Bloomington Environmental Quality Indicators

A report by the

Environmental Commission
City of Bloomington, Indiana
July, 2001

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City of Bloomington, Indiana
401 N. Morton Street, PO Box 100
Bloomington, IN 47402
(812) 349-3518

Table of Contents

Introduction

Did you know that over the period 1950-2000 Bloomington was the fastest growing city in Indiana, and that the population has increased 14 percent since 1990? In Monroe County, the population increased 7 percent over the same decade but the number of registered vehicles increased 40 percent. This confirms that there are more cars on the road and people are spending more time in traffic.

More people also generate more waste. The amount of trash going to the Monroe County landfill has decreased since the early 1990's (from about 7,000 tons per month to 6,000 tons), despite the growing population. The recycling and yard waste programs have effectively diverted much material from the landfill, extending its useful life. However, IDEM estimates that Monroe County generates nearly 130,000 tons of solid waste per year, well over one ton per person. Much of this waste is hazardous and most of that is released into the atmosphere. The EPA reported that over 400 tons of toxins were released into the air of Monroe County in 1999 with General Electric being the single biggest source.

A growing population also puts additional pressure on our water supply. We rely on Lake Monroe for water but it is faces several serious problems. Soil erosion is contributing to increasing sedimentation, which causes problems with water quality and aquatic health, water depth and navigation, reservoir lifespan, and the aesthetic and recreational value of the lake. Streams draining into the watershed carry with them various toxic pollutants that have led to fish consumption advisories. The high numbers of boats also lead to increased pollution from oil and gas, as well as from untreated human sewage. People from other areas are often surprised to learn that our drinking water supply is not better protected.

Increasing human population and development has also led to degradation and fragmentation of natural habitats that serve as home for wildlife and sources of recreation and relaxation for local residents. It is estimated that less than 1 percent of Indiana's landscape approximates pre-European conditions. Greenspace preservation is high on many Bloomingtonian's list of priorities but greenspace is disappearing fast as forests and fields are converted into roads, parking lots, housing developments and strip malls. The city's Growth Policies Plan calls for an increase in tree cover but the Environmental Commission's own study indicates that tree cover is decreasing. Natural vegetation serves many critical roles such as the production of oxygen, filtering air and water pollutants, reducing runoff and soil erosion, moderating climate and providing food and habitat for wildlife. We know that Bloomington receives many visitors for IU athletic events and its varied cultural and social offerings, but how many tourist dollars are generated by people attracted to the beautiful hills and forests of the area?

All is not gloom and doom however. We live in a great community and have a lot to work with. There have been many environmental positives since the last BEQI report was published in 1997. Some of them include additional greenspace preservation (Latimer Woods, Leonard Springs, Indiana University's Research and Teaching Preserve), the PCB problem has largely been solved, new bike lanes, multi-use trails and the Greenways plan, continued compliance with the air quality attainment zone, point source emissions are down, the city is updating its Growth Policy Plan in recognition of the problems generated by unfettered urban sprawl, and many wildlife populations (e.g. bald eagles, wild turkeys) are healthy and growing. Within the community there is a healthy, vigorous debate over our vision for the future that is centered on the environment.

The Bloomington Environmental Commission's Bloomington Environmental Quality Indicators (BEQI) 2001 report contains information about environmental indicators in Bloomington that should prompt us to think, debate and enact policy. There are seven chapters, each densely filled with information and data, on population and land use, energy, waste management, air quality, water quality, soil erosion and natural areas. These indicators, similar to economic indicators like the unemployment rate or the Dow-Jones Industrial Average, help us assess the long-term effects of our environmental policies and priorities. The U.S. EPA defines an environmental indicators as a parameter, or some value derived from parameters, which provides managerially significant information about patterns or trends in the state of the environment, in human activities that affect or are affected by the environment, or about relationships among such variables.

The Bloomington Environmental Commission is a citizen's advisory commission whose primary role is to advise the Bloomington Planning Department on environmental impacts of development proposals. It consists of 12 members of the community ranging from academics and government employees to individuals representing the private sector. Half of the members are appointed by the Mayor and half by the Common Council. In addition its advisory role, the Environmental Commission conducts research and publishes reports on various environmental issues relevant to the City of Bloomington. A number of these reports are available on our web site (http://www.city.bloomington.in.us/planning/ec), including the 2001 BEQI report. A hard copy can be requested through the Planning Department (812-349-3423). An informed citizenry is essential to a democratic society. Take a look and we welcome your comments!

Keith Clay
City of Bloomington
Environmental Commission

I. Population and Land Use

Introduction

The world's human population has been growing at an accelerating rate since the 1800s. The magnitude of this population increase is unprecedented. According to the U.S. Census Bureau, the global population surpassed 6 billion people in 1999. Although fertility rates have begun to decline, the world's population is expected to reach 7.9 billion people by 2025.[1] According to the 2000 Census results, the U.S. population is an estimated 281 million. The U.S. population is projected to reach 335 million by 2025. The age structure of the population is also expected to shift over the course of the next 25 years. The world's elderly population (ages 65+) is expected to double by 2025. This shift will prompt increasing demands for elderly support and care. Urbanization is also rapidly occurring throughout the world. Currently, 80 percent of the U.S. population lives in urban or suburban areas.[2] By 2025, 60 percent of the world's population is expected to inhabit urban regions.[3]

A growing population requires more food, water, energy and living space. The rate of population growth affects a community's ability to sustain a prosperous, healthy environment. An increase in the population growth rate and population density can strain the resources of a community and decrease greenspace. A higher population within a region generates greater waste and pollution while urbanization limits the ability of ecosystems to cleanse and renew themselves through natural processes.

1. Population Trends and Projections

a.) Definition

The number and age of people living within a community provides useful information about its needs and consumption patterns. The natural increase and migration within an area determines population growth. More people require more space, more cars, and more goods. A larger population affects the environment in rough proportion to its size. Additional residents generate more solid and hazardous wastes, emit higher levels of air pollution and use more water and energy. Theoretically, more people can also allow a city to afford the cost of pollution control technology. In addition, the age structure of a community dictates the type and amount of goods and services desired.

For example, an older population will demand more health care services and fewer schools than one with young families.

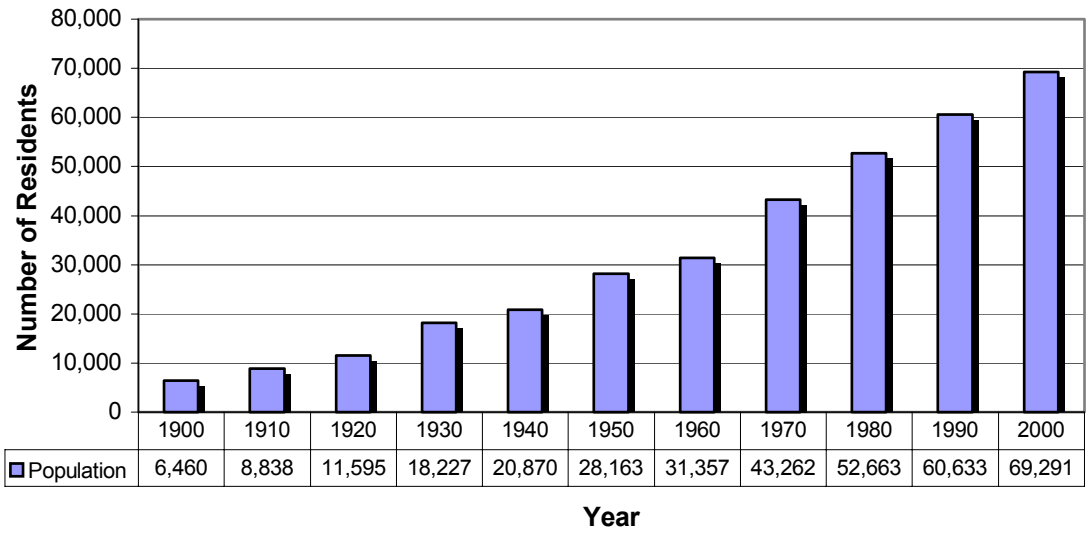
b.) Indicators

Results from the 2000 Census show that the population of Indiana increased 9.7 percent from 5,544,159 to 6,080,485 residents since 1990. In comparison, the nation as a whole grew by 13.2 percent during the same period.[4] Bloomington and Monroe County have experienced moderate but steady growth in the last decade. The recent release of the 2000 Census data reveals that Bloomington's population increased from 60,633 to 69,291 residents from 1990 to 2000. According to this data, the City increased its population by about 14.3 percent, or 8,658 residents in the last decade[5] (See Figure 1.1).

The population of Monroe County increased 10.6 percent since 1990. According to the most recent census, the population of the County grew by 11,585 residents from 1990 through 2000[6] (See Figure 1.2). In the next decade the County is expected to grow an additional 4.6 percent to 126,161 residents.[7]

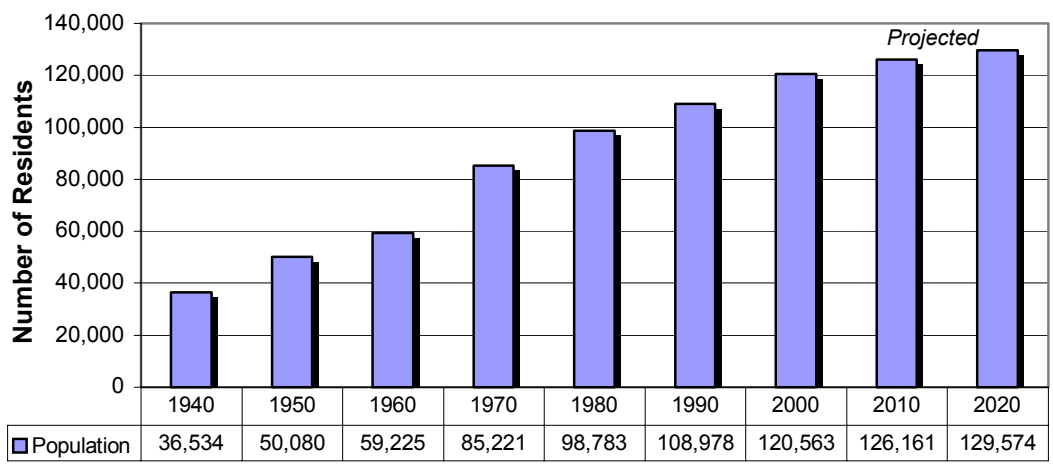
Although the population has grown in Monroe County, its land area has remained constant at 394.4 square miles. Therefore, in the last decade the County's population density has increased from 276.3 to 305.7 residents per square mile, a 10.6 percent increase. Annexations since 1990 have increased Bloomington's land area from 15.1 to 20.28

Figure 1.1



Source: Indiana Business Research Center

Figure 1.2



Source: Indiana Business Research Center

square miles. This increase in land area has lead to a 15 percent decrease in population density from 4,015.4 to 3,416.7 residents per square mile during the period from 1990-2000[8] (See Figure 1.3).

In the decades from 1950 to 2000, Bloomington experienced an increase of 41,128 residents. As such, the city leads the list of the fifteen largest Indiana cities in percentage increase of total growth by more than doubling its population since 1950 (See Figure 1.4). During this period, Bloomington moved from the nineteenth largest city in Indiana to the seventh largest. Much of Bloomington's population growth can be attributed to the growth of Indiana University. In 1950, 19,514 students were enrolled at IU. Since that time, student enrollment has grown to 37,076 students, a 90 percent increase in student population.[9]

The presence of Indiana University also influences the age structure of Bloomington and Monroe County. In Monroe County, the most recent age group figures indicate that

Figure 1.3

Population Density			
Bloomington			
Year	Land Area (sq. mi)	Population	People/sq. mi
1950	3.7	28,163	7611.6
1960	5.3	31,357	5916.4
1970	8.4	43,262	5150.2
1980	10.6	52,663	4968.2
1990	15.1	60,633	4015.4
2000	20.28	69,291	3416.7
Monroe County			
Year	Land Area (sq. mi)	Population	People/sq. mi
1950	394.4	50,080	127.0
1960	394.4	59,225	150.2
1970	394.4	85,221	216.1
1980	394.4	98,783	250.5
1990	394.4	108,978	276.3
2000	394.4	120,563	305.7

Source: IBRC and U.S. Census Bureau

Figure 1.4

Population in Indiana and Selected Cities (1950-1999)								
	1950	**1960**	**1970**	**1980**	**1990**	**1990***	**2000**	**Change from 1950-2000**
INDIANA	3,934,224	4,662,498	5,195,392	5,490,224	5,544,159	5,544,159	6,080,485	2,146,261
Indianapolis	427,173	476,258	746,992	711,539	741,952	742,219	791,926	364,753
Ft. Wayne	133,607	161,776	178,269	172,391	173,072	202,995	205,727	72,120
Evansville	128,636	141,543	138,764	130,496	126,272	126,172	121,582	-7,054
South Bend	115,911	132,445	125,580	109,727	105,511	106,055	107,789	-8,122
Gary	133,911	178,320	175,415	151,968	116,646	116,587	102,746	-31,165
Hammond	87,594	111,698	107,983	93,714	84,236	84,248	83,048	-4,546
Bloomington	**28,163**	**31,357**	**43,262**	**52,663**	**60,633**	**63,504**	**69,291**	**41,128**
Muncie	58,479	68,603	69,082	77,216	71,035	71,828	67,430	8,951
Anderson	46,820	49,061	70,787	64,695	59,459	59,494	59,734	12,914
Terre Haute	64,214	72,500	70,335	61,125	57,483	57,461	59,614	-4,600
Lafayette	35,568	42,330	44,955	43,011	43,764	49,762	56,397	20,829
Elkhart	35,646	40,274	43,152	41,305	43,627	44,681	51,874	16,228
Mishawaka	32,913	33,361	36,060	40,201	42,608	43,138	46,557	13,644
Kokomo	38,672	47,197	44,042	47,808	44,962	45,189	46,113	7,441
Richmond	39,539	44,149	43,999	41,349	38,705	n/a	39,124	-415

Percentage Population Changes in Indiana and Selected Cities (1950-1999)							
	1950-60	**1960-70**	**1970-80**	**1980-90**	**1990-2000**	**1990*-2000**	**1950-2000**
INDIANA	18.51%	11.43%	5.67%	0.98%	9.67%	9.67%	54.55%
Indianapolis	11.49%	56.85%	-4.75%	4.27%	6.74%	6.70%	85.39%
Ft. Wayne	21.08%	10.19%	-3.30%	0.40%	18.87%	1.35%	53.98%
Evansville	10.03%	-1.96%	-5.96%	-3.24%	-3.71%	-3.64%	-5.48%
South Bend	14.26%	-5.18%	-12.62%	-3.84%	2.16%	1.64%	-7.01%
Gary	33.16%	-1.63%	-13.37%	-23.24%	-11.92%	-11.87%	-23.27%
Hammond	27.52%	-3.33%	-13.21%	-10.11%	-1.41%	-1.42%	-5.19%
Bloomington	**11.34%**	**37.97%**	**21.73%**	**15.13%**	**14.28%**	**9.11%**	**146.04%**
Muncie	17.31%	0.70%	11.77%	-8.00%	-5.07%	-6.12%	15.31%
Anderson	4.79%	44.28%	-8.61%	-8.09%	0.46%	0.40%	27.58%
Terre Haute	12.90%	-2.99%	-13.09%	-5.96%	3.71%	3.75%	-7.16%
Lafayette	19.01%	6.20%	-4.32%	1.75%	28.87%	13.33%	58.56%
Elkhart	12.98%	7.15%	-4.28%	5.62%	18.90%	16.10%	45.53%
Mishawaka	1.36%	8.09%	11.48%	5.99%	9.27%	7.93%	41.45%
Kokomo	22.04%	-6.68%	8.55%	-5.95%	2.56%	2.04%	19.24%
Richmond	11.66%	-0.34%	-6.02%	-6.83%	1.08%	n/a	-1.05%

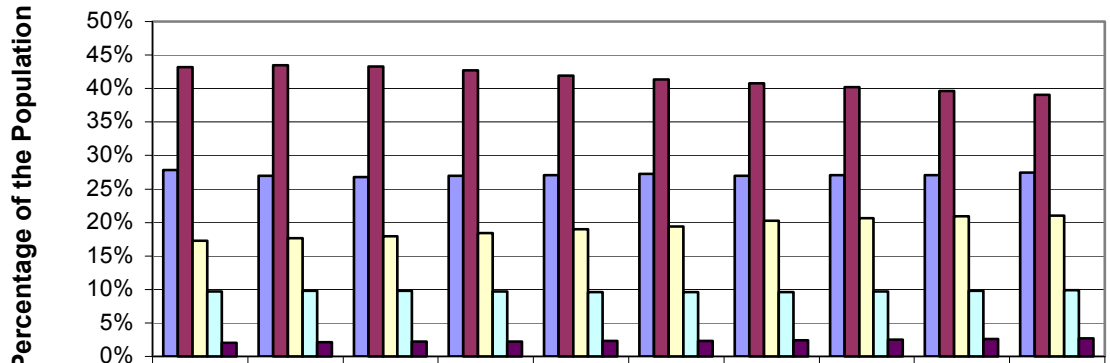
*1990 Census data retabulated based on updated boundaries

Source: Indiana Business Research Center

39.1 percent of the population is comprised of the age group from 20-39 years. By comparison, 28.6 percent percent of the state population falls within the same age bracket.[10]

According to the Indiana Business Research Center (IBRC), Bloomington and Monroe County are expected to continue to experience a gradual aging of their population during the next 50 years. From 1990 to 1999, the percentage of the population over 80 years of age in Monroe County has increased from 2.1 percent to 2.7 percent (See Figure 1.5). This increase from 2,255 to 3,119 residents in the oldest age bracket represents a 38.3 percent increase during this period. In comparison, Indiana's population over 80 years of age increased by 22.6 percent, from 159,580 to 195,702 residents from 1990 to 1999.[11]

Figure 1.5



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0-19	27.8%	27.0%	26.7%	27.0%	27.1%	27.3%	26.9%	27.1%	27.1%	27.4%
20-39	43.2%	43.5%	43.3%	42.7%	41.9%	41.4%	40.8%	40.2%	39.6%	39.1%
40-59	17.2%	17.6%	18.0%	18.4%	19.0%	19.4%	20.3%	20.6%	20.9%	21.0%
60-79	9.7%	9.8%	9.8%	9.7%	9.6%	9.6%	9.6%	9.7%	9.8%	9.9%
80+	2.1%	2.2%	2.2%	2.3%	2.3%	2.3%	2.4%	2.5%	2.6%	2.7%

Source: Indiana Business Research Center

c.) Interpretation and Evaluation

As one of Indiana's fastest growing cities, Bloomington has risen from the eighth to the seventh largest city in the state in this past decade. Bloomington's population growth since 1990 can be attributed to both natural population increase and land annexation. According to the Indiana Business Research Center a third of the city's growth in population is due to annexation. The 1990 Census population figures can be readjusted according to the current city boundaries to remove annexation effects on population. This shows the natural population growth of the city to be 9.11 percent, or an increase of 5,787 residents (See Figure 1.4). These figures indicate that Bloomington continues to grow, not only by natural population increase (births minus deaths) and migration, but also by the land expansion of the City itself.

Monroe County's population density grew consistently with its population growth in the last decade (10.6 percent increase). Bloomington's population density actually decreased by 15 percent, despite its significant increase in population. This is attributed to land annexations that have increased the area of the City by 34.3 percent since 1990. Land annexations demonstrate that the growth of Bloomington is encroaching into the surrounding region with an expansion of its city limits. This decrease in population density can also be used as an indicator of urban sprawl (see section 1.3 - Urban Sprawl).

The student population remains a large component of the population in Bloomington. At the start of the 2000 academic year, approximately 37,076 students were enrolled at Indiana University. The student population is included in the official Census count of Bloomington residents. Students are counted at their "usual place of residence" which is determined by at least six months of residence. Therefore, most full-time students at IU – Bloomington are reflected in the most recent Census population counts.[12] This indicates that approximately half of the Bloomington population is made up of students. The student population influences the age structure of the City and determines the needs of the community.

On the county level, age group data trends support national and state observations that the overall population of Monroe County is aging. In 1999, the elderly population (80+) represented 3.3 percent of the total state population while 2.7 percent of the population was 80 years or older in Monroe County.[13] In the past decade, Monroe County's percentage of older residents is catching up to the state figures. Monroe County's elderly population (aged 80+) grew at a faster rate than the rest of the state from 1990-1999. Trends show that this component of population continues to grow larger even with population growth. This indicates that not only is the present population aging but people in this age bracket may be moving into the region. This shifting of the age structure will prompt changes in the demands on the community. An increasing elderly population will require increased retirement provisions, facility accessibility, and health care services.

Population growth is often considered a positive indicator of a community. Such trends point to a strong local economy, available opportunities, and a pleasant living environment. However, high rates of population growth strain the sustainability of the community.

Population growth leads to a loss of open space, increased pollution and congestion, and increased demands on city infrastructure. Trends indicate that Bloomington has experienced a steady but moderate growth in population over the last two decades. Such growth allows the city to anticipate the city's needs and manage development. Attention should also focus on how such population growth will affect the local air, water, and land quality. Annexations of surrounding regions have increased the land area of Bloomington and contributed to an increase in resident population. In an effort to keep up with and manage the city's growth, the Planning Department has recently revised and re-drafted the Growth Policies Plan (GPP) for the city. The plan attempts to guide future development of the City and discourage urban sprawl with consideration to environmental protection, transportation, neighborhood character, and economic development. It is a working example of how population trends affect many aspects of maintaining a sustainable community.

The Census 2000 data is currently being released in increments. Detailed demographic data and more accurate population projections of the region are forthcoming. This information will provide further insight into the population and land use trends of Monroe County and Bloomington.

d.) Linkages

Population and its effects are linked to each subject in this report. The number of people living within a community and how they interact with the surrounding environment affects the quality of the land, water, air, and wildlife. Population is closely connected to development, transportation, and the local economy.

