofit stormwater studies to solve high priority problem areas (already ongoing at Rosemont Business Campus and Strafford Office Complex); implement "greening" projects in the Wayne Business District.**

    - **Develop Backyard Rain Garden model concept for voluntary application by homeowners, demonstrating how walkways, patios, other landscaping can be made to provide important water quantity and water quality functions; pursue funding for developing owner matching grant program to incentivize program in the highest priority areas (e.g., Ithan sub-basin drainage immediately upstream of existing Middle School site in Wayne).**

- **Education: Using the EAC, the League of Women Voters and other resources, promote educational venues on all levels that communicate the importance of stormwater management and other essential elements of the water cycle and overall water resources management (e.g., a stormwater workshop is already being planned).**

3. *Implement watershed-wide planning principles as developed by the Darby Creek River Conservation Plan and other appropriate watershed planning processes.*

    - **Enact Riparian Buffer regulations! This is the most critical single recommendation of the Darby Creek RCP. Radnor needs to be a leader riparian buffer management effort; reasonable distances must be determined!**

    - **Develop Riparian Buffer Restoration/Reforestation programs through the work of the EAC and other Township groups (various grant programs are available).**

    - **Promote stormwater as above, natural resource management as above, open space conservation as below. Place the highest priority on daylighting of enclosed streams and naturalizing of channelized streams; consider undertaking a Township-wide study of the streams to prioritize those stream segments most in need of restoration; then pursue restoration projects.**

4. *Work to preserve the natural woodlands which remain in the Township through minimum disturbance/minimum maintenance land development techniques, site conservation, and other practices; reinforce tree protection requirements and promote re-vegetation and re-forestation strategies with native species, compatible with sound landscape ecology principles.*

    - **Better tree/woodlands protection, management, and regulation. Incorporate optimal tree protection regulations in Township regulations, including rigorous tree removal standards and rigorous tree replacement requirements. Provide incentives, positive and negative, in the subdivision/land development regulations for a minimum disturbance/minimum maintenance approach to site development.**

    - **With EAC and other assistance, evaluate additional management actions (regulations?) which might be taken for those priority woodland masses and linking corridors identified in the Comprehensive Plan; also consider further evaluation of these priority Radnor township woodlands.**

    - **Establish pilot projects of reforestation on Township-controlled parcels, building onto existing forested masses with highest priority.**

- **With EAC and other assistance, develop private-owner-oriented woodland programs of reforestation.**

5. *Work to preserve those open spaces remaining in the Township, using all direct means such as acquisition, as well as less direct regulatory programs; prioritize those open spaces, taking into account factors such as proximity to wildlife habitat and forage areas, aesthetic values, water resource values, and other factors relating to landscape ecology management.*

    - **Continue to implement the recommendations from the Township's existing Park and Recreation Plan, as updated and revised.**

    - **Consider formation of a Radnor Township land trust which would intensify private-owner oriented efforts for open space conservation and land stewardship; also reinforce linkages with existing land trusts such as the Brandywine Conservancy.**

    - **Develop an intensified program of Land Stewardship owner interaction, identifying and prioritizing all those property owners with conservation potential; outreach efforts that communicate the benefits of conservation techniques such as donation, bargain sale, and so forth should be developed (materials are readily available, such as from Chester County Planning Commission, the Brandywine Conservancy, elsewhere).**

6. *Integrate management of noise, artificial light, and odor into the Township's planning and management program.*

    - **Better Regulations**

    - **Better Buffering Regulations**

7. *Work to protect air quality through mobile source emission strategies developed in the transportation-planning element of the comprehensive plan and through integrating transit oriented development and other auto trip reduction strategies into overall planning.*

    - **Traffic mobility/traffic calming as elsewhere**

    - **Screening/landscaping/woodland protection as above**