2. Development

a.) Definition

Broadly speaking, we define development as the conversion of woodlands or agricultural lands to residential, commercial or industrial areas. Most states have laws requiring counties, or similar jurisdictions, to adopt a plan or set of policies to guide how an area grows. City and county governments write zoning ordinances to enforce the development plan policies and identify the type and density for particular parcels. The public process of creating a plan, writing a zoning ordinance and the day-to-day task of approving development proposals often results in lively community debate that centers around residents' visions for their city and values placed on certain natural resources.

b.) Indicators

As the population in Bloomington and Monroe County grows, more homes are needed to house new residents and growing families. To support the growing community,

more retail, commercial, and industrial development often occurs.

In 2000, the Bloomington Planning Department received 830 permit requests. Almost 25 percent of these requests were for new construction of single family residences. 39 permit applications were for multi-family residential units and 17 applications were for new commercial construction projects. This is similar to the 1999 data in which 221, or 26 percent, of the 843 permit applications were for single family residences. In that same year, 60 permit applications were for multi-family residences and 24 applications were for commercial buildings.[14]

According to the Bloomington Planning Department, the development of low-density, single-family housing peaked in 1992-1993 and has since declined. Higher-density residential development (including single- and multi-family housing) has increased during the same time period. Residential development has shifted toward higher-density housing since 1991. The overall average residential density for new construction was 5.8 units per acre in 1991 and 6.58 units per acre in 1998.[15]

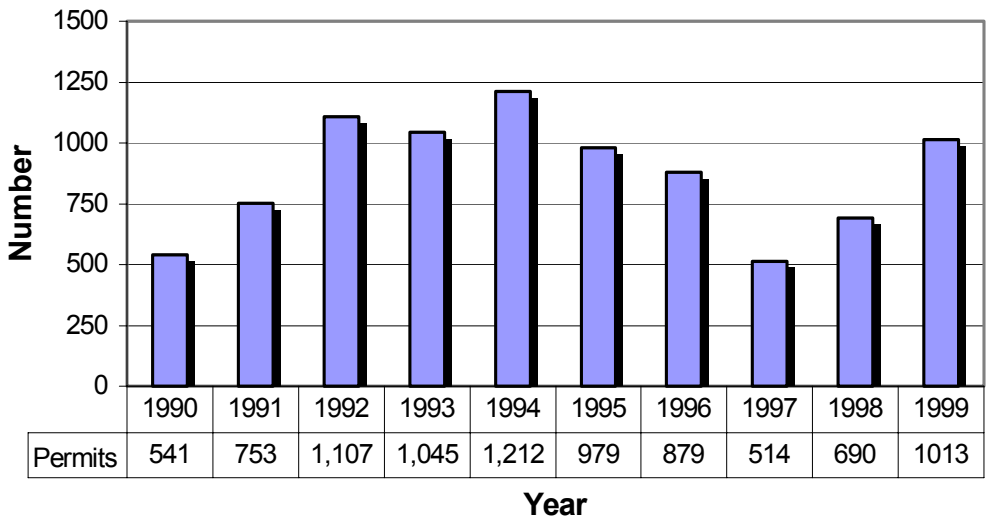
In Monroe County, a total of 1013 residential construction permits were approved. This is a 47 percent increase from the number of approved permits in the previous year[16] (See Figure 1.6).

Commercial development trends have mirrored residential development. Approximately 4.25 acres is commercially developed for every 100 new housing units. As of 1999, the rate of commercial land development is outpacing the approval rate of commercial zones.[17]

The trend in industrial development has shown the most dramatic decline in recent years. Less than 20 acres of industrial land within the Planning Jurisdiction has been developed since 1991. Industrial development has mainly occurred outside of the City's Planning Jurisdiction.[18]

Annexations increased the area of the city from 3.7 square miles in 1950 to 15.1 in 1990.[19] Since 1990, the city has annexed 5.18 additional square miles bringing Bloomington's land area up to 20.28 square miles.[20] From 1950 to 1999, the population density in Bloomington decreased 57 percent from 7,612 to 3,291 residents per square mile. For Monroe County, where the land area is fixed at

Figure 1.6



Source: U.S. Census Bureau

394 square miles, the population density has increased from 122 to 306 residents per square mile (See Figure 1.3 -Urban Sprawl). The decrease in Bloomington's population density can be attributed to the growth of the city limits via annexation from the County. As a result of this development, Bloomington's urban community has grown to include a much larger portion of Monroe County. The increase in population density in Monroe County indicates that there are many more residents occupying space within the county limits.

In 1991, Bloomington adopted the Growth Policies Plan (GPP) to guide development decisions for the 1990-2010 period. Recently, an updated version of the GPP has been drafted and is currently under revision. The plan identifies seven guiding principles:

- Compact Urban Form: Encourage contiguous urban development and allow moderately higher residential densities to limit urban sprawl.
- Nurture Environmental Integrity: Recognize that the natural resources and environmental sensitivity of the land in and around Bloomington that should be maintained, protected and enhanced as development occurs.
- Leverage Public Capital: Use and expand existing public infrastructure systems wisely and at capacity to avoid added costs and discourage outward growth.
- Mitigate Traffic: Reduce demand for vehicle trips and encourage positive alternate modes of transportation throughout the city.
- Serve Diversity: Development should accommodate different lifestyles, income levels and household characteristics. A diverse public should have equal access to natural areas, public amenities and the development review process.
- Conserve Community Character: Maintain core neighborhood character and quality, support downtown revitalization, and pursue a strong relationship to Indiana University
- Sustain Economic and Cultural Vibrancy: Maintain and diversify future employment opportunities and encourage artistic and cultural events within the city.

In 1995, the Common Council adopted a revised zoning ordinance to implement the policies laid out in the Growth Policies Plan. The ordinance defines land use zones and requires compliance with environmental standards. The requirements address the following environmental issues: landscaping; tree preservation, transit, bicycle and pedestrian access; compliance with all applicable state and federal environmental laws; development around karst features; wetland protection; construction on steep slopes; protection of water resources; control of erosion and siltation; and stormwater management. Since that time, other changes have been incorporated into the zoning ordinance. This includes: Telecom tower (telecommunications facility) requirements; revision of the enforcement section to allow for zoning violations ticketing; more restrictive standards for certain scenic and gateway corridors; and adjustments to the Planned Residential Overlay allowance for residential uses.[21] Changes under consideration for the future include the possible elimination of downtown density limits. Other changes will not occur until after the adoption of the revised Growth Policies Plan.

Until 1997, the City controlled development in a large area outside its borders called the Two-Mile Fringe. The area was a border about two miles wide encircling the city. The document, Memorandum of Understanding, transferred control of this land from the planning jurisdiction of Bloomington to Monroe County.

c.) Interpretation and Evaluation

The population density within a region can yield information about development patterns. The increase in land area through annexation indicates that Bloomington is developing into surrounding regions. Perhaps the trend in population density is better evaluated using Monroe County data since the land area has remained constant. The population density in the County has been steadily increasing since 1950. More people within a particular area require increased housing and economic needs. These needs lead to increased housing,

commercial and industrial development. Bloomington's population density trends in conjunction with annexation will be discussed further in the next section focused on urban sprawl.

The Planning Department's 1999 Land Use Analysis Draft states that commercially zoned land development is occurring at a rapid rate. From 1991 to 1999, the average annual consumption of commercial land was 25 acres per year and demand has been increasing. As of the 1999 analysis, only 153 acres of commercially zoned land was remaining within the Planning Jurisdiction. Using this information, models projected that commercial land consumption will reach a limit between 2003-2005. The analysis attributed the demand for commercial development to population growth within the City.[22]

The options that exist to accommodate the observed rapid commercial development include converting residential or industrial zoned land to commercial, developing outside the city's planning jurisdiction, and encouraging redevelopment of the downtown area and other vacant non-residential space within the City.[23]

The City's Planning Department in conjunction with the Environmental Commission works to analyze environmental consequences associated with development and to mitigate adverse effects through a tree preservation policy, an erosion control ordinance and, careful planning in environmentally sensitive areas such as karst or lake watershed areas. Erosion associated with construction and development has been a problem throughout the 1990s and has prompted numerous ordinance revisions and enforcement studies (See Chapter 6). Urban sprawl continues to be a major issue and the driving force behind the "Compact Urban Form" development initiative for Bloomington. Increased attention should be given to the two-mile fringe area surrounding the City in light of urban sprawl and traffic concerns.

The city has worked to encourage diversity and conserve community character as Bloomington grows and develops. The community generally accommodates a wide range of lifestyles and incomes and continues its support of the downtown area. Goals related to traffic have been difficult to achieve as vehicle registrations continue to rise. The process of adopting the Zoning Ordinance and Growth Policies Plan and its recent revision process has resulted in open communication among city departments, citizen groups, and the Plan Commission. Although these policies attempt to manage growth and development, continual construction of housing complexes and major retail outlets removes greenspace and strains the health of the surrounding environment.

d.) Linkages

The effects of development are linked to greenspace, wildlife, transportation, employment, air quality, and water quality.

3. Urban Sprawl

a.) Definition

With the U.S. population growing by over 2 million people per year, our cities and towns are growing as well. New homes, grocery stores, gas stations and malls continue to be developed. Poorly planned development results in urban sprawl and the effects include loss of greenspace and farmland, the disappearance of traditional neighborhoods, the degradation of the city's inner core, and an increased dependency on automobiles, to name a few.

One of the main problems with the issue of "sprawl" is that it is poorly defined. Below are several attempts to formally define this complex issue.

- The Vermont Forum on Sprawl defined sprawl as "dispersed development outside of compact urban and village centers along highways and in rural countryside".
- Reid Ewing, associate professor at Florida International University in Miami, called

sprawl, "random development characterized by poor accessibility of related land uses such as housing, jobs and services like schools and hospitals".

- The EPA has taken a more quantitative approach and defines sprawl as "a residental development at a density of three dwelling units per acre or less".
- At a May, 1998 Transportation Research Conference, Anthony Downs identified ten traits of sprawl:
  1. Unlimited outward extension
  2. Low-density residential and commercial settlements
  3. Leapfrog development
  4. Fragmentation of powers over land use among many small localities
  5. Dominance of transportation by private automotive vehicles
  6. No centralized planning or control of land-uses
  7. Widespread strip commercial development
  8. Great fiscal disparities among localities
  9. Segregation of types of land uses in different zones
  10. Reliance mainly on the trickle-down or filtering process to provide housing to low-income households.

Urban sprawl has many environmental, social and financial costs.[24] Environmental costs of sprawl include the loss of agricultural land and wetlands to development, increased flooding due to impervious surfaces, decreased biodiversity because of habitat loss, microclimate changes from the changes in land cover, and increased air pollution due to increased automobile use.

There are many social costs of urban sprawl as well. A sprawling city tends to have abandoned city centers because homes on the outskirts of town are cheaper than fixing up an older house in the center of town. Suburban strip malls and cookie cutter houses that accompany sprawl cause a loss of a sense of community. Finally, the dependence on automobiles, increased air pollution, and substantially higher emergency response times in suburban areas lead to increased health problems.

The fiscal costs to sprawl tend to attract the most attention from policy makers and should therefore be emphasized. Sprawling cities have substantially higher infrastructure and services costs, such as building and maintaining new streets, extending sewer, water, and power lines, etc. Increased dependence on cars means that people spend more money on gas and maintenance. Harder to quantify are the monetary losses of longer commute times. Another effect of the increased impervious surfaces is increased flooding, which equates to increased spending for municipalities. In addition, many of the environmental and social costs contribute to the fiscal costs of urban sprawl as well.

Urban sprawl was a commonly used buzzword in Bloomington's 2000 elections. Most people point to all the new development on the edge of the city as sprawl. But is Bloomington really sprawling or is it just growing?

b.) Indicators

Conclusive indicators of sprawl are difficult to identify. There are some indirect factors that may suggest that Bloomington is experiencing sprawl. One possible indicator of urban sprawl is a drop in population density. Outward growth should grow at a rate equivalent to population growth. However, if the area of a city is growing faster than the population, it may be sprawling. Between 1990 and 2000, Bloomington's population grew 14.3 percent, while its area grew 34.3 percent, resulting in a 15 percent decrease in population density. As a result of Bloomington's expansion, there are fewer people per square mile.

Another indirect indicator of urban sprawl is a disproportionate increase in vehicle use and population. Citizens of a sprawling area are often more dependent on their cars. While the population of Monroe County increased 7.3 percent between 1990 and 1999, the number of registered vehicles increased 40.8 percent. This disproportionate increase suggests that an increasing proportion of people in the county are driving cars.

The amount of road miles necessary to service developing areas also increases in a sprawling community. Since 1990, the amount of road miles managed in Bloomington has increased 25 percent, from 157 to 197 miles.

Since direct indicators of urban sprawl in Bloomington are limited, perhaps actual examples that characterize "urban sprawl" would demonstrate Bloomington's sprawl issues more effectively.

c.) Interpretation and Evaluation

A decrease in the city's population density and disproportionate increase in the number of vehicle registrations in the county are a few indicators that suggest that Bloomington is sprawling. A sprawling community requires increased transportation and may be responsible for the disproportionate increase in vehicle registration compared with population. Roads must be built to access sprawling development areas. Costs are incurred by the community from continued road building and maintenance. Increased road miles in the region also increases the amount of storm water runoff and its associated negative environmental effects.

Observations of the type of development that is currently occurring around the city may be most valuable in demonstrating Bloomington's struggle with sprawl.

A report put out by the Environmental Commission in August of 2000 described many ways that urban sprawl can be controlled.[25] The tools to reduce urban sprawl address the following goals; concentrate development in the downtown area, discourage suburban development, preserve farmland and greenspace, and reduce dependency on cars. Some of the specific tools described in the report include: special tax incentives, brownfield redevelopment, urban growth boundaries, various zoning techniques, protecting agricultural land, transfer of development rights, traffic calming, and pedestrian malls.

Monroe County is currently investigating urban sprawl concerns with the development of an urban sprawl task force and research team. This is a city/county cooperative effort that aims to identify urban sprawl problems and the associated costs to the community and environment within the County.

The 1991 Growth Policies Plan calls for a "more compact urban form" and the restraint of "outward spatial expansion"[26], but the density of the city has dropped approximately 15 percent since then. Despite the goals of the Growth Policies Plan, current city zoning ordinances encourage urban sprawl. Efforts to curb urban sprawl in Bloomington would not only improve the environmental and social aspects of the community, but would also save the city and its residents money.

d.) Linkages

Urban sprawl is linked to population growth, development, greenspace, stormwater runoff, transportation, employment, resource consumption, land quality, water quality and air quality.

4. Transportation

a.) Definition

The increase of traffic congestion in a city is an effect of population growth, development and dependence on automobiles. Original streets in city centers were not designed for the amount of traffic they now receive. While cars and trucks operate more efficiently today than 30 years ago, they remain major contributors to air pollution problems. From 1970 to 1999, vehicle miles traveled in the U.S. increased 140 percent.[27] Studies show that vehicle traffic is responsible for approximately 70 percent of carbon monoxide concentration levels in the nation and 90 percent of the concentration levels in urban areas.[28] Incomplete combustion of fossil fuels causes carbon monoxide concentration to increase, contributing to the formation of smog. On a global level vehicle emissions contribute to carbon dioxide in the atmosphere which traps

solar heat and accelerates the global warming process.

b.) Indicators

From 1990 to 1999, registered vehicles in Indiana increased from 4,624,591 to 5,625,264, or by 21.6 percent. In the same time period, vehicles registered in Monroe County increased by 40.8 percent, from 64,840 to 91,303 vehicles. Car registrations increased by 34.1 percent while truck registrations increased dramatically by 61.9 percent from 1990 to 1999 (See Figure 1.7). Over the last two decades, total motor vehicle registration (including motorcycles) in Monroe County increased from 58,586 to 91,303, a 56 percent increase.[29]

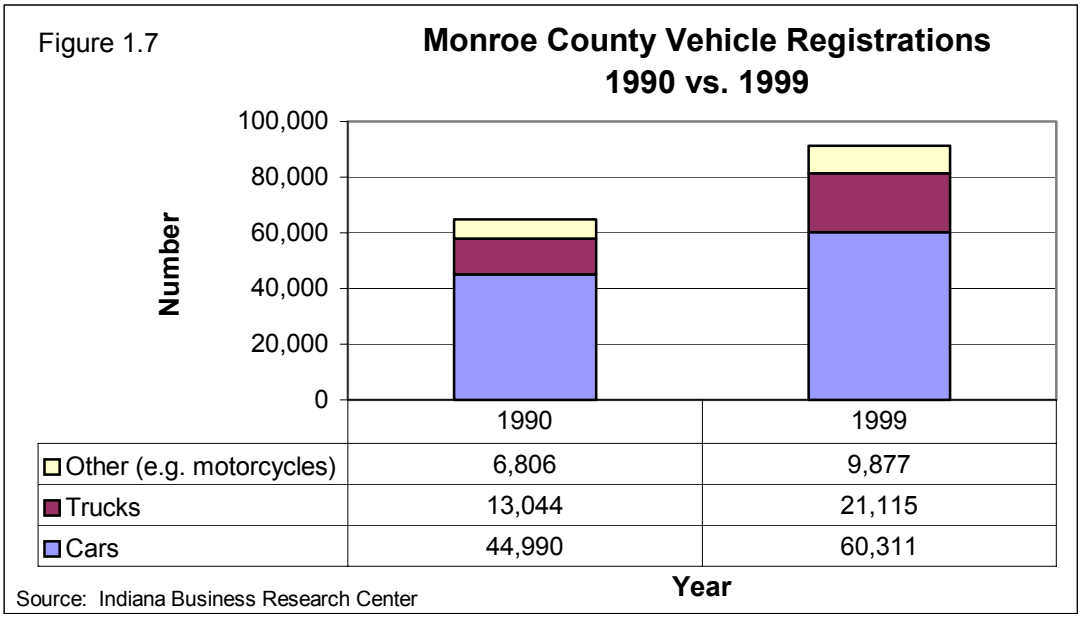
According to 1990 U.S. Census data, 71 percent of Monroe County residents drove alone to work. 12 percent carpooled and 10 percent walked while merely 4 percent used public transportation, bicycled or used another means (See Figure 1.8). In 1990, 59 percent of the Monroe County workforce had an average commute time of 10-25 minutes while about 6 percent of the workforce traveled between 45 to 90 minutes.[30] Forthcoming 2000 Census information will provide valuable comparison data. The Indiana Business Research Center reports that in 1998, 80 percent of the Monroe County workforce commuted from within the county, while 20 percent traveled from surrounding counties. This ratio of commuting patterns has remained relatively constant at 80 percent and 20 percent since 1990.[31]

Along with more people, homes and cars, Bloomington has more road miles to manage. Bloomington had 104 miles of road in 1972, the earliest year for such records. In 1990 the City had 157 road miles and in 2000 the City managed 197 road miles, a 25 percent increase. It is expected that in 2001, this figure will increase to 204 miles.[32]

Heavily traveled streets in Bloomington include: Whitehall Pike, S. Walnut, N. Walnut from E. 6th to E. 10th, S.R. 45/46 Bypass, S. College Mall Road, E. 3rd from S. Smith to S. College Mall Road, and E. 10th near Indiana University's main library. Current traffic volume on College Mall Road south of 2nd Street is nearly 19,000 vehicles per day.[33]

In 1998, Bloomington began construction on a series of transportation infrastructure projects, known as the Transportation 2000 Initiative. This $23 million group of projects includes vehicle and pedestrian infrastructure projects aimed at improving the City's transportation network. In 2000, the City completed work on one of the projects involving the intersections of 3rd, 5th and Adams Streets. The realignment was necessary to alleviate the congested

Figure 1.7

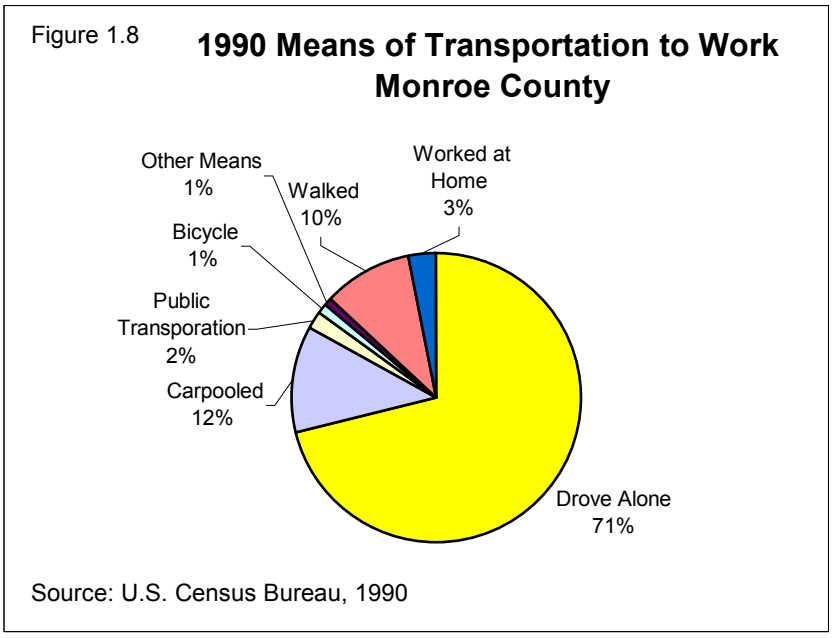


Source: Indiana Business Research Center

intersection and ease traffic flow from the downtown to the westside. Other completed projects include improvements made to Clarizz Boulevard and Patterson Road. Pedestrian projects that have been completed include the Kirkwood Avenue Streetscape. Sidewalks and crosswalks were widened to enhance pedestrian safety. The project was coordinated with storm water infrastructure improvements made under Kirkwood Avenue, Dunn Street and 6th Street. The city is also investigating the use of traffic calming devices to slow traffic and increase safety in residential neighborhoods. Such devices include traffic circles, speed humps, curb bulbs and well placed trees.

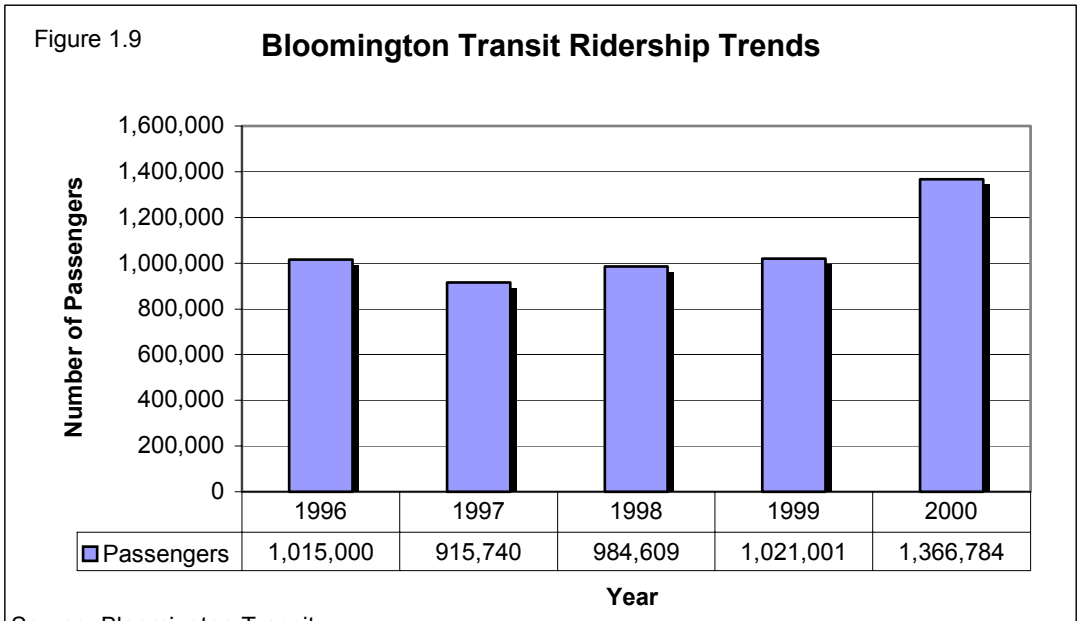
Two public transit systems serve Bloomington residents: Bloomington Transit (BT) and the Indiana University Campus Bus. From 1996 to 1999, Bloomington Transit ridership increased from 1,015,000 to 1,021,001

Figure 1.8



Source: U.S. Census Bureau, 1990

Figure 1.9



Source: Bloomington Transit
Personal Communication - Joe Lilly, Operations Mgr.

passengers. The ridership in 2000 increased to 1,366,784 passengers, an increase of 34 percent in just one year (See Figure 1.9). In 2000, Indiana University students were introduced to a pre-payment program that allowed them to ride BT busses using a valid school ID. The effect of this change was most evident in September 2000 when there was a 74 percent increase in ridership compared to September 1999.[34] The IU Campus Bus system had ridership of 1,888,492 for the 1999-2000 fiscal year. Since 1997, campus bus ridership has been fairly static.[35]

In 2000, the City expanded its range of alternative modes of transportation with the introduction of the Bike 'N' Ride Program. New bike racks installed on city buses encourage the combined use of public transport and bike riding. The program aims to help reduce traffic congestion and parking demand in the City. According to city maps, there are approximately 3.5 miles of bike lanes in the City. Walking and biking to work are options that only a small percentage of commuters use. Within IU's student population, however, a larger percentage choose these options due to parking shortages on campus, short trip distances, and budget constraints.

Indiana University began a carpool matching service in 1994 to reduce the traffic volume arriving on campus each day. Today, the program is still effective and has received steady use. The most successful matches have occurred among commuters traveling from outside the county.[36]

c.) Interpretation and Evaluation

Similar to patterns exhibited in the rest of the country, Bloomington residents have become increasingly dependent upon personal motorized transportation. The increase in car and truck registration from 1990-1999 is not just attributed to population growth. Monroe County's population grew by 7.3 percent while vehicle registration grew by 40.8 percent from 1990 to 1999. In Monroe County, per capita vehicle ownership has also risen. In 1990, vehicle ownership was 0.53 cars per person. In 1999, the figure increased to 0.70 vehicles per person. Truck (including sports utility vehicles) registrations surged since 1990 with a 62 percent increase. Truck and SUV's are not as fuel efficient as passenger cars. Therefore, increased truck numbers will negatively affect air quality. The increased use of automobiles by more people for longer periods has created clogged intersections within the City and County during commuting hours.

Other travel options exist for Bloomington commuters – such as carpooling and public transit. In Monroe County, only one-quarter of commuters used non-motorized transportation or shared a ride in 1990. Prior to the new IU student pre-paid public bus travel system, trends indicate that public transportation has not been entirely utilized by Bloomington residents. Between 1990 and 1999, bus ridership increased less than one percent. Although gas prices achieved record highs in the summer of 2000, city bus ridership did not increase as a result. This indicates that Bloomington residents did not turn to public transportation as an alternative to using their personal vehicles.[37] The IU campus bus ridership is largely dependent on the on-campus student population. Ridership remains fairly stable due to a stable on-campus student population.

The increased use of public transportation would alleviate congestion associated with continued population growth and help the city avoid air quality problems. The American Public Transit Association (APTA) emphasizes the importance of public transportation in easing traffic congestion. They estimate that one bus full of people is equivalent to a line of moving automobiles stretching six city blocks at 25 mph. APTA also estimates that per passenger mile a full bus emits only 20 percent of the carbon monoxide that a single-person automobile does.[38]

Bloomington is forced to manage traffic created by increased population and development. Projects undertaken in the Transportation 2000 Initiative to address the City's transportation needs are nearing completion. The need for more projects in the

future will be necessary to meet the demand of a growing city. The city's efforts to improve bike and pedestrian routes encourage residents to use alternative modes of transportation or change their travel patterns. Recently, the City has commissioned a private consultant to develop a Greenways Program that provides a network of pedestrian and bike paths throughout the city. The project aims to enhance the transportation alternatives of the City, utilize the downtown area, and reduce student auto traffic.

To decrease the negative effects of traffic in Bloomington, residents, major employers and city policy makers need to increase efforts to persuade people away from their cars. Over the long term, educational and marketing initiatives could be enhanced to encourage alternative transportation methods.

d.) Linkages

Transportation and its effects are linked to air quality, water quality, stormwater runoff, wildlife (increased accidents, habitat loss and fragmentation), noise levels, and loss of open space. Population growth and development determine trends in transportation and traffic.

5. Employment and Earnings

a.) Definition

At first glance, a strong economy and a clean environment may not seem to be connected. They are, however, inextricably linked. Theoretically, a community with a strong economic base and growing wages also has a strong tax base with which to fund environmental protection programs and a proactive educational system. Profitable manufacturing and agricultural operations are able to afford to alter production practices in the short run to prevent pollution in the long run. On the other hand, a profitable economy may stimulate increased consumption of goods and energy, thereby, creating more waste.

The President's Council on Sustainable Development addressed the relationship between the economy and the environment in its 1996 plan for "Sustainable America."

"An economy that creates good jobs and safeguards public health and the environment will be stronger and more resilient than one that does not. A country that protects its ecosystems and manages its natural resources wisely lays a far stronger base for future prosperity than one that carelessly uses assets and destroys its natural capital. Thinking narrowly about jobs, energy, transportation, housing or ecosystems – as if they were not connected – creates new problems even as it attempts to solve old ones."[39]

b.) Indicators

According to data collected by the Bureau of Economic Analysis, the unemployment rate and earnings indicate that the Monroe County's economy continues to grow. The nominal per capita personal income (PCPI) for Monroe County residents increased by 65 percent, or $8,890 between 1988 and 1998 (See Figure 1.10). The average annual growth rate of PCPI during this period was 5.1 percent, higher than the average annual growth rate of PCPI for the state which was 4.6 percent. However, Monroe County's 1998 PCPI remains below the state PCPI of $25,163 (See Figure 1.11). Nominal total personal income (TPI) in Monroe County grew by 82 percent with an average annual growth rate 6.2 percent. Total personal income includes earnings, dividends, interest, and rent. Earnings comprised 68 percent of the 1998 TPI in Monroe County.[40]

Figure 1.10

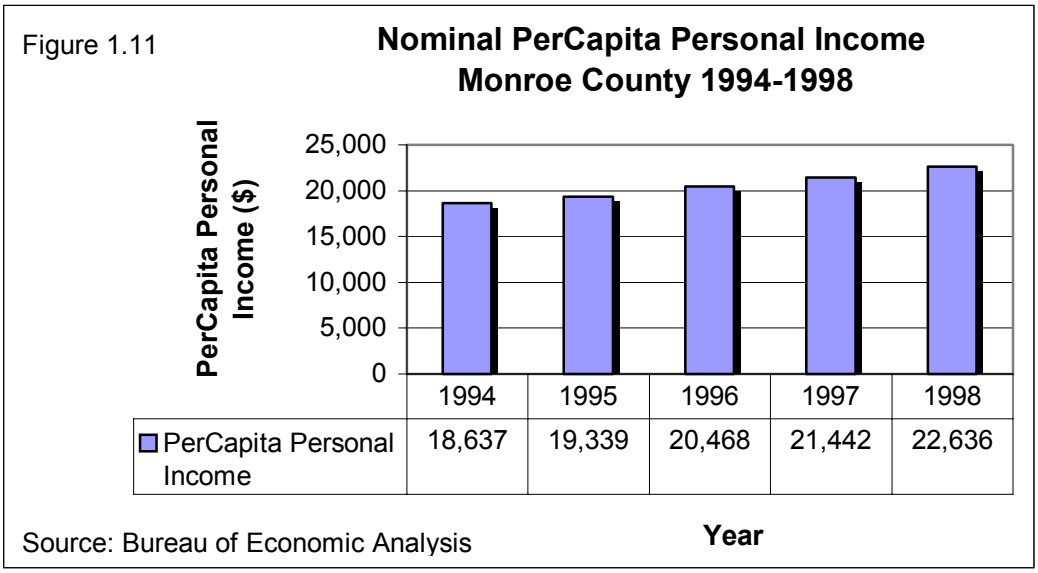
Bloomington Per Capita and Total Personal Income (Nominal)				
	Per Capita		Total	
Year	Nominal $	Annual Average	Nominal ($000)	Average Annual
1988	$13,746	Nominal Growth Rate	$1,447,831	Growth Rate
1998	$22,636	5.10%	$2,638,689	6.20%

Source: Bureau of Economic Analysis

Earnings in each industry sector, with the exception of mining, grew in Monroe County from 1994-1998 (See Figure 1.12). The largest industries were state and local government, services, and durable goods manufacturing. The services industry grew the fastest of all sectors from 1988-1998 at an annual growth rate of 8.0 percent.[41]

For the past two years, the unemployment rate in Indiana has remained very low. Figures recently released by the Indiana Department of Workforce Development revealed a statewide unemployment rate of 2.4 percent – the seventh lowest in the nation. By comparison, the unemployment rate for the U.S. was 3.8 percent. In the Indianapolis area, the rate reached a low of 1.8 percent.[42] The Bloomington Metropolitan Statistical Area (MSA), showed a decrease in the unemployment rate to 2.3 percent in 1999. This is a decline of 2 percentage points since a high of 4.3 percent observed in 1994.[43] (See Figure 1.13)

Figure 1.11



Source: Bureau of Economic Analysis

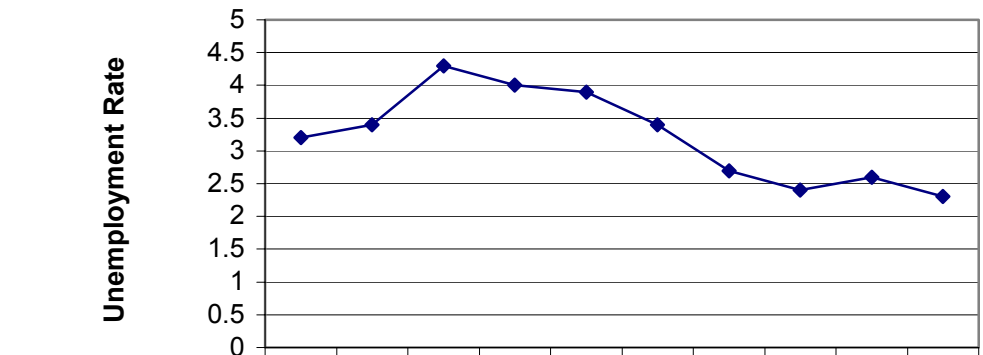
Figure 1.12

Monroe County
Nominal Earnings by Industry (Thousands of Dollars)

	1994	1995	1996	1997	1998
Farm Earnings	648	-490	591	1,474	1,866
Nonfarm earnings	1,622,784	1,688,439	1,781,606	1,874,565	1,993,763
Private earnings	1,136,047	1,169,182,	1,229,338	1,297,046	1,385,722
Ag. Services	7,089	7,642	8,560	9,033	10,000
Mining	8,511	8,210	7,993	9,004	8,983
Construction	103,683	104,133	111,199	112,953	115,307
Manufacturing	332,391	336,728	343,892	369,428	391,637
Transporation and public utilities	66,573	68,079	72,508	74,970	79,182
Wholesale trade	45,940	45,153	49,239	55,772	65,981
Retail trade	174,908	175,327	178,365	185,120	193,154
Finance, insurance and real estate	70,619	78,767	87,931	94,533	98,823
Services	326,333	345,143	369,651	386,233	422,655
Government	486,737	519,257	552,268	577,519	608,041

Source: Bureau of Economic Analysis

Figure 1.13



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Unemployment Rate	3.2	3.4	4.3	4.0	3.9	3.4	2.7	2.4	2.6	2.3

Year

Source: Bureau of Economic Analysis

*MSA - Metropolitan Statistical Area, includes areas outside of city limits

The Indiana Business Research Center notes that the state economy will continue its growth. Recent forecasts indicate economic growth in the upcoming year will occur at a slower pace than in the past two years. However, Indiana's economic recovery that began in 1991 will continue into its eleventh year.[44]

c.) Interpretation and Evaluation

The most recent data indicates that Bloomington and Monroe County have a healthy economy. This is expected as Indiana and the nation experiences a strong economy.

The cost of living in Bloomington remains below national averages. Bloomington often appears on "best city" lists due to the city's strong business community, education, and low cost of living. Bloomington continues to attract new business as well. In 2001, the City will join the high-technology business community when it welcomes the Telecommerce Center to the downtown district. Announced in June 2000, the Telecommerce Center will provide a location for internet firms and telecommunication companies.[45]

Bloomington's goals include maintaining a strong and growing economy to ensure long-term prosperity of the business community. The quality of Bloomington's environment, culture, and recreational activities attract new business to the area. A healthy economy allows the public and the business community to focus on long-term goals and make changes to consumption and disposal habits to help protect Bloomington's valuable characteristics and natural resources.

d). Linkages

Economic growth and wages are linked to population growth, development, natural resources, and waste management.

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II. Energy

Introduction

Worldwide energy consumption increased by 84 percent from 1970 to 1997.[1] During the same period, U.S. energy consumption increased by 42 percent, from 66.43 to 94.21 quadrillion BTUs.[2] The United States accounts for approximately 25 percent of the world's energy consumption. In the period from 1997 to 2020, worldwide energy consumption is projected to increase an additional 60 percent, from 380 to 608 quadrillion BTUs. A significant portion of the projected increase in energy demand will come from developing nations. Oil is expected to remain the world's primary energy source through 2020 by maintaining a 39 percent share of global energy consumption. Worldwide demand for oil is expected to reach approximately 113 million barrels per day by 2020. [3]

The use of renewable energy sources, including hydroelectric power, is not expected to increase significantly in the next 20 years. The International Energy Outlook projects a 54 percent increase in global renewable resource consumption from 1997 to 2020. This increase in renewable energy consumption will merely maintain its 8 percent share of the world's energy consumption in the next two decades. In the United States, renewable energy use is expected to increase from 0.8 quadrillion BTUs to 1.7 quadrillion BTUs from 1997 to 2020. Wind-power has exhibited the greatest increase of use as a renewable energy source in industrialized countries with approximately 13,400 megawatts generating capacity in 1999.[4]

The rising demand for energy has largely been met by increased burning of fossil fuel sources such as oil, coal, and natural gas. Carbon dioxide, a greenhouse gas that contributes to global warming, results from the burning of fossil fuels. In the U.S, carbon dioxide emissions increased by 11 percent in from 1990 to 1997. Atmospheric carbon dioxide concentrations have increased by 29.6 percent since the Industrial Revolution occurred in the 1880s.[5] From 1997 to 2020, worldwide carbon emissions are expected to increase by 61 percent, from 6.2 to 10 billion metric tons. Natural gas is increasingly being used as a fuel source in industrialized countries because gas-fired energy plants are more efficient and produce less air pollution than other fossil-fuel burning plants.[6]

Bloomington's Energy Consumption

a.) Definition

Electricity used in Indiana generally originates at coal-burning plants scattered throughout the region. The plants are interconnected via a "grid" making it difficult to pinpoint the exact source of local electricity at any given time. However, much of the electricity used in this region originates at a coal-fired plant near Evansville. Natural gas pipelines also provide energy for uses such as heating. The Indiana University Physical Plant operates its own coal-fired energy plant in conjunction with natural gas fired boilers to generate energy for the University.

b.) Indicators

Bloomington residents obtain electricity from PSI/Cinergy and natural gas from Indiana Gas-Vectren Corporation. Indiana University's Physical Plant provides electricity and heat to most of the buildings on campus.

Electricity use in the Bloomington area, which includes Ellettsville, rose in recent years due to increased residential and commercial demand. Since 1995, residential electricity consumption increased 11 percent, from 209,571 to 232,771 total megawatt hours (MWH). Commercial use also increased during this period from 466,551 to 510,864 MWH, a 9.5 percent increase. However, industrial use declined by 50 percent from 1995 to 1999. In 1999, total consumption from industrial, residential, and commercial customers in the local area was 778,309 megawatt hours[7] (See Figure 2.1). Indiana University's electricity consumption has decreased 5.8 percent in recent years. Use during the 1995-1996 fiscal year totaled 5,112 MWH and 4,814 MWH during the 1997-1998 fiscal year[8] (See Figure 2.2).

Reporting system changes at Indiana Gas prevents data comparison prior to 1996. The available data obtained from the Indiana Gas Corporation shows a decrease in gas consumption from 1996 to 1998 in all

Figure 2.1

Bloomington Electricity Usage - Total Megawatt Hours (MWH)				
Year	Residential	Commercial	Industrial	Total*
1990	183,145	401,582	61,386	646,113
1991	197,030	419,223	61,212	677,465
1992	184,566	417,835	64,902	667,303
1993	202,565	436,048	67,589	706,202
1994	204,813	448,949	66,476	720,238
1995	209,571	466,551	68,839	744,961
1996	216,525	469,952	59,477	745,954
1997	*Data not available*			
1998	218,329	497,479	47,977	763,785
1999	232,771	510,864	34,674	778,309

Source: PSI/Cinergy -Personal Communication Marvin Peters

*Total does not include street lighting

Note: Direct comparisons cannot be made between the 1990-1994 data and the 1995-2000 data due to changes in data reporting by the company.

Figure 2.2

Indiana University Natural Gas and Electricity Consumption		
Fiscal Year	Gas Consumption - Total Therms	Electricity - Megawatt Hours (MWH)
95-96	4,965,235	5,112
96-97	5,153,744	4,859
97-98	4,431,931	4,814

Source: IU Physical Plant, Annual Operations Report

customer sectors (See Figure 2.3). The greatest decline occurred in the industrial sector with a 25.7 percent decrease in gas consumption from 1996 to 1998.

Indiana University's natural gas consumption has declined 11 percent during the 1995-1998 period (See Figure 2.2). Coal consumption by Indiana University has remained relatively stable from 1990 to 1998 [9] (See Figure 2.4).

The IU Physical Plant uses both high sulfur bituminous coal and natural gas to heat the campus during the winter months. The plant has significantly reduced its reliance on coal since the 1970s when it burned nearly 100,000 tons annually. The plant now burns between 50,000 and 60,000 tons of coal each year.[10]

In 1999, the City of Bloomington began an Energy Savings Project to improve the efficiency of city facilities and reduce costs while benefiting the environment through energy conservation. The city retrofitted light fixtures, installed high efficiency thermostats and replaced furnaces. Over the next ten years, the efficiency improvements are projected to save the city $256,000. From November 1999 to June 2000, savings of nearly $30,000 were realized.[11]

c.) Interpretation and Evaluation

Many factors contribute to the difficulty of identifying local energy consumption trends. Weather tends to be a major determining factor in annual energy use. Both PSI/Cinergy and Indiana Gas altered their methods for calculating and reporting energy usage, making data incomparable between years. The overall increasing trend in electricity usage may be due to population growth, increased use per person, or a combination of the two. The reduction in industrial use can be attributed to the closure of major industrial companies in the local area in recent years. According to previously reported economic trends, the local economic base has shown a shift from industrial to service-orientated business.

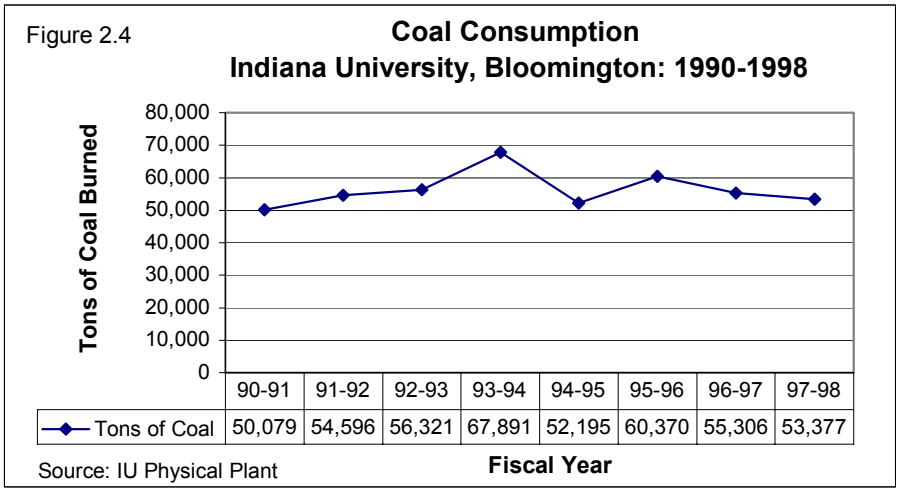
Electricity data from Indiana University indicates a trend of declining electricity usage. This can be attributed to efforts to increase energy efficiency on campus. On-going air

Figure 2.3

Bloomington Natural Gas Consumption (Dth)				
Year	Residential	Commercial	Industrial	Total
1996	2,284,734.0	1,314,667.4	774,425.5	6,447,549.1
1997	2,245,297.2	1,240,345.1	680,982.2	4,166,624.5
1998	1,917,517.9	1,122,937.7	574,848.8	3,615,304.4

Source: Indiana Gas

Figure 2.4



Source: IU Physical Plant

conditioning upgrades contribute to increased energy efficiency. Also, the university has made lighting improvements and replaced windows throughout the campus in recent years. Other energy reduction efforts include upgrading four of the steam plant's six burners to burn natural gas as well as coal. There is, however, conflict between energy efficiency improvements and indoor air quality upgrades. Indoor air quality enhancements such as winter-time humidification and fresh air integration require a substantial amount of energy and diminish the positive effects associated with efficiency upgrades.[12]

IU's long-term goal is to further reduce coal consumption and increase use of natural gas as an energy source. Although it is not as cost-effective, natural gas boiler systems are more energy efficient. Natural gas can cost up to 3 times as much as using coal for energy generation. The percentage of natural gas versus coal use is dependent on weather, gas prices, and budget constraints. During this past winter season (2000-01), Indiana University has increased its coal use due to high natural gas prices and a cold winter season.[13]

d.) Linkages

Energy use and production are linked to air quality, global warming, waste generation, water quality, and natural resource depletion. Energy consumption may also be linked to economic factors such as per capita income. An increase in per capita income may prompt an increase in energy consumption as people can afford it. Population growth and development may also increase the energy demand of the community.

[1]International Energy Outlook 2000; U.S Dept. of Energy; http://www.eia.doe.gov/oiaf/ieo/index.html; accessed 2001.
[2]U.S. Census Bureau. *Statistical Abstract of the U.S.: 1999*; Washington DC, 1999.
[3]International Energy Outlook 2000
[4] Ibid.
[5] Brown, Lester. State of the World: 1999; Worldwatch Institute, W.W. Norton & co., NY; 1999.
[6] International Energy Outlook 2000.
[7] Peters, Marvin, PSI/Cinergy. Personal communication, November 2000.
[8] Indiana University Physical Plant, Annual Operations Reports
[9] Ibid.
[10] Matson, Charles. Indiana University Physical Plant. Personal communication; 1997, 2000.
[11] City of Bloomington; http://www.city.bloomington.in.us/mayor/news_releases/2000/1020b.htm; accessed January 2001.
[12] Matson, Charles; 2000.
[13] Ibid.

III. Waste Management

Introduction

In 1997, Americans generated 217 million tons of municipal solid waste. This amounts to 4.4 pounds of garbage per person per day. Of the solid waste generated, paper and paperboard comprises 38.6 percent, yard waste 12.8 percent, food waste 10.1 percent, plastics 9.9 percent and metals 7.7 percent. Of the waste generated in 1997, 28 percent or 60.8 million tons was recycled. This is an increase from the amount recovered in 1980 when just 9.6 percent, or 14.5 million tons of waste was recovered through recycling. Waste recycled per person increased from 0.35 to 1.2 pounds per day between 1980 to 1997.[1]

By managing municipal waste, we address potential pollution problems. Source reduction and waste recycling can substantially reduce the generation of solid waste. Recycling prevents the emission of greenhouse gases into the air, saves energy, and supplies raw material to industry. In 1996, solid waste recycling prevented the emission of 33 million tons of carbon into the air.[2]

Hazardous waste generation, disposal, and clean-up are carefully monitored by the EPA through laws such as the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), and the Superfund Act. In the U.S. approximately 20,000 hazardous waste generators produced 279 million tons of hazardous wastes regulated by RCRA in 1995.[3] Improperly disposed hazardous and harmful wastes caused the contamination of thousands of sites throughout the United States. The most contaminated sites are listed on the National Priorities List as "Superfund" sites. In 1998, Indiana ranked 13th in the U.S. for the greatest number of Superfund sites with 30.[4] As of 1998, 1,245 sites were on the National Priorities List.[5]

1. Solid Waste and Recycling

a.) Definition

Solid waste is generally comprised of municipal waste – everyday trash such as food scraps, packaging, bottles, and paper materials – but it may also include construction materials and yard waste. The disposal of waste requires the use of land to bury it or an incinerator to burn it. Landfill and incinerator operations must meet all federal design and operating regulations. The volume of solid waste produced reflects, to a certain extent, the consumption and disposal of resources in Bloomington.

Improper disposal of harmful waste into landfills may result in contamination of soil or groundwater, or cause health problems to landfill employees and nearby residents. Harmful waste channeled to an incinerator not capable of treating it can result in dangerous air emissions. Modern landfill and incinerator designs and operation practices have been developed to minimize these environmental and health risks.

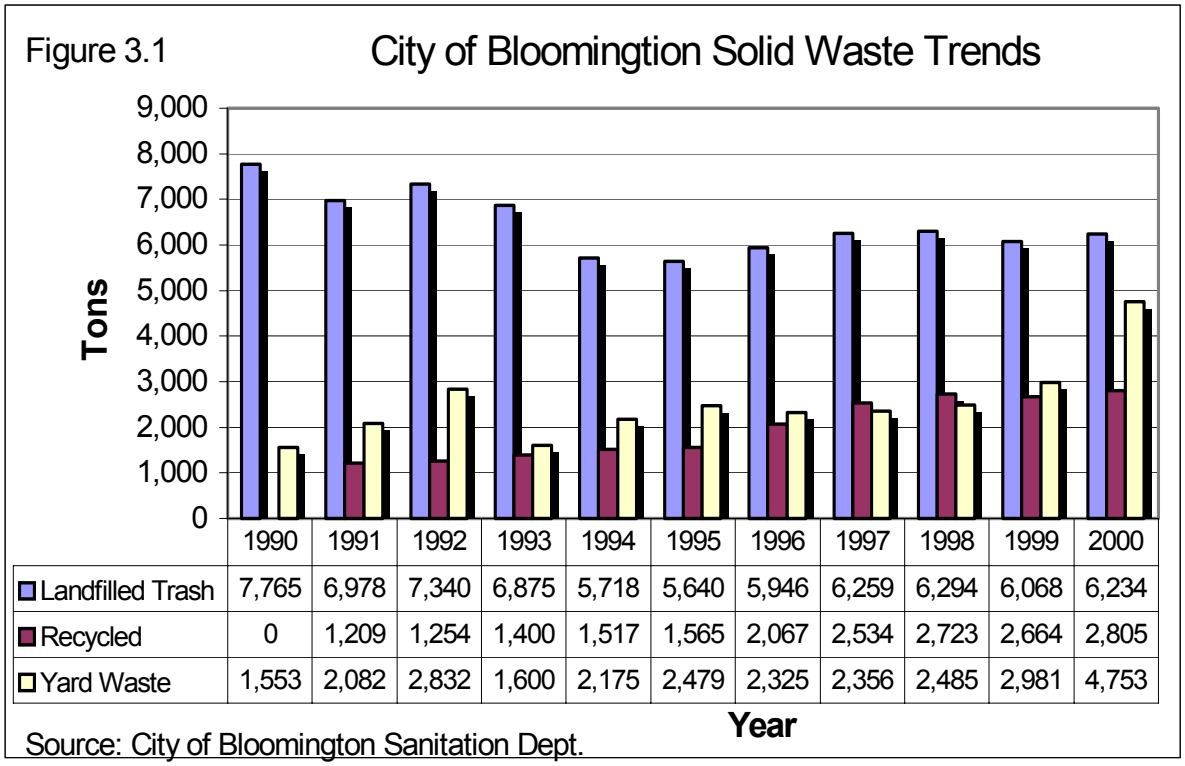
Programs to recycle materials, deter pollution, reduce waste, and reuse products reduce the need to build more landfills or treat hazardous waste. They also reduce the need to manufacture materials or products whose production process can harm the environment. Recycling precludes using additional renewable and non-renewable resources such as trees and petroleum products. In the long run, participation in such programs will reduce environmental and/or social costs as well as economic costs.

b.) Indicators

The City of Bloomington Sanitation Department collects residential solid waste, yard waste, and recyclable material within city limits. City crews take more than 90 percent of the municipal waste collected to the Monroe County Landfill, located north of Bloomington on Anderson Road. The Monroe County Solid Waste Management District operates the landfill as well as several drop-off sites in the county.

In 1991, Bloomington began a voluntary curbside recycling program. City crews pick

Figure 3.1



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Landfilled Trash	7,765	6,978	7,340	6,875	5,718	5,640	5,946	6,259	6,294	6,068	6,234
Recycled	0	1,209	1,254	1,400	1,517	1,565	2,067	2,534	2,723	2,664	2,805
Yard Waste	1,553	2,082	2,832	1,600	2,175	2,479	2,325	2,356	2,485	2,981	4,753

Source: City of Bloomington Sanitation Dept.

up mixed paper, plastic bottles, glass, aluminum, and steel cans every other week. Residents can also drop off recyclables at the Monroe County Central Station and other drop off sites throughout the county.

Bloomington residents pay a $1 fee per 32-gallon (40-pound) trashcan for curbside trash pickup and $0.25 per bag of yard waste. Residents attach a color-coded tag to each can or bag ready for pick up. No tags are necessary for curbside recycling. The city sales of trash tags totaled $510,429 in 1999, compared with $496,209 in 1994, the first full year of the tag program.[6] The Monroe County Solid Waste District operates a similar trash bag program at four drop off sites in the county.

The Bloomington Department of Sanitation serviced 12,187 households in 2000.[7] In the same year, 6,234 tons of municipal waste were collected and landfilled, a 19.7 percent decrease since 1990[8] (See Figure 3.1). Based on this data each household in Bloomington serviced by the city's sanitation program landfilled approximately 1,023 pounds of waste in 2000.

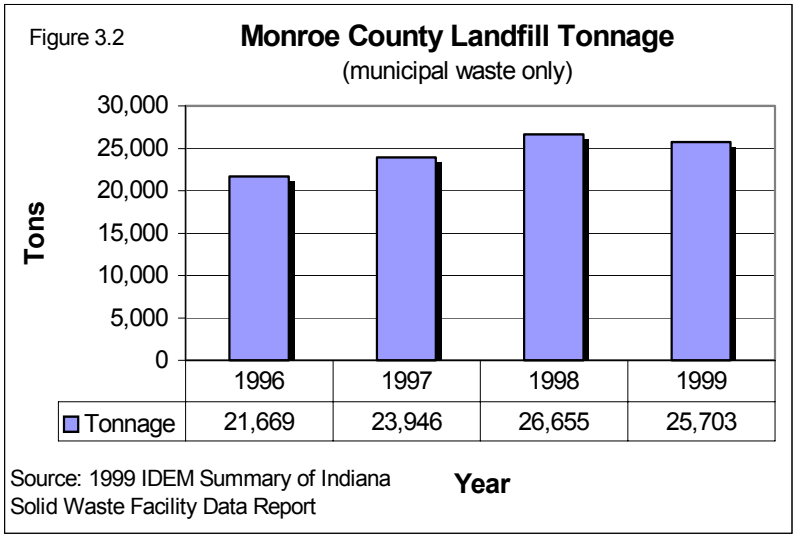
The amount of recycled waste increased from 1,209 to 2,805 tons, or 132 percent, since the city recycling program began in 1991.[9] Although recycling has increased in the last decade, the total amount of waste collected has increased 48 percent, from 9,318 tons in 1990 to 13,792 tons in 2000 (See Figure 3.1).

From 1996 to 1999, state records indicate that the total amount of municipal waste disposed at the Monroe County landfill increased by 18.6 percent[11] (See Figure 3.2). Currently, the Monroe County Landfill receives about 100 tons per day of municipal waste, drop-off waste, construction and destruction debris. About 37.5 percent of the landfill waste is made up of paper or paperboard, 17.9 percent is yard waste, and 11.5 percent is rubber, textiles and wood.[12] With recent upgrades, officials expect the Monroe County landfill facility to serve the community for the next 60 years.[13]

Private waste disposal companies also transport and dispose of solid waste generated in the city and county. Some of this waste goes to the Monroe County landfill and a portion is transported out of the county. For example, the Rumpke transfer station collected a total of 61,917 tons of municipal waste and 7,180 tons of construction and demolition waste in 1999. 91.5 percent of the waste collected at Rumpke originated from Monroe County. All the waste collected by Rumpke went to their privately-owned landfill in Greene County.[14]

IDEM's Office of Land Quality estimates the total amount of waste generated in each county based on point of origin reports. From 1991 to 1999, it is estimated that the amount of solid waste generated in Monroe County increased 34 percent, from 100,932 to 134,747 tons[15] (See Figure 3.3).

Figure 3.2



Source: 1999 IDEM Summary of Indiana Solid Waste Facility Data Report

Indiana University's waste disposal system operates independently from the City's sanitation services. Indiana University disposed of approximately 45,000 total tons of solid waste from 1990-1999. More than 80 percent of the waste is transported to the Monroe County landfill. The Indiana University recycling program began in 1990 and currently diverts 22-25 percent of the total waste generated each year from landfilling. An average of 150 tons of waste is recycled per month.[16]

This past year, Bloomington received the 2000 Governor's Award Honorable Mention for excellence in recycling with a 49 percent residential participation rate. Participation is encouraged because residents can save money in trash tags by recycling more waste material. In addition, the amount of solid waste that was diverted from the Monroe County Landfill from 1996-1999 saved the city $553,712 in landfill fees.

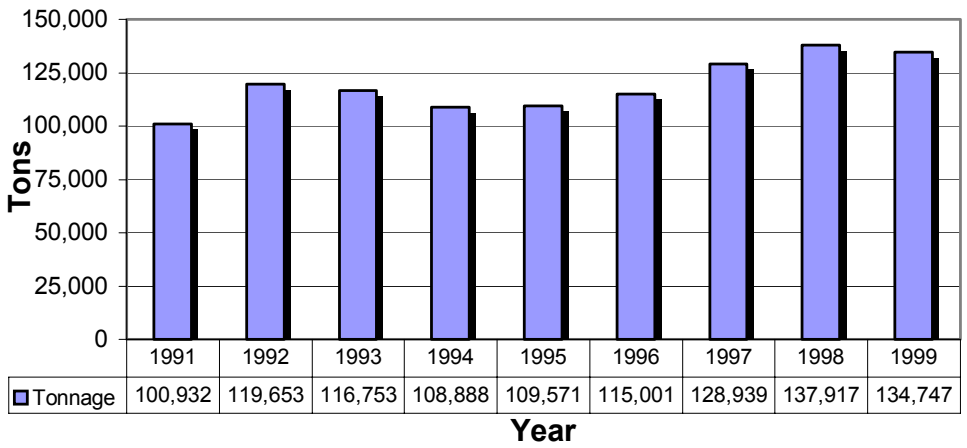
c.) Interpretation and Evaluation

Quantifying how much solid waste a community generates is difficult because of different collection systems, waste streams, and reporting methods. The solid waste figures reported by the Bloomington Sanitation Department do not represent all the waste generated in Bloomington, only the amount that the city collects. For example, many apartment complexes employ private waste companies to dispose of residents' waste. Similarly, not all of the waste collected in the City is transported to the Monroe County Landfill. The Rumpke Transfer Station collects a large amount of waste from Monroe County that is transported out of the County. Although these waste generation and disposal streams are difficult to track, available data can be used as indicators of waste trends.

According to data from the Bloomington Sanitation Department, the amount of trash that is landfilled has decreased by almost 20 percent in the last decade despite a 14 percent increase in population. Much of this decrease can be attributed to the success of the voluntary curbside recycling program. The amount of waste that is recycled has more than doubled since the program's inception in 1991. Although recycling rates have improved, the total amount of waste collected in Bloomington has increased. This can be attributed to the increase in population, the expansion of City limits from annexations, and an increase in per capita waste generation. The City's Sanitation Department reports an increase in per capita waste generation to 0.039 tons in 2000.

Due to the population growth of the city and county, the amount of waste generated in the

Figure 3.3



Source: 1999 IDEM Summary of Indiana Solid Waste Facility Data Report

region is inevitably increasing. Bloomington's residents have been successful in increasing the proportion of waste that is recycled each year but, overall, data indicates that they are generating more waste each year.

Many commercial locations and apartment complexes use private companies to dispose their solid waste. Therefore, the actual amount of waste generated in Bloomington is higher than the figures recorded by the City Sanitation Department. Many apartment complexes in Bloomington do not participate in recycling programs due to higher costs. The opportunity exists to reduce landfill disposal by pursuing ways to encourage apartment complexes to employ recycling practices.

Similar to the observed increasing trends in waste generation, the Monroe County Landfill experienced an increase in the amount of landfilled municipal waste from 1996-1999. The County landfill receives waste from many sources throughout the county including private disposal services and drop off waste, therefore these figures may indicate overall increasing regional trends in waste disposal. County estimates made by IDEM also indicate that solid waste generation has risen since 1991. This may be, in part, attributed to the increase in Monroe County population during this period and increasing per capita waste generation.

The Rumpke transfer station collected 69,097 tons of waste in 1999, 91.5 percent of which originated in Monroe County. Therefore, approximately 63,000 tons of waste generated in Monroe County was transported out of the county through the Rumpke transfer station. The Monroe County landfill collected a total of 26,089 tons of waste (municipal *and* non-municipal) in 1999.[17] This means that most of Monroe County's waste is transported out of the County for disposal rather than landfilled at the Monroe County landfill.

Indiana University relies on its recycling system to reduce campus solid waste generation. Recycling receptacles are placed throughout campus. IU is continually working to improve the cost-effectiveness of the program by working with local recycling agencies.

These data sources point to an overall increase in waste generation and disposal in the region despite positive trends in recycling programs. Bloomington residents should be aware of the amount of waste they produce and consider where it ultimately goes for disposal. Decreasing the amount of waste that residents produce will minimize environmental and economic costs to the community.

There are opportunities to further reduce the amount of waste that is landfilled. For example, nearly 38 percent of the landfill waste is paper and paperboard – a readily recyclable and reusable material. Also, the recycling program participation rate could be raised beyond 49 percent. The amount of material recycled needs to continue its upward trend and alternative waste reduction and disposal initiatives should be continually investigated. Bloomington and Monroe County are currently making efforts to improve the solid waste system and to ensure that solid waste is handled properly.

d.) Linkages

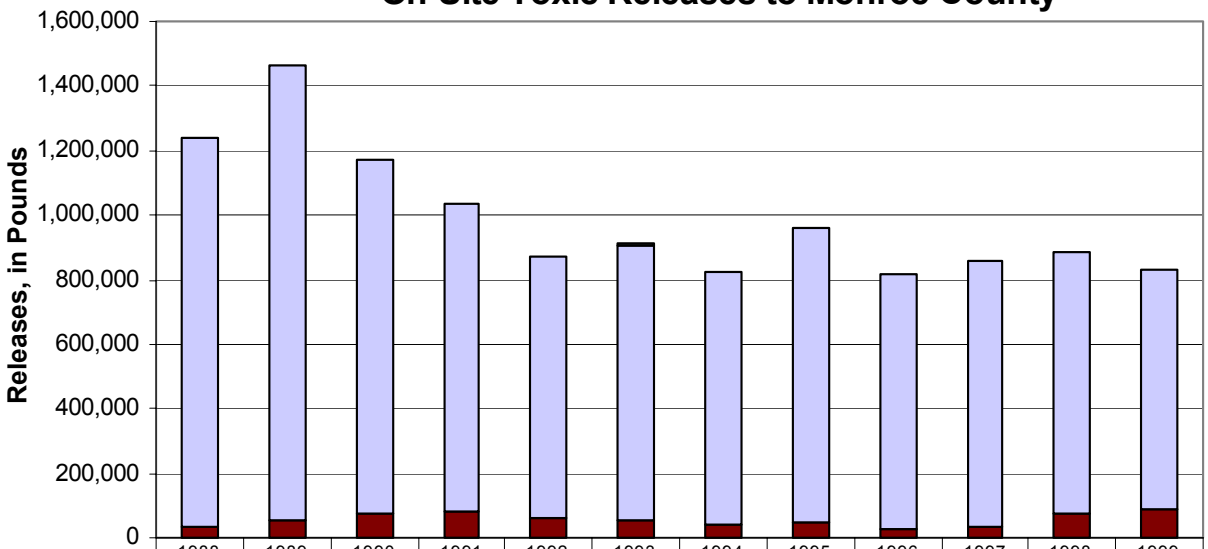
Solid waste is linked to land quality, groundwater contamination, air pollution, public health, recycling and energy use. Population growth and consumption rates determine solid waste production. Poor trash disposal practices decrease a community's quality of life and the quality of the surrounding environment.

2. Hazardous Materials and Waste

a.) Definition

Because of their toxicity to human health, certain wastes are classified as hazardous under federal law. Several federal laws govern the disposal and clean up of designated hazardous waste. The three main laws include: the Resource Conservation and Recovery Act

Figure 3.4



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Releases to Land	0	0	0	0	0	1,040	15	20	15	117	0	0
Surface Water Discharges	292	792	270	10	75	0	0	0	0	0	1,000	1,000
Stack Air	1,206,134	1,412,936	1,090,137	953,043	807,010	854,958	783,169	912,649	786,001	822,811	812,826	742,599
Fugitive Air	35,160	51,715	77,858	82,828	62,374	53,971	42,407	46,976	28,508	35,716	74,603	87,559

Source: USEPA Toxic Release Inventory

(RCRA), the Toxic Substances Control Act (TSCA), and the Superfund law (also known as the Comprehensive Environmental Recovery Compensation and Liability Act). Hazardous waste can persist or migrate when released untreated into the environment, creating health risks for people and wildlife many years into the future. The term "hazardous waste" applies to waste that is ignitable, corrosive, reactive, and explosive or contains a certain amount of toxic chemicals.

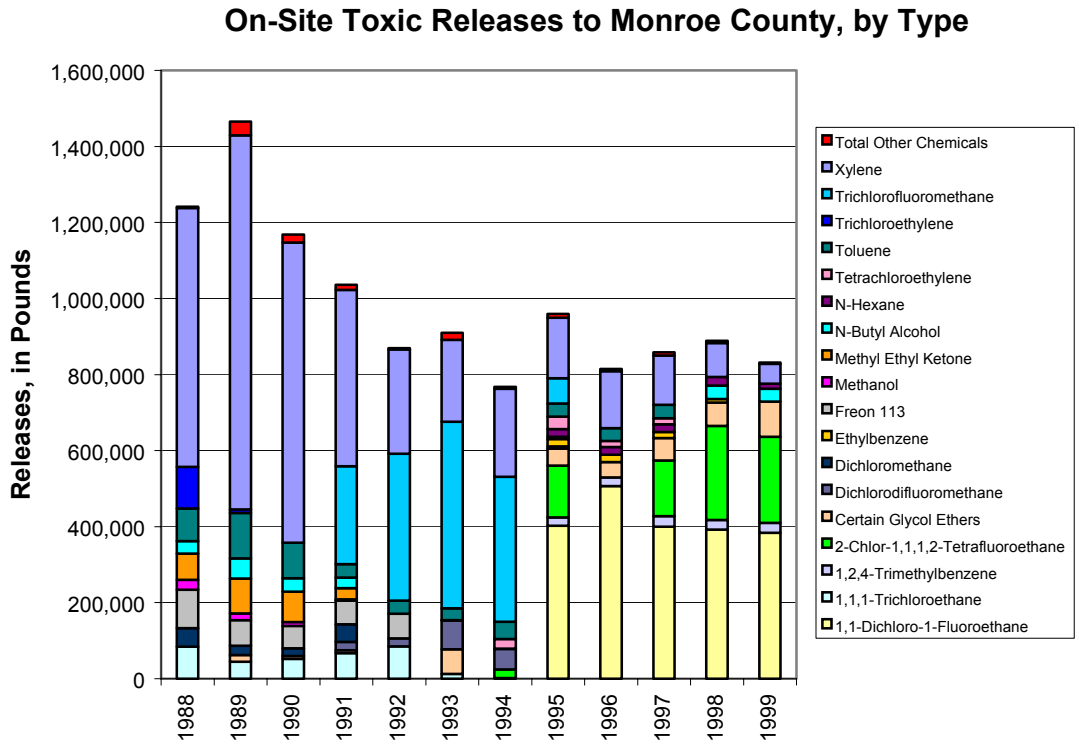
Examples of hazardous waste include banned pesticides, known carcinogens, waste solvents from industrial plants, and radioactive substances. Commonly found household hazardous wastes include many strong household cleaners, used motor oil, spent batteries, antifreeze, and pesticides.

Each year the EPA publishes the Toxic Release Inventory (TRI) as mandated by the federal Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986. Congress passed the law to give citizens information about the toxic substances released in their community every day. The TRI provides the public, industry, and government with key environmental data. Private manufacturers that use or emit one or more of the 650 listed chemicals must report how much they release to the air, land or water. The EPA required facilities to submit release data by June 2000 for the 1999 TRI report, published in April 2001.

A number of revisions to the TRI have occurred since its inception. In 1995 the EPA added 300 new chemicals to the list of TRI reportable chemicals. Of these, 20 compounds were reported in Indiana. In 1998, the EPA added seven new industrial sectors that must annually report toxic releases. These newly reporting industries included metal mining, coal mining and electric utilities. Due to this change, the number of reporting facilities in Indiana increased from 1004 in 1997 to 1074 in 1998. In Indiana, electric utilities were most significant as they accounted for 97 percent of reported releases for the newly reporting industrial sectors in 1998.[18]

Many non-industrial sources and small businesses are not required to report toxic

Figure 3.5



Source: USEPA Toxic Release Inventory

releases for the TRI. For example, the TRI does not account for auto emissions or non-point source releases of pesticides and fertilizers. Thus, the number of toxic substances released to the environment is actually higher than reported by the TRI.

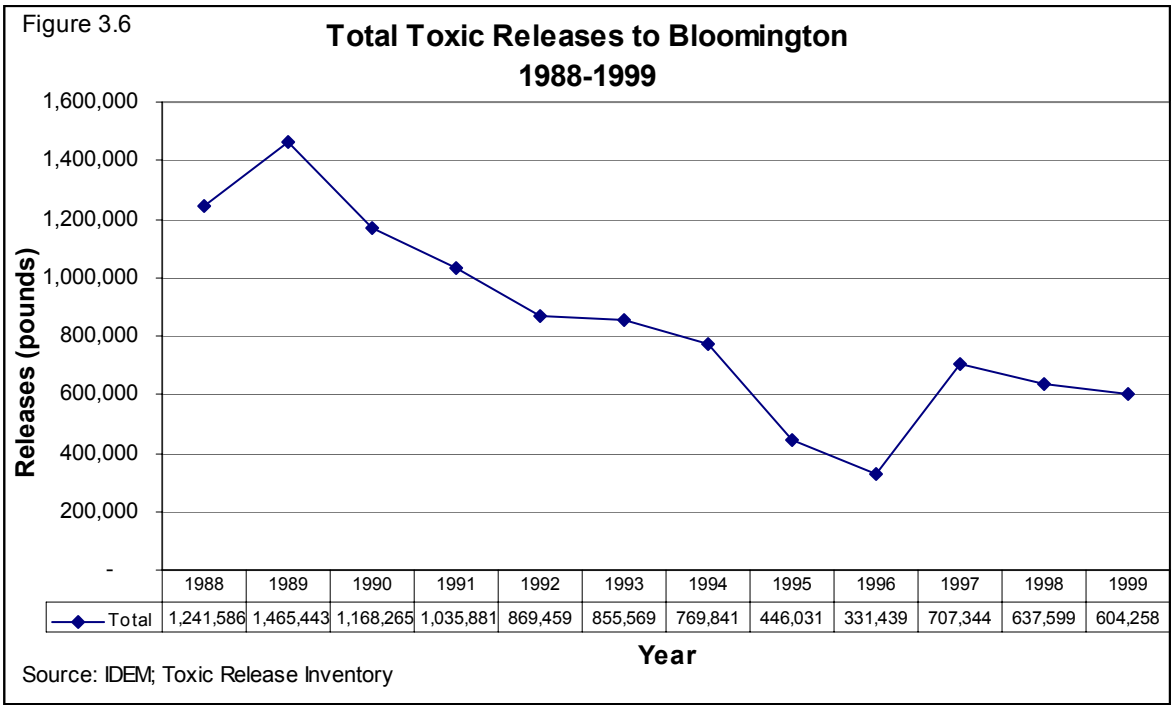
b.) Indicators

In the United States, TRI-reportable toxic releases have decreased by 1.5 billion pounds or 45.5 percent since 1988. In Indiana, over 198 million pounds of toxic materials were released on and off-site in 1999, ranking Indiana ninth in the nation for total amount released. This represented a 4.7 percent increase since 1998. Newly-designated industrial sources accounted for 73 million pounds, or 37 percent, of the total releases in 1999.[19] Releases to the air accounted for over 71.5 percent of the total on-site toxic releases in Indiana.[20]

From 1988 to 1997 (prior to the inclusion of newly designated industrial sources), Indiana manufacturers decreased their toxic on-site releases to the environment by 69 percent (from 190 million pounds in 1988 to 59 million pounds in 1997) according to IDEM's 1999 Pollution Prevention and Toxic Release Inventory Annual Report. The addition of the new industrial sectors to the TRI resulted in a 75 percent increase in reported on-site releases from 1997 to 1998.[21]

Data from the TRI show that facilities in Monroe County reduced their toxic releases by 31 percent from 1988 to 1997. From 1997 to 1999, toxic releases in Monroe County increased 3.2 percent (See Figure 3.4). The vast majority of toxic releases in Monroe County occurred to the atmosphere. Chemicals comprising the largest percentage of those released to Monroe County in 1999 include 1,1-Dichloro-1-Fluoroethane, 2-Chloro-1,1,1,2-Tetrafluoroethane, and xylene (See Figure 3.5). 1,1-Dichloro-1-Fluoroethane is a possible neurotoxicant and has the potential to deplete ozone. Xylene, commonly used to manufacture consumer and pesticide

Figure 3.6



Source: IDEM; Toxic Release Inventory

products, is a human toxicant to the major organs and can affect the central nervous system.[22]

Toxic releases to Bloomington decreased 43 percent from 1988 to 1997 (See Figure 3.6). Despite an increase in newly reporting sectors in 1998, Bloomington manufacturers further decreased their releases by 14.6 percent from 1997 to 1999. In 1999, the largest generators in Bloomington were General Electric Company and Otis Elevator Company releasing 565,363 and 29,275 pounds of toxic material to the environment, respectively. Another major source, Cook Inc., located in

Ellettsville, released 226,935 pounds in 1999.[23] Appendix A lists all of the TRI-listed sources in Monroe County and their respective on-site toxic releases reported for 1999.

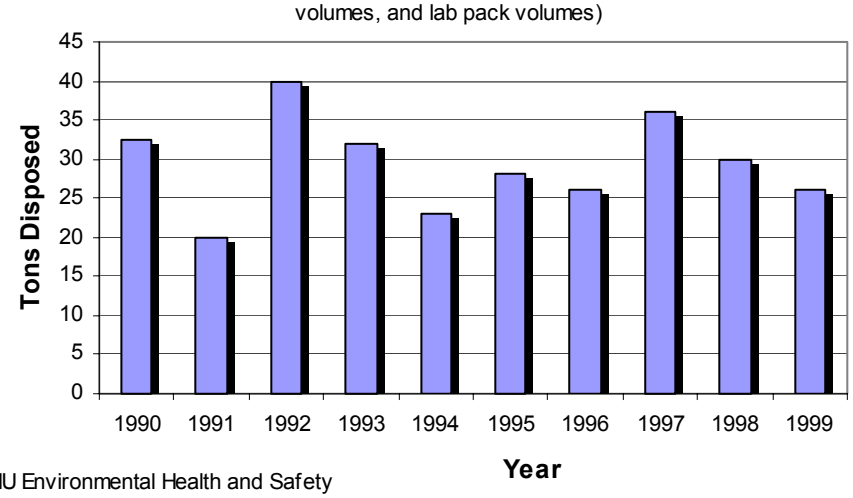
While Indiana University is not required to report toxic releases to the TRI, IU officials track hazardous waste disposal. In 1999, IU shipped approximately 26 tons of hazardous waste to permitted landfills. The types of waste generated include solvents, metals, photo fixer chemicals, lab pack materials, and other miscellaneous materials. Lab pack volumes are highly variable and are correlated with lab clean-outs of unused chemicals rather than the actual generation of hazardous waste[24] (See Figure 3.7).

The average household typically contains 3-10 gallons of hazardous waste. The Monroe County Solid Waste Management District operates a regional facility to collect and properly dispose of hazardous waste from households and businesses that produce small amounts of harmful waste (Conditionally Exempt Small Quantity Generators). The facility collects paint, used motor oil, batteries, antifreeze, pesticides, solvents and other materials. The hazardous materials facility has recently begun a collection and recycling program for products that contain mercury. Mercury is a known developmental toxicant and can be found in household items such as thermometers.[25]

c.) Interpretation and Evaluation

Laws to protect human health have had a positive effect on the total quantity of hazardous chemicals entering the local environment. Although, TRI reports since 1988 have demonstrated a downward trend in toxic chemical releases in Monroe County and Bloomington, residents must realize that the

Figure 3.7



Source: IU Environmental Health and Safety

TRI report does not consider all toxic chemicals released into the environment. Non-point sources and small generators also contribute to the accumulation of toxic chemicals into the environment.

According to the TRI data, the rise in toxic releases in Bloomington from 1996 to 1997 is attributed to a significant increase in reported toxic releases from GE Appliances, Inc. GE reported a total release of 175,471 pounds in 1996 and a total release of 550,683 pounds in 1997. This increase may be due, in part, to the expansion in the list of reportable chemicals required by the TRI.

The overall decline in Bloomington toxic releases may be attributed to increased recycling of materials, reduced air emissions and decreased chemical use. Reductions may also have been prompted by publication of the toxic release inventory and more stringent emission controls for hazardous waste and air emissions since 1988.

Exempt from the Community Right-to-Know Act, Indiana University is not required to report emissions from its coal-fired steam plant. Businesses with less than 10 employees are also not required to report. Residents must also consider their toxic inputs to the environment as they use many garden chemicals and household hazardous chemicals. Continued education and outreach is needed to reduce the use of these chemicals and to increase the use of household hazardous waste disposal facilities.

Changes in reporting – the addition of listed chemicals in 1995 and expansion of reporting sectors in 1998 – should be considered when comparing years and analyzing trends. For the entire state, the addition of newly reporting industries increased total on-site releases from 70 million pounds in 1997 to 133 million pounds in 1998 – a significant increase. Due to these TRI reporting changes, a direct comparison of total on-site releases cannot accurately be made from 1988 to 1999 but overall trends can be observed.

Scientists have debated the overall effect of continued hazardous waste inputs into the environment. The long-term effects of many chemicals are still unknown. Figure 3.5 illustrates the extensive assortment of chemicals that are released into Monroe County.

The development of the toxic release inventory has played a significant role in the attempt to regulate and reduce the amount of toxic material that is released into the environment. The large volume of toxic materials released by Indiana should be a cause for concern for all residents. The expansion of newly reporting industrial sectors in 1998 revealed that the electric utility industry in Indiana is a national leader in total on-site toxic releases – 61,049,964 pounds of toxic substances were

released in 1998, mostly to the air. Air emissions have the ability to reach a greater area, thereby, affecting the entire state, including the Bloomington area.

Steps have been taken to reduce the level of toxic releases in Indiana. Two years ago, Governor Frank O'Bannon issued a challenge to manufacturers to reduce the State's total releases reported by the TRI by fifty percent of 1995 levels by 2002. If considering only the pre-1998 reporting industries, the state has reached a 25 percent decrease thus far, but the addition of newly required reporting sectors increased reports of the overall on-site releases to the environment. Fortunately, the inclusion of additional reporting industrial sectors in 1998 has raised awareness of other major hazardous material sources throughout the state and may prompt further reduction initiatives and pollution prevention.

d.) Linkages

Because the majority of toxic releases in Monroe County are to the atmosphere, the release of hazardous material is directly related to air quality. Hazardous waste generation and disposal can also be linked to the pollution of soil, surface water, groundwater, and long term health effects of local residents. Pollution prevention programs, the development of more stringent emission laws, and public education can mitigate the effects associated with hazardous waste generation.

3. PCBs in Bloomington

Note: This report does not aim to summarize all reports or give a comprehensive overview of the ongoing debate concerning PCBs and their regulation. It merely provides a general update on the current situation and alerts readers to the continuing problems. Documents entered onto the public record are located at the Monroe County Library and the Business-SPEA Library on the IU campus.

a.) Definition

PCBs, or polychlorinated biphenyls, comprise a family of organochlorine chemicals that are chemically stable and persistent in the environment. They are relatively insoluble in water, but are soluble in oils and fatty substances. There are 209 forms of PCBs. They possess an excellent ability to insulate electricity and prevent transmission loss. Widespread use since the 1920s has resulted in low level PCB contamination throughout the world.[26]

PCBs have been shown to have significant health effects. They cause elevated liver enzyme levels, chloracne, and may affect reproduction. They cause cancer in animals and may also cause cancer and other chronic diseases in humans. Fetuses and infants are potentially more susceptible to health problems than adults. PCBs are categorized as endocrine disruptors. They may mimic or interfere with hormones that control reproductive development and behavior.[27]

PCBs are usually associated with soil contamination and the contamination of sediments in waterways. Some research has shown that plants can take up PCBs through surface adsorption. Animals can ingest PCBs by eating plants in contaminated soils. When ingested, the chemical is stored in fat tissue, which leads to the bioaccumulation of the contaminant in the animal. Predators generally eat animal portions containing the highest PCB concentrations. Animals high on the food chain, including humans, are subject to the highest PCB exposures, a process called biomagnification.[28]

b.) Indicators

Westinghouse Electric Corporation manufactured electrical capacitors containing PCBs from 1958 to 1977 in Bloomington. Capacitors not meeting quality standards were disposed in four dumps in Monroe County and one in Owen County. Wastewater containing PCBs from the Westinghouse facility was discharged to the City's wastewater treatment system. The sludge by-product from the treatment process was given away to city residents to use as a soil additive, resulting in the contamination of several residential yards. PCBs contaminated the soil and drainage ditches at the Westinghouse facility, now called

the ABB plant. In addition, Fell Iron and Metal salvaged the copper contained in the capacitors, which resulted in the contamination of that site.
A legally binding consent decree signed in 1985 by all involved parties estimated that 650,000 cubic yards of soil were contaminated with PCBs. Groundwater and surface water were also contaminated.

Four sites were declared federal Superfund sites in 1983-84 due to high levels of PCB contamination: Lemon Lane Landfill, Neal's Landfill, Neal's Dump, and Bennett's Dump near Bennett's Quarry. Two additional sites, Winston Thomas Treatment Plant and Monroe County's Anderson Road Landfill also required cleanup as dictated by a 1985 consent decree. Other sites associated with Westinghouse were not included in the consent decree but also required remediation. These sites included Fell Iron and Metal, ABB plant, the West Side of Clear Creek, Illinois Central/Quarry Spring and Conard Branch of Richland Creek.

A color map showing Bloomington's PCB clean-up sites can be found at the end of this report.

A 1994 public health assessment, updated in 1996, concluded that residents living in the Monroe-Owen County region are not generally at risk of exposure to PCBs. However, people who salvaged copper from PCB contaminated capacitors and residents who have eaten fish from contaminated streams increased their PCB "body burden," according to the Agency for Toxic Substances and Disease Registry (ATSDR).[29]

The first phase of clean up occurred in 1987. Regulators sought to remove limited amounts of contaminated sediments and contain pollution at the six consent decree sites. The second phase was to involve the construction and operation of a high temperature incinerator using municipal solid waste as a fuel source. The incinerator plans were abandoned in 1995 after the Bloomington community voiced strong opposition due to concerns over emissions, long-term operation, and ash disposal.

Remediation Projects:

- Anderson Road Landfill – Located north of the city, this facility currently serves as the Monroe County's Landfill. Approximately three acres (4,847 tons) of the 80-acre landfill were excavated in 1987.
- Fell Iron and Metal – Salvage operations took place at this 5.4-acre site from 1958 to 1968. In 1989, more than 500 capacitors were removed from the site and disposed of in two licensed incinerators. Approximately 16,000 cubic yards (approximately 400 truckloads) of soil were excavated at that time and stockpiled on-site for several years. The contaminated soil was transported to Utah for final disposal in a TSCA waste landfill in 1996. PCB levels on site are below 10 parts per million (ppm) compared to an EPA health threshold of 25 ppm.
- ABB Plant (former Westinghouse facility) – Approximately 18,000 cubic yards of contaminated material was removed and 3,000 cubic yards of non-PCB waste were removed from this site in 1995 and transported to the Utah facility. PCB levels on site now measure less than 10 ppm.
- Residential yards – In 1989-90, 120 residential yards were identified as sites where contaminated sludge was deposited. Of those sites, three were found to have soils with PCB concentrations greater than 10 ppm. In 1995-96, soil from two contaminated yards was excavated.
- Winston Thomas – Located on 26 acres south of Bloomington, this site served as the City's wastewater treatment plant from 1933-1962. Wastewater contaminated treatment lagoons, all components of the facility, the west side of Clear Creek, and an area adjacent to Gordon Pike Road. Sample results of the sludge found PCBs levels up to 4,000 ppm. An interim storage facility was installed at the site. In 1998, remediation was performed on the abandoned lagoons, the trickling filter, the perimeter of the drying beds, and the south berm of the tertiary lagoon. Remediation of the 17-acre tertiary lagoon began in 1998 and was completed in the fall of 1999. An intermittent spring in this area was sampled

twice, in October 1998 and May 1999, and showed PCB contamination.

- Neal's Dump – This site in Owen County was used as a disposal site from 1966-1971. The site is 0.5 acres wide and 20 feet deep. Groundwater and soil was contaminated with PCBs. In 1983, capacitors were removed and a clay cap and fence was installed at the site. 7,250 tons of PCB contaminated material was disposed of off-site. A total of 2,430 capacitors were removed. Final sampling showed an average of 0.8 ppm contamination. Remediation was completed in November, 1998. The area around the site can be redeveloped for residential use. Groundwater monitoring around the site is conducted twice a year – no PCBs have been detected thus far.
- Lemon Lane Landfill – This site is located on 10.7 acres in Bloomington at Vernal Pike and Highway 37. The landfill contains two sinkholes and is located near a cave. It was listed as a Superfund site in 1983. Soil contamination was measured as high as 57,000 ppm. Contaminated water from the Illinois Spring Complex drains to the southeast and eventually to Clear Creek. In 1987, the landfill was capped with a polyethylene liner and fenced. The Lemon Lane remediation project was completed in December 2000. More than 80,000 tons of material was removed from the site and transported to a licensed landfill in Michigan. A permanent, seven-layer synthetic cap with 24 inches of compact clay was installed on top of the site. Twelve inches of sand and six inches of topsoil were then placed on top of the clay to promote vegetation growth. Groundwater issues continue to be a concern at this site. An interim water treatment plant was installed at Illinois Central Spring in May 2000. It treats 1,000 gallons of contaminated spring water per minute. Treated water is non-detectable for PCBs.
- Bennett's Dump (Bennett Stone Quarry) – This site is located 2.5 miles northwest of Bloomington in a sparsely populated area. The four-acre site contains three contaminated areas. A large number of capacitors were dumped at the site during the 1960s and 1970s. PCB levels were measured as high as 380,000 ppm. Stout Creek, located along the site's west side, had sediment contamination measured at 5 ppm. In 1985, 252 capacitors and 14 cubic yards of contaminated soil were removed from the site. A 14-16 inch clay cap was installed and the area was fenced. In 1999, 36,172 tons of soil and 1,756 capacitors were excavated and transported off-site. A 12-inch soil cover was placed over the site. Final measurements showed that the site measured 11.3 ppm – under the 25 ppm standard. In 2000 approximately 10 cubic yards of contaminated sediments were removed from Stout Creek. Viacom (formerly Westinghouse) is currently implementing a groundwater monitoring plan.
- Neal's Landfill – This site was operated from 1950 to 1972 on 18 acres in western Monroe County. PCB soil contamination was measured in excess of 200,000 ppm. Ground and surface waters at the site were contaminated along with fish and vegetation. Water in Conard's Branch of Richland Creek and stream sediment and fish were also contaminated. In 1987, interim control measures were implemented, including removal of visible capacitors and stained soils, installation of liners, a two foot thick clay cap, a one foot layer of soil and a fence. Creek sediments were removed along a 4,500-foot length of Conard's Branch and a spring water collection and treatment system was installed. In 1999, the first phase of the cleanup began. 41,747 tons of highly contaminated soil was excavated and transported to an off-site facility. 4,119 capacitors were removed. 90,000 cubic yards of landfill material was consolidated to reduce the landfill size to 10 acres. A final landfill cap was installed. Groundwater and surface water monitoring plans are currently under development.[30]

The region's wildlife, including birds and fish, has been adversely affected by the extensive PCB contamination. The state has issued fish advisories for Richland Creek and Clear Creek because fish were found to have elevated PCB concentrations. The Indiana State Department of Health's 2000 Fish Consumption Advisory recommends that residents should not eat any

fish from Clear Creek. Certain fish species from Richland Creek should not be eaten more than once per month due to elevated PCB levels.[31] A U.S. Fish and Wildlife study found that migrating waterfowl are susceptible to PCB contamination, making them "unfit for human consumption." The study found birds that spent as few as 10 days on the Winston Thomas plant lagoon had PCB levels 19-78 times higher than U.S. consumption guidelines for poultry.[32]

c.) Interpretation and Evaluation

The Agency for Toxic Substances and Disease Registry (ATSDR) reached the following conclusions in late 1996 regarding human health risks and the PCB contamination.

- Current conditions present no apparent public health hazard to the general population.
- Private drinking water wells near Neal's Dump may be adversely affected.
- Recontamination is appearing in off-site springs and streams down-gradient from PCB sites.
- A comprehensive evaluation of the public health implications associated with specific remediation technologies cannot be completed due to insufficient information.[33]

PCBs represent one of Bloomington's largest environmental problems. The longer the pollution remains in the community the larger the threat of long-term health risks. Public debate, conflict, scientific studies, and remediation efforts have occurred for almost 20 years. Bloomington residents played a major role in PCB remediation strategies, including blocking the construction of a PCB incinerator in the community.

PCB site clean up action has proceeded during the last few years, resulting in several clean-up completions or near completions. Lemon Lane is the most recent Superfund site to declare final remediation in December 2000. Although the threats from the affected sites have been minimized, clean up efforts have not restored these locations to their pre-contamination condition. At most sites, caps and fencing represent final treatment. Surface and groundwater PCB contamination is still occurring. Stream sediments in Clear Creek have prompted concern from the EPA. The sediments are currently being evaluated to see if removal action needs to be implemented. Fish consumption advisories indicate that PCBs persist in the local aquatic food chain. Groundwater has also become a high priority. Due to groundwater contamination and the proximity to resident wells, the groundwater flows at many sites require continued monitoring. The EPA and environmental consultants are currently evaluating the groundwater at Winston Thomas and Lemon Lane. Leaking storage tanks at the former water treatment plant is another priority PCB issue in Bloomington that needs immediate attention.

The PCB contamination in Bloomington has been far reaching. The remediation of contamination sites deemed "high priority" in the early 1980s is only now nearing completion. The City has learned to keep the public well involved in the decision making process and frequently update status notifications. Efforts to assess the long-term health risks of PCBs continue with ensuing debate. Surface and groundwater contamination ensures continued PCB persistence in the local environment and will require continued monitoring and clean-up efforts well into the future.

d.) Linkages

PCB contamination is linked to many environmental quality indicators including land quality, air quality, surface and groundwater quality, habitat, and wildlife. It is also connected to long-term environmental health risks and affects the local economy.

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IV. Air Quality

Introduction

Global warming, stratospheric ozone depletion and acid rain are issues that arise during national and international debates on air quality. The International Panel on Climate Change (IPCC) has confirmed that human induced air pollution is causing the global warming that will result in wide-ranging adverse impacts on human health.[1] Since the end of the nineteenth century, global mean surface temperatures have risen 0.5-1.0°F. If the current rates of greenhouse gas production are not reduced, global temperature could rise an additional 1.6-6.3°F in the next century.[2]

The federal Clean Air Act (CAA), amended in 1990, regulates six main criteria pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide and particulate matter (PM10 -particles with diameters of 10 micrometers or less). The EPA has proposed revisions that would include more stringent 8-hour ozone standards as well as standards for particles with diameters of 2.5 micrometers or less (PM2.5) but these regulations are currently under federal review. Cities or counties that do not meet the federal standards for one or more criteria pollutants are designated as "non-attainment" and must reduce pollution levels. In 1999, 62 million people lived in counties designated as non-attainment areas for at least one of the six criteria pollutants.[3]

Over 150 million tons of air pollution was released into the air in the United States in 1999 (not including carbon dioxide). Approximately 98 percent of the United States carbon dioxide emissions are generated by fossil fuel combustion. All criteria pollutant concentrations in the United States have decreased since the enactment of the Clean Air Act in 1970, except for nitrogen dioxide. Nitrogen dioxide emissions have increased 17 percent from 1970 to 1999. Generated by automobiles and coal-fired power plants, nitrogen dioxide emissions contribute to the formation of ground-level ozone (smog) and acid rain. Air toxic emissions are estimated to have decreased 23 percent from 1990 to 1996 throughout the country. Although overall national trends show an improvement in air quality, the air in rural areas has worsened in the last 10 years. Because air pollutants can travel many miles from their original sources, natural areas such as national parks have recently shown high pollution concentrations in the air.[4]

Air Quality in Bloomington

a.) Definition

At the local level, air quality problems focus on health-related effects, smog and visibility. Poor air quality from a variety of pollutants can cause or aggravate cardiovascular disease, asthma, respiratory infections, and cancer. Toxic air pollutants can cause serious health problems such as cancer and reproductive problems. Children and the elderly are the most susceptible to health problems caused by exposure to poor air quality. Air pollutants can be deposited onto soil or into lakes and streams and cause health problems. Air pollution, acid rain, ground-level ozone, and hazardous (toxic) air pollutants also harm the environment and natural ecosystems. The EPA estimates that ground-level ozone has cost 500 million dollars in agricultural and commercial forest yield reductions.[5]

Air pollution comes from many sources. Stationary sources or point sources include factories and power plants. Area sources are made up of small sources that are aggregated together rather than tracked individually. Automobiles are considered mobile sources. Natural sources such as windblown dust also contribute to air pollution.

Ambient air monitoring sites are located throughout the country to measure criteria pollutant concentrations of a certain area. The EPA is able to use the monitoring data as an indication of the nation's air quality. Pollutant emissions data are estimated using a combination of actual measurements, engineering models, and estimates. Area emissions account for stationary, area (combined small sources) and mobile sources. Factors such as industrial activity, vehicle miles traveled, fuel consumption and technology changes are considered in area emissions estimates.[6]

b.) Indicators

The city of Bloomington and Monroe County currently meet the federal air quality standards; that is, the region is "in attainment" for each of the criteria pollutants. However, no agency regularly monitors the ambient air quality in Bloomington. Thus, no ambient air quality data exist for the criteria pollutant concentrations in Bloomington.

Although the Bloomington region is in attainment for ozone, ozone levels become elevated during the summer months. Ozone and the pollutants that form it can be transported across the state. Ozone generated in other regions can affect the air quality of Bloomington. Using monitoring data and models, the Indiana Department of Environmental Management (IDEM) determined that during the summer of 1999, 8-hour ozone concentration levels became unhealthy for sensitive groups in the Bloomington area.[7]

According to emissions data, Indiana University generates the largest amount of criteria pollutant emissions in the Bloomington area, stemming from its coal plant. The plant emits particulates, carbon monoxide, sulfur dioxide, nitrogen dioxide, and volatile organic compounds. In 1996, Indiana University generated 3,248 tons of sulfur dioxide, 61 tons of carbon monoxide, 158 tons of nitrogen dioxide and 4 tons of particulate matter (PM-10; diameter less than 10 micrometers). Other air pollution sources in Bloomington include Rogers Group Bloomington Asphalt and Crushed Stone, General Electric Company, and Otis Elevator.[8]

More broadly speaking, the air in Indiana meets federal standards for sulfur dioxide, carbon monoxide, lead, and particulate matter based on the data from statewide ambient air monitoring sites. Ozone levels exceed federal standards in some parts of the state during hot, sunny days. Counties in southeastern and northwestern Indiana currently violate the 1-hour ozone standards. The Indianapolis area has recently come into attainment for ozone but is at risk of not meeting the new 8-hour ozone standard, currently not enforced.[9]

Volatile organic compounds (VOCs), nitrogen oxides (NOx) and sunlight react to form ground-level ozone (smog). Power plants and

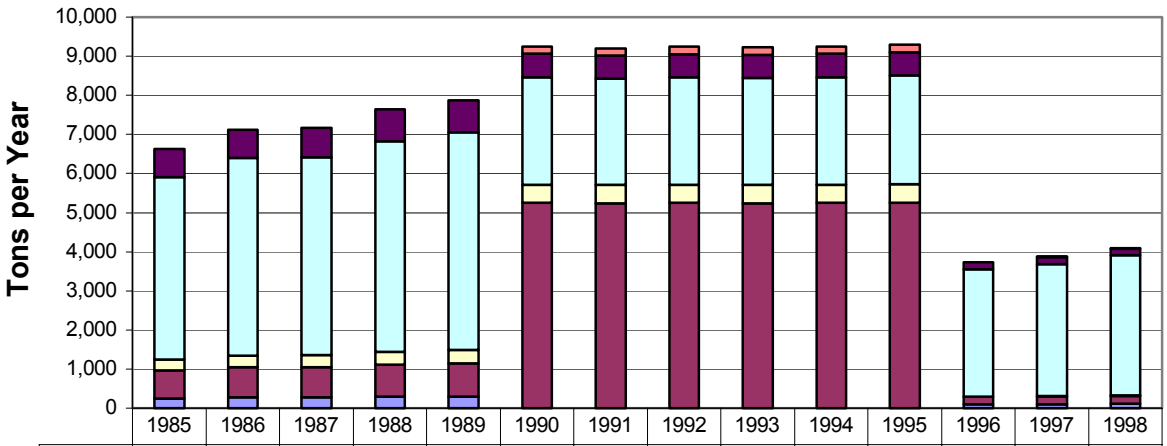
motor vehicles produce 61 percent of the nitrogen oxides in the state. Consumer/small commercial sources and motor vehicles account for 56 percent of the volatile organic compounds (VOCs) generated in the state.[10]

The EPA's National Emissions Trends (NET) database estimates point source emissions and area source emissions by county. Emissions from large stationary sources are recorded individually and combined into the point source emissions report. Mobile source and small stationary source emissions are aggregated as county-level area emissions. These area sources are too small and numerous to be recorded individually.

Overall, point source emissions in Indiana have decreased from 1990 to 1998. Sulfur dioxide emissions from point sources decreased 35 percent, nitrogen dioxide decreased 21 percent and particulate matter (PM10) decreased 65 percent. As point source emissions decreased, many area source emissions increased during the same time period in the state. Carbon monoxide emissions increased 19 percent, nitrogen dioxide increased 14 percent, and particulate matter (PM10) increased 60 percent.[11]

In Monroe County, point source emissions have been highly variable from year to year (See Figure 4.1). This may be due to limitations in the measurement and estimation techniques used. Particulate matter with diameters less than 2.5 micrometers (PM2.5) and ammonia (NH_3) were not recorded prior to 1990. Figure 4.1 shows a drastic decline in sulfur dioxide emissions from 1989 to 1990, but since that time sulfur dioxide emissions have risen. From 1990 to 1998, sulfur dioxide emissions have increased 30 percent but 1998 emissions data still represents an overall decrease in emissions since the mid-1980s. According to the data provided in the NET report, industrial fuel combustion sources are responsible for the very large increase in nitrogen dioxide emissions from 1990 to 1995 but emissions declined in recent years. Point source particulate matter emissions, both PM10 and PM2.5, have substantially decreased from 1995 emission values.[12]

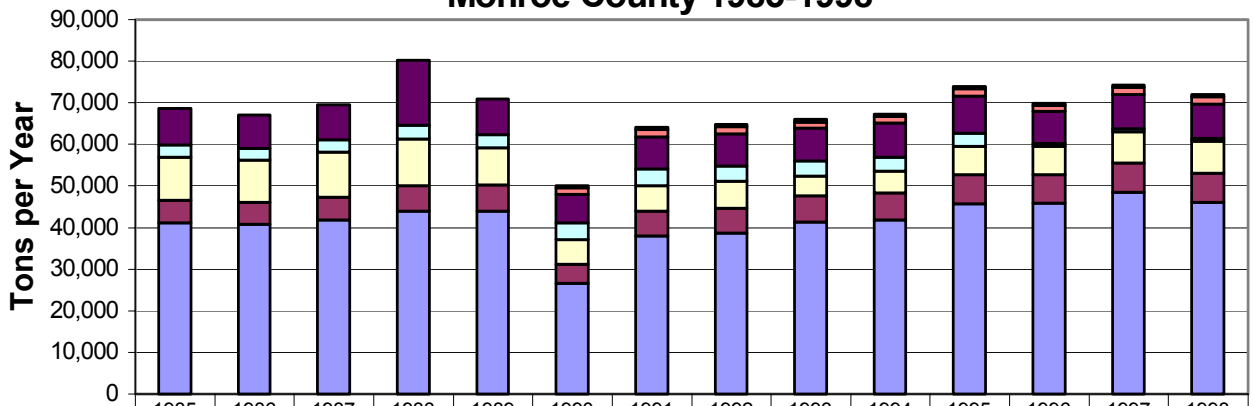
Figure 4.1



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
NH3	-	-	-	-	-	1	1	1	1	1	1	1	1	1
PM2.5	-	-	-	-	-	186	184	185	185	186	187	10	10	10
VOC	727	719	741	816	826	595	595	595	595	595	595	174	179	171
SO2	4,656	5,043	5,066	5,382	5,558	2,756	2,722	2,750	2,737	2,751	2,786	3,248	3,373	3,584
PM10	286	310	311	331	341	466	462	465	464	466	470	15	15	15
NOx	710	767	771	820	846	5,246	5,241	5,245	5,243	5,246	5,250	185	191	198
CO	253	273	275	292	301	1	1	1	1	1	1	102	105	107

Source: EPA National Emissions Trends Tier Report

Figure 4.2



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
NH3	-	-	-	-	-	499	499	531	562	556	553	547	557	571
PM2.5	-	-	-	-	-	1,614	1,731	1,781	1,494	1,582	1,828	1,446	1,718	1,745
VOC	8,778	8,074	8,392	15,529	8,515	6,693	7,677	7,721	7,956	8,204	8,857	7,797	8,322	8,197
SO2	2,920	2,925	2,991	3,289	3,109	4,123	3,987	3,722	3,620	3,363	3,233	557	581	589
PM10	10,339	10,069	10,840	11,291	9,029	5,992	6,194	6,406	4,744	5,246	6,800	6,949	7,529	7,830
NOx	5,384	5,336	5,534	6,132	6,259	4,529	5,847	5,932	6,342	6,414	6,962	6,796	7,014	6,894
CO	41,216	40,736	41,766	43,921	43,949	26,581	38,083	38,773	41,238	41,835	45,705	45,857	48,576	46,119

Source: EPA National Emissions Trends Tier Report

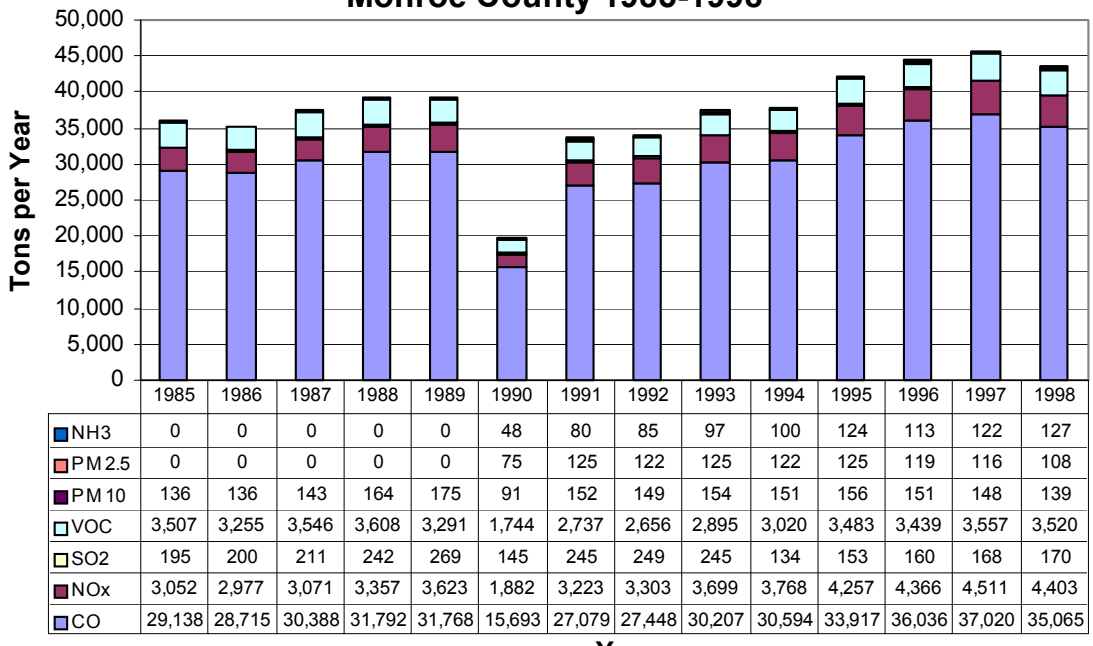
Monroe County area source emissions data include all small generators such as houses as well as mobile sources. No strong trends of criteria pollutants are apparent from 1985 to 1998 according to Figure 4.2. Sulfur dioxide decreased most dramatically from 1995 to 1996, which the NET report attributes to a decrease in small industrial fuel combustion sources. Nitrogen dioxide emissions and carbon monoxide emissions have increased since 1985. Nitrogen dioxide increased 28 percent and carbon monoxide increased 12 percent from 1985 to 1998.[13]

The National Emissions Trends database separates area source emissions into categories or "tiers." Figure 4.3 shows the amount of area emissions originating from highway vehicle sources in Monroe County from 1985 to 1998. Total nitrogen oxide emissions from vehicles have increased 44.3 percent from 3,052 to 4,403 tons per year. Total carbon monoxide emissions have increased 20.3 percent from 29,138 to 35,065 tons emitted per year.[14] Data from 1990 seem anomalous when compared to other years and may be due to reporting and/or estimation errors.

The majority of hazardous (toxic) air pollutants are generated from man-made sources such as industrial smokestacks or automobiles. EPA tracks hazardous air pollutants (HAPs) separately from criteria pollutants. EPA established the Air Toxics Program to reduce the risks to public health and the environment from hazardous materials released to the air. Technology-based standards were implemented to reduce emissions.[15]

Released every three years, EPA's National Toxics Inventory (NTI) estimates hazardous air pollutants emitted from stationary and mobile sources within county-wide areas. Currently, 1996 data is the most recent available while 1999 inventoried data is pending release. In 1996, ten point sources located in Monroe County emitted hazardous air pollutants. That year, a total of 128,457 pounds of hazardous air pollutants were generated by point sources in Bloomington.

Figure 4.3



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
NH3	0	0	0	0	0	48	80	85	97	100	124	113	122	127
PM 2.5	0	0	0	0	0	75	125	122	125	122	125	119	116	108
PM 10	136	136	143	164	175	91	152	149	154	151	156	151	148	139
VOC	3,507	3,255	3,546	3,608	3,291	1,744	2,737	2,656	2,895	3,020	3,483	3,439	3,557	3,520
SO2	195	200	211	242	269	145	245	249	245	134	153	160	168	170
NOx	3,052	2,977	3,071	3,357	3,623	1,882	3,223	3,303	3,699	3,768	4,257	4,366	4,511	4,403
CO	29,138	28,715	30,388	31,792	31,768	15,693	27,079	27,448	30,207	30,594	33,917	36,036	37,020	35,065

Source: EPA National Emissions Trends Tier Report

United Tech.-Otis Elevators generated 110,298 pounds of hazardous air pollutants, 85 percent of the total emissions in Monroe County. General Electric generated 970 pounds and Indiana University emitted 894 pounds of hazardous air pollutants in 1996.[16]

Appendix A, associated with the hazardous waste section of this report, shows the amount of toxic air pollutants released in the form of fugitive and stack air for each reporting source in Monroe County in 1999 as reported by the Toxic Release Inventory Report (TRI). Although this data is more recent, it is not as comprehensive for "hazardous air pollutants" as the National Toxics Inventory (NTI).

When all hazardous air pollutant point sources and area sources (including mobile sources) are combined, a total of 3,441,845 pounds of hazardous air pollutants were emitted in 1996. Vehicle emissions made up 45 percent of the total hazardous air pollutant emissions.[17]

c.) Interpretation and Evaluation

Volatile organic compounds and nitrogen oxides can be transported across regions and contribute to the formation of ozone (smog) in Bloomington during the summer months. Ozone levels have become unhealthy for sensitive Bloomington residents during certain periods when conditions favor smog formation. As traffic increases within Bloomington, VOC and NOx emissions will also increase, resulting in higher ozone levels. The increasing elderly population of Bloomington and Monroe County (See Figure 1.5) is especially susceptible to the health risks associated with elevated ozone during the summer months.

Point source emissions in Bloomington depend on the industries present in the region. Dramatic decreases and increases of emissions such as in the carbon monoxide and nitrogen oxide emissions data may be due in part to changes in industrial and commercial fuel combustion sources.[18]

Indiana University remains a large source of air pollution. In 1996, 100 percent of the sulfur dioxide emissions in Bloomington was attributed to fuel combustion at the Indiana

University power plant. Sulfur dioxide emissions are expected to mirror the increase in coal consumption at IU caused by weather and high gas prices this past winter (see Section II. Energy).

Point sources are not the only sources of air pollution in the region; in fact, they contribute a small portion of the total pollutant emissions. Aggregate estimates of area sources are important to obtain an overall view of air pollution emissions. As Figures 4.1 and 4.2 illustrate, area emissions are considerably greater than point source emissions. For example, carbon monoxide generated by area sources was 431 times greater than point source carbon monoxide emissions.

Area source emissions estimates show that mobile and small sources are the main generators of air pollution in the region. Greater consideration should be given to reducing these area source emissions. Small businesses, cars, and even homes contribute to area air pollution. An increase in managed road miles and registered automobiles in Bloomington and Monroe County may prompt the increase of mobile source emissions including volatile organic compounds, nitrogen oxides, particulate matter, and carbon monoxide. Figure 4.3 illustrates the large amount of air pollutants emitted as a result of vehicle travel in the county. Carbon monoxide and nitrogen dioxide emissions have increased by 20 percent and 44 percent, respectively.

The 1996 data available from the National Toxics Inventory indicates that a majority of the hazardous air pollutants in Bloomington are also generated from non-point sources such as small area sources and mobile sources. Approximately 3,331,547 pounds of hazardous air pollutants were generated from sources other than major point sources in 1996. This indicates that the combined emissions of individual small generators cause the greatest proportion of air pollution produced in the region.

The emissions data in the National Toxics Inventory (HAPs) and the National Emissions Trends Report (criteria pollutants) represent estimated values. These data cannot replace the value of ambient air concentration measurements of criteria pollutants. Computer models and state regulators do not predict criteria pollutant concentrations to reach "non-attainment" levels in Monroe County in the near future so the area is not monitored for criteria pollutant concentrations. Since no ambient air measurements have been taken in recent years, a comprehensive evaluation of Bloomington's air quality cannot be made. To complete a thorough analysis of Bloomington's air quality, ambient air measurements need to be obtained.

Although, officials do not expect Monroe County to reach non-attainment status in the near future, estimates show an increase in criteria air pollutant emissions in the county. The implications of reaching non-attainment status are great. An area not in attainment for one or more of the criteria pollutants is classified based on the severity of the pollution. The state customizes clean-up requirements and deadlines to bring the affected area into compliance. If an area fails to meet a clean-up deadline, stricter requirements are established. An area in non-attainment may suffer economic losses if industries are penalized or denied emission permits.

Pollutants released into the air affects large areas of the country and many people because they can be transported many miles away from their original source. The air pollution of surrounding areas and the entire state should be taken into consideration when evaluating Bloomington's air quality.

d.) Linkages

Air quality is linked to population, industrial development, energy production, transportation, and waste generation and disposal. Regional air pollution can also affect land and water quality. Air pollution is transported over a large area and can affect many regions.

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[3] EPA, Office of Air and Radiation. *Annual Air Quality Trends Summary Report, 1999*. http://www.epa.gov/airtrends/; accessed 1/25/01.
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[6] Ibid.
[7] Ibid.
[8] EPA; National Emission Trends (NET) database; http://www.epa.gov/air/data/netemis.html; accessed 2/14/01.
[9] Indiana Department of Environmental Management; *State of the Environment Report 2000*.
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[12] Ibid.
[13] Ibid.
[14] Ibid.
[15] Unified Air Toxics Website; http://www.epa.gov/ttn/uatw/basicfac.html; accessed 2/15/01
[16] EPA; National Toxics Inventory database; http://www.epa.gov/airsdata/nti.htm; accessed 2/14/01
[17] Ibid.
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V. Water Quality and Quantity

Introduction

The amount of water on earth remains essentially constant throughout time, recycling from surface-water to clouds to rain via the hydrologic cycle. Water covers 80 percent of the earth's surface. Only 1 percent of the earth's water is available in aquifers, lakes, and streams for drinking and other human uses. The average American consumes about 183 gallons of water each day for domestic uses such as cooking, washing, drinking, and flushing. Thirty-four billion gallons of water are processed each day for home and commercial use by about 60,000 public water systems in the United States. Public water facilities serve 85 percent of the population while the remaining 15 percent rely on private wells and other sources.[1]

The earth's available freshwater is a finite resource and is threatened by excessive consumption and pollution. The demand for freshwater has increased due to population increase, industrial development, irrigation demand, and urbanization. Annual global water withdrawals have increased by an average of 2.5-3.0 percent while annual population growth has been 1.5-2.0 percent since 1940. By 2025, it is estimated that 70 percent of the world's accessible freshwater will be exploited.[2] In search of new freshwater supplies to meet growing demand, engineers have dammed rivers, drilled wells, and transported water over great distances. These solutions no longer work in many places. Rivers run dry, water tables drop and ecological systems change with freshwater over-exploitation.

Pollution threatens the quality and health of many surface water ecosystems. Every two years, the U.S. Environmental Protection Agency mandates that states and tribes survey the quality of the water in a portion of their streams, rivers, lakes and reservoirs. Of those surveyed in 1998, approximately 40 percent were not clean enough to support fishing or swimming. Leading pollutants to streams, rivers, and lakes include sediments, nutrients, metals and pathogens (bacteria) primarily from agricultural and urban runoff.[3] In Indiana, 76 percent of the streams assessed and nearly 100 percent of the lakes assessed in 1998 fully or partially supported aquatic life. 62 percent of the streams assessed can support full human body recreation contact according to health standards.[4]

1. Stream and River Water Quality

a.) Definition

Streams and rivers carry water, nutrients, and sediment from higher lands to lower valleys before discharging to larger bodies of water. They provide habitat for many aquatic communities and riparian communities. The geographical area from which water flows to a discharge point is called a watershed. Watersheds can be as large as the Mississippi River's, comprising states from Minnesota to Louisiana, or as small as the drainage area for Jordan Creek which lies completely within the Bloomington city limits.

The activities that occur in a watershed directly affect the water quality of its streams. For example, sediment pollution originates from agriculture production, timber harvest, homebuilding, and runoff from urbanized areas. Runoff entering waterways carries soil, nutrients such as phosphorus and nitrogen, and chemicals to the entire stream system and eventually to the discharge water body. Excess nutrients encourage aquatic plant growth and decay. The decay process consumes dissolved oxygen that aquatic animals need to survive. The aquatic community can be compromised if dissolved oxygen levels deteriorate. Excessive sedimentation can inundate benthic (bottom-dwelling) communities and suffocate fish. Scientists measure discrete parameters as part of the process to determine the health of a stream. Parameters include: nutrient levels, temperature, dissolved oxygen content, alkalinity, water flow and depth. Biological sampling of living organisms such as macroinvertebrate and fish communities can yield valuable information about the condition of a stretch of river or stream over time. For example, the presence of organisms that are intolerant of pollution generally indicates good water quality. Because of their constant movement, streams and rivers have the ability to flush themselves of pollution if the source is eliminated and given sufficient time.

b.) Indicators

The City of Bloomington lies within the White River watershed. However, the City lies on the divide between two sub-watersheds: the East and West Forks of the White River. Clear Creek and Jackson Creek form in the city and drain south toward Salt Creek, which discharges to the East Fork of the White River. Stout Creek and Griffy Creek in north Bloomington drain to Bean Blossom Creek, which in turn discharges to the West Fork of the White River.

The East and West Forks of the White River merge at the northern border of Pike County just east of Vincennes. The White River eventually discharges to the Wabash River in southwestern Indiana.

The most harmful water pollutants in Indiana include pathogens such as *E. coli*, nutrients such as phosphorus, chemical contaminants such as PCBs, pesticides, heavy metals, and excess siltation from soil erosion.[5]

In the state's most recent report of water quality, 98 percent of the stream miles surveyed in the East Fork of the White River basin fully or mostly supported a healthy aquatic system. Fewer stream miles were assessed for recreation use, but 60 percent of those surveyed were clean enough to allow swimming. (The standard for full body contact is less than 235 *E. coli* bacteria per 100 ml.) In the West Fork, the state found 77 percent of the stream miles fully or partially supported a healthy aquatic community. Of the stream miles surveyed for recreational use, 78 percent percent were clean enough for swimming.[6] These percentages greatly vary from year to year as the location and amount of stream miles assessed change annually.

The City of Bloomington, in conjunction with Monroe County, surveyed the water quality of the streams in and around the city in 1997 with the aid of a state grant and a private consultant. A color map of Monroe County waterways can be found at the end of this report. Those results, in combination with

other local and state reports and assessments, provide following picture of local streams:

- **Clear Creek**

Clear Creek serves as the primary drainage for Bloomington. Sampling of Main Clear Creek occurred at Miller Drive, Country Club Drive, and between Adam's and Allen Streets. Results from a biological sampling performed in 1996-1997 for the City/County report indicate that macroinvertebrate communities intolerant of pollution were not present in Main Clear Creek. Moderate to severe water quality problems were assessed based on biotic index scores and habitat scores. Impairments that prevent Clear Creek from supporting a healthy aquatic community include riparian habitat damage, presence of toxic substances, sedimentation, excess nutrients and algae, and sewage-related problems.[7]

Index of Biotic Integrity (IBI) scores were calculated based on recent assessments of the fish communities in the region's streams. These scores yield information about the streams' ability to support healthy fish communities and can be used as indicators of water and habitat quality. Sampling at two Clear Creek sites within Bloomington (at First Street and near RR south of Hillside) resulted in scores of 33 and 26 – "poor" ratings (See Figure 5.1). A third Clear Creek sampling site south of the City at Fluck's Mill Road received a relatively high IBI score (48) and "good" rating.[8]

Figure 5.1

Index of Biotic Integrity (IBI) Score Ranges	
48-52	Good
40-44	Fair
< 34	Poor

The City/County report found concentrations of *E. coli* bacteria exceeded the Indiana standard for swimming by more than seven times at two sampling sites in Main Clear Creek. These results indicate possible sewage releases into an underground storm drainage network that the stream passes through just downstream of the sampling site at Miller Drive. Illegal sanitary connections to the underground storm water system may also be responsible. This storm drainage network should be targeted for improvement to prevent these elevated levels of *E. coli* contamination in Clear Creek.[9]

The Dillman Wastewater Treatment Plant discharges into Clear Creek. Although strict discharge limits are in place, the effluent alters the stream water chemistry. Nitrates, total phosphorus, pH, and the alkalinity of the stream are altered downstream of the discharge point.[10]

The study found that the West Fork of Clear Creek had fewer pollution problems but also exhibited riparian habitat damage, sedimentation and eutrophication (excess nutrients and algal growth) problems.[11]

In its regular study on the state's water quality, the Indiana Department of Environmental Management tests Clear Creek near the confluence with Salt Creek. The most recent report assesses Clear Creek as severely impaired. The report describes Clear Creek as not adequately supporting native aquatic life, having elevated concentrations of *E. coli*, and contaminated with PCBs.[12] IDEM reports have described Clear Creek as highly impaired for over ten years, indicating that Clear Creek has not shown any improvement in water quality in the last decade.[13]

As discussed in the section dealing with PCB's in Bloomington, Clear Creek has been affected by PCB contamination. Due to the contamination, the state has issued its highest fish advisory level on Clear Creek. Clear Creek in Monroe County is listed as a Group 5 waterway. This means that no fish from these waters should be consumed due to PCB and mercury contamination.[14]

- **Jackson Creek**

The City/County study describes Jackson Creek as having excellent potential as a greenspace corridor and natural resource for the community. The impairments that were observed included some riparian habitat damage, indications of the presence of toxic substances, elevated sedimentation, and eutrophication problems. *E.coli* concentrations

measured in 1997 were elevated above the recreation standard at a sampling site near the end of South Rogers Street. Failing septic systems along the creek are possible sources of contamination. Habitat scores and (macroinvertebrate) biotic index scores indicated severe water quality problems.[15] A recent analysis of fish communities performed in 2000 also indicates water impairment. Fish assemblage IBI scores were low (28-32) and received a "poor" rating.[16]

- **Stout Creek:**

According to the most recent state water quality report, Stout Creek impairment problems earned it a "medium" severity ranking. Areas of concern that are citied include PCB and mercury contamination.[17] Due to the PCB and mercury contamination, the 2000 Indiana Fish Consumption advisory designates Stout Creek as a group 2 and 3 stream for small and large creek chubs, respectively. Group 2 recommends no more than one meal per week and Group 3 advises against eating more than one meal per month.[18]

- **Jack's Defeat Creek:**

Although the 1997 City/County study found that the upper sites of Jack's Defeat Creek (near Ellettsville) have a significantly impaired aquatic community, two downstream sampling sites showed better water quality. Sedimentation from erosional processes was the major contributing factor in the impairment of its water quality.[19] The most recent state water quality reports ranks Jack's Defeat Creek as "medium" severity due to impaired biotic communities.

- **Griffy Creek:**

The City/County study took samples upstream of Lake Griffy. The South Fork of the creek exhibited excessive sedimentation problems likely related to rapid urbanization in the South Fork sub-basin.[20] Analysis of Griffy Creek performed in 1998 for the city's Griffy Lake Watershed GIS Mapping and Management plan showed elevated levels of coliform bacteria at a sampling site near the upper end of Griffy Lake where the three forks converge. Suspended solid concentrations became elevated during high flow storm events related to erosion. The South Fork of Griffy Creek showed higher levels of urban runoff pollutants than the North Fork. These pollutants are toxic to aquatic life and are attributed to rapid urbanization in the South Fork region of the watershed.[21]

- **Cascades Creek**:

Cascades Creek is located in northern Bloomington in an urbanized area. It is heavily used for recreational purposes and receives a substantial amount of urban storm water runoff. Toxic substances such as petroleum hydrocarbons and heavy metals enter the stream from street runoff and storm sewers. Sedimentation problems associated with erosion also impair water quality. The City/County report recommends the construction of a storm water detention/retention treatment facility to curb the water quality problems caused by urban runoff.[22]

- **Bean Blossom Creek**

The 1998 State water quality report ranks Bean Blossom Creek as having "low" impairment but cites *E. coli* problems as an area of concern. It is suspected that failing septic systems along the creek may be causing *E.coli* contamination. Sedimentation and eroding streambanks are also problematic.[23]

c.) Interpretation and Evaluation

Various data and reports indicate that streams within the urbanized areas of Bloomington are substantially impaired. Erosion and sedimentation problems are prevalent in the region's streams. Excess sedimentation degrades stream water quality and impairs the streams' ability to fully support healthy aquatic communities. Toxic substances enter the stream systems via storm water runoff of urban areas (Storm water runoff, its sources and management is discussed further in Section 4 of this chapter.) PCB contamination in Bloomington has affected the fish in Clear Creek and Stout Creek. Fish consumption advisories recommend against consuming any fish from Clear Creek.

From these indicators, it is evident that the activities within the urbanized region of Bloomington have had a negative effect on its stream systems. Data collected from stream sites outside of the city limits show improvement in water quality and habitat. For example, improvement was noted along Clear Creek south of the city and along Jack's Defeat Creek outside of Ellettsville. This provides evidence that the activities within Bloomington's urban area have degraded local streams but these trends can be reversed.

Eroding stream banks and sediment carried by runoff is a major source of stream sediment loads. Riparian habitat restoration would improve the water quality and aquatic communities of the region's streams by reducing the inflow of sediment. Riparian habitat restoration and filter strips would also reduce the flow of nutrients into the streams. Adherence to erosion control measures in developing areas and construction sites would also reduce sediment inflow. Storm water system improvements may also reduce the runoff of toxic chemicals from the City's streets. Best management practices to reduce the problems associated with storm water runoff are described in greater detail in Section 4 on Storm Water Runoff.

The stream systems in Bloomington can become excellent recreation areas and natural resources for the city. They can serve as valuable greenspace corridors within the community. The Bloomington Parks and Recreation Department is developing trails along Jackson Creek and Clear Creek for the community to enjoy. Improvement of the riparian habitat along the waterways will provide recreation opportunities and wildlife habitat. Education and community cooperation is required to reverse urban stream degradation and enhance these natural resources within the City.

d.) Linkages

Stream water quality is linked to lake water quality, wildlife habitat, and recreational opportunities. Storm water runoff, transportation, wastewater treatment, erosion and urban development impacts stream water quality. The quality of local streams affects the quality of downstream rivers and ultimately other communities.

2. Lake and Reservoir Water Quality

a.) Definition

Lakes and reservoirs receive water from streams and their accompanying pollutants. As water inflow slows down, the stream sediment loads drop out and sedimentation occurs. Pollutant concentrations and sediment deposits increase over time. Water temperatures in lakes and reservoirs in this area rise in the summer causing thermal stratification and, if nutrients are available, the growth of aquatic plants and algae. Scientists use several indicators to describe and analyze the water quality of lakes and reservoirs, including: water clarity, the amount and type of algae present, temperature, dissolved oxygen, concentration of nutrients, and the level of acidity. Trophic state indices are often used to categorize the water quality of a lake. The Carlson Trophic State index is most frequently used. Developed in 1977, the index is based on the measurements and relationships of total phosphorus, chlorophyll a, and Secchi disk transparency. Using these parameters, lakes can be ranked according to their level of productivity (See Figure 5.2 for scores and classifications). Very productive lakes (i.e. those that support large populations of plants and algae) result from high nutrient levels and are classified as eutrophic. Lakes with low biological productivity, characterized by exceptionally clear water, are classified as oligotrophic.

Figure 5.2

Carlson's Trophic State Index	
20-39	Oligotrophic
40-54	Mesotrophic
55-64	Eutrophic
65+	Hypereutrophic

b.) Indicators

The lakes in Monroe County are actually man-made impoundments, or reservoirs. Monroe County has three reservoirs: Monroe, Griffy and Lemon. Lake Griffy and Lake Lemon were originally constructed to provide Bloomington with drinking water. Today, Lake Monroe is Bloomington's primary water source but Lake Griffy and Lake Lemon remain emergency back-up sources.

▪ **Lake Monroe**

Lake Monroe is located approximately 10 miles south and east of Bloomington. The U.S. Army Corps of Engineers completed construction of the Monroe Reservoir in 1965 and remains responsible for its operation. The reservoir provides drinking water, flood control, recreational opportunities, and wildlife habitat. Lake Monroe serves as the drinking water source for more than 100,000 people in Bloomington and surrounding communities. It also has become one of the most important recreational and economic resources in southern Indiana, averaging 1.27 million visitors per year from 1982 to 1992.[24]

As the largest lake in the state, the 10,750-acre reservoir lies almost entirely in Monroe County (it is partly in Brown County). Lake Monroe's watershed extends 440 square miles across Monroe, Brown, and Jackson Counties. Very small portions lie in Bartholomew, Lawrence, and Johnson Counties. Approximately 90 percent of the watershed is forested, including parts of the Hoosier National Forest (78,000 acres) and Yellowwood State Forest (40,000 acres). Salt Creek provides most of the watershed's drainage.[25]

During the 1990s, several issues regarding the existing and future quality of Lake Monroe prompted increased concern including deteriorating water quality, increasing watershed development, the threat of shoreline development, and the lake's economic value. Based on data collected in 1992 and 1993, the Lake Monroe Diagnostic and Feasibility Study was developed to identify problems occurring within the lake and to generate technically feasible solutions to these problems. The study identified the following problems and issues requiring management:

1. Poor water transparency in the Upper and Middle Basin. The suspension of fine clay particles limits the amount of light available to algae, increases turbidity, and decreases the aesthetic appeal of the lake.
2. High phosphorus concentrations measured in the Upper Basin.
3. Sediment loading to the lake from erosive alluvial soils along stream banks and valley bottoms in the watershed.
4. Shoreline erosion causing poor water transparency, sediment accumulation, degraded aesthetics, and property damage.
5. Sediment accumulation in the upper ends of the lake has caused local navigation problems.
6. Urbanization and construction within the watershed could increase the current sedimentation rate (0.03 inches/year) by a factor of 10 to 100.
7. Elevated concentrations of arsenic, chromium, nickel and zinc in sediments sampled from Sugar Camp Creek Bay.
8. Heavy human recreational use contributes to lake degradation and threatens the enjoyment of the lake.
9. More study is required to investigate the presence (or absence) of algal toxins in the lake.
10. The scenic beauty of the Lake Monroe's shoreline zone should be maintained.
11. No comprehensive, coordinated program to protect and manage Lake Monroe and its watershed exists.[26]

In the report, best management practices applied to the agriculture, forestry, and construction industry within the watershed were identified to ease most water quality problems experienced in Lake Monroe. These practices would help prevent the flow of excess water, sediments, and nutrients into the lake. Within the lake, shoreline erosion and human use management would also improve lake quality and maintain high drinking water quality.

- **Lake Griffy**

Lake Griffy is a 109-acre reservoir located approximately 2 miles north of Bloomington. The watershed area of Griffy Lake is approximately 6.6 square miles and is drained by Griffy Creek. The lake provides recreational activities and serves as an emergency potable water supply for Bloomington.[27]

The students and faculty at Indiana University have studied water quality parameters at Griffy Lake for a number of years. Griffy Lake is mesotrophic to eutrophic according to data collected by IU students in the fall of 1999.[28] Total phosphorus concentrations averaged 0.037 mg/L during a late summer sampling. Dissolved oxygen was plentiful at the surface but dropped to near zero below 6 meters. Secchi depth, a measure of water transparency, was measured at 4.5 meters in 1999. Transparency has improved since 1995 when the Secchi depth was measured at 3.5 meters. Slightly lower total phosphorus concentrations were measured in 1995 – with an average concentration of 0.016 mg/L.[29] As in 1999, dissolved oxygen levels approached zero below 6 meters in depth.[30] Bacterial decomposition of excessive plant material and algae causes oxygen depletion in the lake's lower levels.

Rooted aquatic plants continue to be problematic in Lake Griffy. Exotic species, particularly curlyleaf pondweed and Eurasian water milfoil, have formed dense vegetative stands near the shoreline. From 1992 to 1998, Eurasian water milfoil went from being nonexistent to becoming the dominant aquatic vegetation species.[31] These aquatic plants greatly hinder boat navigation and other recreational activities. Proliferation of aquatic plants may reflect the level of nutrient inputs into the lake.

Sedimentation rates into the lake also continue to be a major area of concern. At the mouth of Griffy Creek, a large sediment delta and marshy area continues to expand. Sedimentation rates increase during and after significant rainstorms due to erosion from construction sites and other unprotected areas. Development around the South Fork of the watershed may also be contributing to the sedimentation problem.[32]

In February 2000, a Griffy Lake Watershed GIS Mapping and Management Plan was completed. The study evaluated the effects of watershed land use on the water quality of Griffy Lake. Evaluation of the lake's tributaries showed that the South Fork of Griffy Creek was most affected from nonpoint source pollution. The nonpoint source pollution, specifically excessive sedimentation, was attributed to increasing development in the South Fork region of the watershed.[33]

The study also concluded that the water quality of Griffy Lake has generally improved since the 1970s. The Carlson Trophic State Index (TSI) scores have decreased from a range of 47-75 in the 1970s to 40-50 in the 1990s.[34] Transparency and total phosphorus measurements have also decreased since the 1970s, indicating an improvement of water quality.

- **Lake Lemon**

Lake Lemon is a 1440-acre reservoir and is located in Brown and Monroe Counties. The impoundment was constructed from 1951-1956 to serve as a drinking water source for the city. It provided drinking water to Bloomington until the mid-1970s and is still classified as a back-up water supply. Bean Blossom Creek is the Lake's major tributary draining a watershed that extends approximately 70 square miles.

Created in 1996, the Lake Lemon Conservancy District operates, maintains, and manages Lake Lemon for recreation, wildlife habitat and water quality. Water quality testing is conducted twice a summer in two locations on the lake and one location in Bean Blossom Creek.

Lake Lemon is classified as a eutrophic lake for total phosphorus and Secchi disk transparency. Historical data for the Lake using Carlson's criteria show that the Lake Lemon has been considered eutrophic since

the mid-1970s.[35] Concentration levels of phosphorus and nitrogen are relatively high in the lake. Secchi disk measurements (ranging from 0.2-1.6 meters) taken in 1996-1999[36] show that the lake transparency is poor compared to other Indiana lakes (median Secchi depth of 1.6 meters).[37] Low transparency is caused by algae and suspended sediments in the water.

Sedimentation is a major problem in Lake Lemon.[38] The East end of the Lake acts as a settling basin for sediments entering from Bean Blossom Creek. High sediment loads during storm events and stream bank erosion of Bean Blossom Creek contribute to high levels of suspended solids in the lake.

Failing septic systems along Bean Blossom Creek and the lake shoreline have been identified as significant sources of bacteria and nutrients to Lake Lemon.[39] Fecal coliform concentrations ranged from 15 to 31 coliforms/100 ml in 1996. Although these measurements are below the body contact standard for fecal coliforms, poorly functioning septic systems have caused historically high bacteria concentrations.[40]

Exotic invasive plants impede boating and recreational activities on the Lake and inhibit the growth of native aquatic plants. Eurasian milfoil is treated with herbicide in nuisance areas and Purple loosestrife plants have been aggressively sought out and removed.[41]

A fisheries management plan completed in early 2001 indicates that the fishery is in good condition with a balanced and healthy population. The plan recommends no new stocking efforts, a reduction of the number of bass tournaments, and the addition of habitat structure.[42]

A watershed management plan for Lake Lemon is currently being developed to address the Lake's water quality issues. One of the goals of the management plan is to identify the major sources of sediment in the watershed. A shoreline stabilization program is underway to stabilize eroding areas of the shoreline and reduce non-point source pollution. The stabilization of 2,829 feet of shoreline at nine priority sites around the Lake is to be completed in 2001.

Future goals include the development of a nuisance wildlife and exotic species plan, continued development of the watershed management plan and continued non-point source control and shoreline stabilization.[43]

c.) Interpretation and Evaluation

Lake water quality in Monroe County ranges from good to poor. Eutrophic conditions indicate high biologic productivity as a result of nutrient inputs. These conditions have remained fairly constant over time with slight improvement in the last two decades. Nutrient inputs from the watershed and failing septic systems are sources of nutrient loading in these lakes, specifically Lake Lemon and Lake Griffy.

Sedimentation is a major problem in all Monroe County reservoirs. The source of this problem can be directly attributed to extensive erosion in the watershed and run-off from developed areas.

As in many Indiana lakes, Bloomington area lakes are experiencing invasive plant growth problems. Eurasian milfoil esspecially has become a problem in Lake Lemon and Lake Griffy. In addition to decreasing the recreational value of these lakes, the wildlife habitat and ecosystem quality is significantly decreased by this invasive species. Although herbicide treatments are used to keep the Eurasian milfoil under control, it is extremely difficult and essentially impossible to eradicate from the lakes.

Watershed-level approaches to managing the area's lakes and reservoirs would address many of the lakes' water quality issues. A common theme in all the lakes is the significant input of sediment and nutrients. The Lake Monroe Diagnostic and Feasibility Study recommends that best management practices be used in all industries within the watershed to reduce sediment loads. In-lake practices such as re-grading and vegetative

stabilization would ease shoreline erosion. Failing septic systems along streams and lake shores add nutrients into a lake which contribute to biologic overproduction and eutrophication.

Increased development in the Bloomington area emphasizes the need for land-use analysis and strict adherence to best management practices to reduce erosion and lake sedimentation or the problem will worsen.

Work has begun to manage the health of the region's lake ecosystems and reverse trends of deteriorating lake water quality. For example, the Lake Lemon Conservancy District is actively engaged in monitoring and identifying lake problems and addressing them in an extensive management plan. The City's Griffy Lake Watershed Georgraphic Information System (GIS) Mapping and Management Plan uses GIS technology to analyze the relationship between land use in the watershed and the ultimate health of Griffy Lake. This study enables officials to pinpoint the locations within the watershed that present the greatest threat of contamination. From this, treatment strategies can be developed to reduce non-point source pollution from the watershed. The extensive diagnostic study of Lake Monroe identified problem areas, established priorities and presented management recommendations.

Finally, it is essential that Bloomington residents take part in protecting the region's lakes by supporting land use mechanisms that protect water quality and avoid participating in activities that cause siltation or pollution. The activities that occur in a lake's watershed directly affect the water quality of that lake. Cooperative community efforts to monitor and enhance the area's lakes and watersheds will maintain drinking water quality as well as the lakes' numerous attributes including their beauty, recreational resources, and wildlife habitat.

d.) Linkages

Lake water quality is linked to stream water quality, erosion, development and recreation. It affects drinking water quality, wildlife habitat, and economic health.

3. Water Use and Treatment

a.) Definition

Water designated for consumption must be cleared of contaminants before delivery to customers. After use in sinks, toilets, and showers, water must be treated again prior to discharge to a local creek or river system. Both processes screen out solids, and then chemicals are added to clarify and disinfect the water. Plant operators test water samples frequently for contaminants before and after the treatment process. The more water consumed by the local population, the more needs to be treated at drinking water plants and wastewater treatment plants.

Federal water laws, specifically the Clean Water and Safe Drinking Water Acts, dictate the acceptable concentrations of contaminants in both treated wastewater and drinking water. In recent years, the EPA has strengthened the drinking water standards to improve public health protection and reduce long-term cancer risks. Stringent requirements and public demand has prompted the implementation of more effective treatment processes throughout the country.

b.) Indicators

One drinking water plant and two wastewater treatment plants serve the City of Bloomington. The Monroe Water Treatment Plant obtains water from the Monroe Reservoir, located six miles southeast of Bloomington. The City purchases the water for treatment and distribution from the State of Indiana. The Dillman Road and Blucher Poole facilities serve as the City's wastewater treatment plants (WWTPs). Each plant employs an activated sludge system to treat the wastewater produced by the city. The Dillman Road WWTP discharges treated effluent into Clear Creek and the Blucher

Poole WWTP discharges effluent into Bean Blossom Creek.[44]

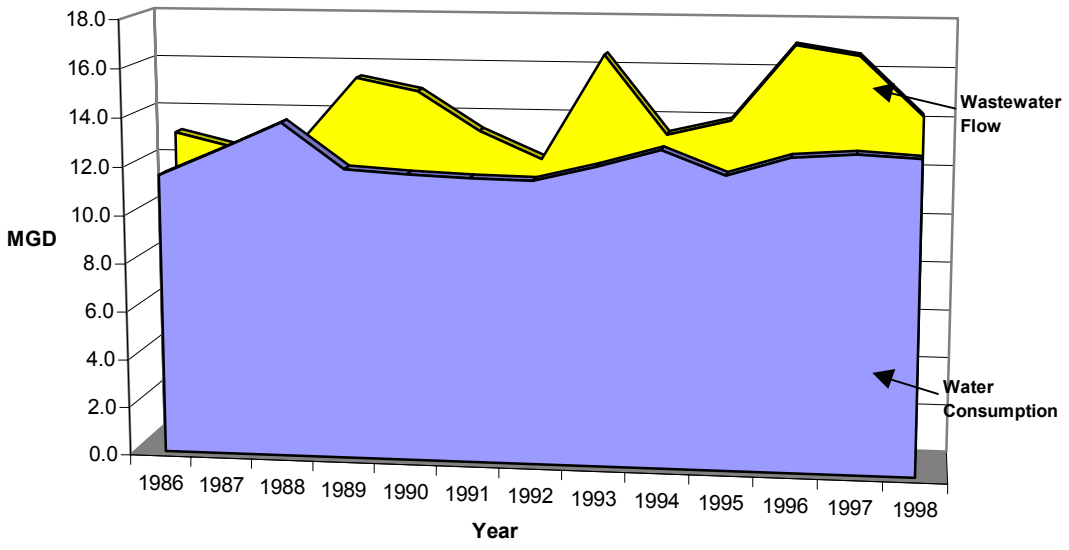
Bloomington's drinking water source, the Monroe Reservoir, is a surface water source. As water travels through the Monroe Reservoir drainage area over the surface of the land or through the ground, it can dissolve naturally occurring impurities and pick up substances produced from human or animal activity. To ensure the safety of the City's water source, officials test the drinking water throughout the year for bacteria, turbidity, radioactive contaminants, inorganic and volatile organic contaminants such as nitrates and trihalomethanes (a by-product of chlorination treatment processes) according to EPA safe drinking water regulations. In 2000, a total of 79 contaminants were tested and 12 contaminants were detected but were well below the EPA highest allowable level. Although official testing requirements are not yet in effect, national concern over the presence of MTBE (a potentially harmful gasoline additive) prompted CBU officials to test Bloomington's drinking water. No trace of MTBE was detected in recent water sampling analysis.[45] Residents have also raised concerns over the possible presence of PCBs in the water supply but technicians have never detected PCBs in Bloomington's treated drinking water.

The Monroe Water Treatment Plant has a design capacity to treat up to 24 million gallons per day (MGD). Since 1986, the amount of water consumed by Bloomington residents has increased by 11 percent (See Figure 5.3). In 1986, Bloomington used an average of 11.6 MGD of drinking water. An average of 12.9 MGD was consumed in 1998. That year, the highest monthly average consumption (19.6 MGD) occurred in September. Peaks in water consumption can be attributed to summer drought conditions experienced as in 1994.[46]

The federal Clean Water Act requires the city to perform daily tests on both the inflow and outflow from the Dillman Road WWTP and

Figure 5.3

Bloomington's Water Use and Treatment



	1986	1987	1988	1989	1990	1991	1993	1994	1995	1996	1997	1998
Average Water Consumption/Day	11.58	12.69	13.84	11.98	11.83	11.72	12.31	13.03	12.04	12.83	13.00	12.86
Average Wastewater Flow/Day	13.01	12.4	12.5	15.4	14.9	13.3	16.5	13.3	13.9	17.0	16.6	14.2

Source: City of Bloomington Utilities Annual Reports

Blucher Poole WWTP. Both inflow and outflow concentrations of suspended solids, biochemical oxygen demand, phosphorus, ammonia, fecal coliform, and PCBs must fall within the prescribed limits of an NPDES permit. Appendix B details the average amount of wastewater treated per day in Bloomington as well as influent and effluent constituents measured for each WWTP. The Dillman Road WWTP meets some of the most stringent limitations in the state because it discharges effluent into a low-flow stream – Clear Creek. Clear Creek is designated as a "0-flow" stream and must be maintained to allow for fishing and swimming at all times.[47]

Phosphorus and ammonia effluent concentrations are strictly regulated during the summer months because these nutrients cause the algal blooms that reduce the dissolved oxygen and degrade the water quality of the discharge waters. Dillman Road WWTP is limited to an effluent concentration of 1.0 mg/L of phosphorus from May to October. An average monthly effluent concentration of 2.0 mg/L of ammonia is required from May to November as opposed to a limit of 5.0 mg/L from December to April. In the past decade, yearly averages for each summer indicate Dillman Road WWTP has met the prescribed limitations for ammonia and phosphorus (See Appendix B).

Fecal coliform tests are used as an indication of the presence of harmful microorganisms. A "primary contact" recreation standard is 235 per 100 mL and the Dillman plant is limited to 200 per 100 mL. An average of 20 fecal coliform bacteria per 100 mL effluent was measured in 1999 and 13 the previous year at the Dillman Road WWTP (See Appendix B). Weekly NPDES limits were exceeded four times in 1999. These suspended solids and mass load limitations were exceeded at times of heavy wastewater inflow.[48]

c.) Interpretation and Evaluation

As the population of Bloomington increased by 10.1 percent from 1990-1999, average drinking water consumption increased by approximately 8.7 percent (from 1990-1998). This trend indicates that the City's water consumption needs have grown along with the population. Weather variations (e.g. seasonal droughts) heavily influence water consumption rates.

Future projects to develop a stand-by power source to the Monroe Water Treatment plant and a new ground storage tank will ensure continuous water service to the City in the event of a prolonged plant power failure and to meet future demands. Other projects to treat recycled backwash and filtrate water differently are currently being developed to further decrease the probability of any contamination of the drinking water supply.[49]

According to drinking water quality testing in 2000, Bloomington has continued to surpass all federal and state drinking water indicating that the City continues to enjoy safe and high quality drinking water.

The Dillman Road WWTP continues to receive the majority of the City's wastewater, an average of 12.2 MGD in 1998, and Blucher Poole WWTP treated an average of 2.0 MGD for the same year (See Appendix B). With some exceptions, the Dillman Road plant operates within the stringent permit limits of its influent and effluent. Violations of permitted discharge mass limits experienced in previous years are associated with sewer infiltration problems and limitations that had been developed with an assumed flow level of 15 MGD.[50] To address this problem, projects are currently underway to increase the treatment capacity of the Dillman Road WWTP facilities and improve the city's aging collection system. A tiered NPDES permit is under consideration by the state that would allow for less stringent discharge limits during high flow periods in the system that coincide with Clear Creek high flows. This adjustment would also ease permit violation problems.

A wet weather study performed in 1997 concluded that stormwater and groundwater infiltration into the sewer system was a major contributing factor in the failure to meet NPDES permit limits periodically by Dillman

Road WWTP. Expanding the treatment capacity will increase the plant's ability to handle peak flow rates during wet weather events. Efforts to rehabilitate Bloomington's aging collection system are ongoing, most recently evidenced by construction in the downtown Bloomington area.[51] The entire wastewater system and infiltration problems need continued attention from Bloomington residents and officials. Unfortunately, collection system reconstruction necessary to ensure WWTP permit compliance often causes traffic disruptions and large capital expenditures. Current projects show the City's commitment to address the problems of wastewater system.

d.) Linkages

Water use and treatment is linked to population growth, energy use, infrastructure, stormwater and weather conditions. Effluent released by the wastewater treatment plants affects the water quality of Clear Creek and Bean Blossom Creek. Sludge produced as a by-product of water and wastewater treatment is transported to the county landfill, thereby affecting solid waste production. Because the Monroe Reservoir is a surface water source, its water quality is directly linked to erosion and surface water runoff.

4. Storm Water Runoff

a.) Definition

Storm water is water from rain and snowmelt that accumulates on the ground surfaces of urban areas such as roads and parking lots. This water is diverted into storm drains and eventually discharged directly into local waterways. The impervious surfaces of urban areas do not allow water to infiltrate into the ground as it would naturally. The EPA estimates that a typical city block generates nine times more runoff than a similarly sized woodland area because the land's capacity to absorb water has been lost.[52] Water remains on the land surface and runs off in large volumes.

Cities construct enclosed underground drainage systems or diversion systems to quickly channel storm water out of urbanized areas and prevent flooding. As the diverted storm water enters a stream, it often causes erosion problems, damages riparian vegetation, and compromises water quality. Storm water runoff discharged into streams results in dramatically changing water levels during wet weather, increased sediment loads, increased water temperatures, and pollutant contamination. As a result, aquatic communities can suffer from urban storm water runoff.[53]

Urban storm water runoff affects water quality, habitat, and public health. As storm water runs off city streets, parking lots, lawns, and rooftops, it carries pollutants to receiving waterways. Pollutants associated with urban runoff include sediment, petroleum hydrocarbons, metals, pathogens, and nutrients such as nitrogen and phosphorus. Of the U.S. waterbodies surveyed, storm water runoff is the leading cause of impairment to those waterways.[54]

Typical pollutant loadings from urban runoff vary according land use (See Figure 5.4). Construction sites are significant sources of sediment loading to local waterways. The quantity of the pollutants discharged into receiving waters tends to increase with the level of urban development, impervious surfaces, and land disturbance.[55]

To improve the quality of discharge streams, local governments are incorporating best management practices (BMPs) into their storm water management programs. BMPs reduce the volume of storm water runoff, provide on-site infiltration and storage, and filter out contaminants from the runoff. BMPs such as the installation of catch basins, infiltration trenches, filter strips, grass swales, and the minimization of the installation of traditional curb and gutters can significantly reduce the negative effects of storm water

Figure 5.4 Typical Pollutant Loadings from Runoff by Urban Land Use (lbs/acre-yr)

Land Use	Total Suspended Solids	Total Phosphorus	Biological Oxygen Demand	Lead	Zinc	Copper
Commercial	1000	1.5	62	2.7	2.1	0.4
Parking Lot	400	0.7	47	0.8	0.8	0.04
HDR	420	1	27	0.8	0.7	0.03
MDR	190	0.5	13	0.2	0.2	0.14
LDR	10	0.04	n/a	0.01	0.04	0.01
Freeway	880	0.9	n/a	4.5	2.1	0.37
Industrial	860	1.3	n/a	2.4	7.3	0.5
Park	3	0.03	n/a	0	n/a	n/a
Construction	6000	80	n/a	n/a	n/a	n/a

HDR: High Density Residential, MDR: Medium Density Residential, LDR: Low Density Residential

n/a: Not available; insufficient data to characterize loadings

Source: Adapted from EPA's Preliminary Data Summary of Urban Storm Water Best Management Practices Report, 1999

runoff. For example, filtration systems removes an average of 45 percent total phosphorus, 32 percent total nitrogen, 71 percent lead, 37 percent bacteria, and 81 percent suspended solids.[56]

b.) Indicators

The city of Bloomington has approximately 150 miles of underground storm sewers in its urbanized region to transport storm water to local streams. Other drainage ways such as curb and gutter systems also transport storm water from the city's land surface to local waterways.

As development increases in Bloomington, the amount of impervious surface area and disturbed land area also increases. In turn, the volume of storm water per rain event that becomes runoff increases. As noted in previous sections of this report the land area in the city has more than doubled since 1970 and the number of city road miles has increased by almost 90 percent since 1972.

Until the early 1990s, there were no requirements to detain and treat storm water on site in either the county or the city. Amendments made to the Clean Water Act in 1987 initiated the development of the EPA's NPDES Storm Water Program to address the non-agricultural storm water sources that negatively affect the nation's waterways. The National Pollutant Discharge Elimination System (NPDES) permitting program requires controls to be implemented to prevent the pollutants of storm water runoff from entering local waterways. Phase I of the program addressed storm water runoff from cities with populations greater than 100,000. Effective as of 1999, Phase II of the program requires small municipalities, such as Bloomington, to obtain an NPDES permit for the municipal storm water system and develop a management program to prevent pollutants from entering local waterways via storm water runoff. Permits must be obtained by March 2003 and management plans must be fully implemented by the end of the permit terms (approximately 5 years).[57]

The City of Bloomington requires that construction sites of any size comply with a specific set of erosion and pollution control requirements to reduce pollutant runoff from the site. These requirements include: (1) site dewatering – sediment laden water must be detained and discharge erosion must be minimized, (2) waste and materials must be properly disposed, (3) sediment must be prevented from being tracked into roadways, (4) all storm inlets must be protected, (5) runoff from adjacent sites must be diverted, (6) all disturbed land must be seeded and stabilized within 14 days of the last ground disturbance, (7) for sites greater than 10 acres,

sedimentation basins must be constructed, (8) filter fences must be installed around the sideslopes of the site, (9) vegetative cover must be established on any vacant land held for development, and (10) soil piles must be stabilized or covered if they remian for more than 14 days.[58]

The Bloomington/Monroe County Urban Non-Point Source Pollution Assessment, completed in 1997, concluded that many of the local streams are negatively affected by urban runoff. High sedimentation loads in these streams accounted for much of the degradation they are currently experiencing (see section 5.1 – Stream and River Water Quality for more details).

In addition to pollution problems, Bloomington's aging storm sewer system suffers from deterioration. Many of the underground pipes were constructed several decades ago and are in need of replacement. In its infrastructure report, the Bloomington Chamber of Commerce wrote: "the investment needed to address existing drainage problems is significant…A comprehensive storm water management plan must be developed that will include system analysis, risk analysis, planning, priority setting, financing, maintenance, construction, water quality and all other necessary regulatory components."[59]

c.) Interpretation and Evaluation

Storm water runoff from Bloomington's urban areas has resulted in water quality problems in local waterways. The pollution caused by urban runoff is a major source of impairment to local waterways according to the 1997 Non-Point Source Pollution Assessment. Increasing development and declining water quality in Bloomington emphasize the need to address non-point source pollution and urban storm water runoff.

Sediment washed down storm water drains from roadways or construction sites is not often considered as a pollutant by the public, but it actually generates serious water quality problems in the local streams and rivers. Figure 5.4 shows that construction sites can deliver a massive amount of total suspended solids to waterways via storm water runoff. This highlights why the city's erosion control requirements should be carefully followed and enforced.

Bloomington will be required to meet the NPDES permit requirements and develop a comprehensive management plan under the second phase of the EPA's NPDES Storm Water Program. Efforts are currently underway to meet these upcoming requirements.

It is easy for people to forget where storm water goes once it disappears down a storm drain. Residents must understand that storm sewers discharge directly into local streams without any treatment. Often, storm water can be just as polluted as the wastewater that goes to wastewater treatment plants. Residents must be educated about storm water runoff and encouraged to use best management practices throughout the city to ensure the quality of the creeks, rivers, and lakes in the region.

d.) Linkages

Storm water runoff is linked to water quality, erosion, population growth, transportation, development and urban sprawl.

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VI. Soils, Erosion, and Siltation

Introduction

Soil erosion occurs when the natural ground cover is removed from the land. A major problem for agricultural lands, soil erosion results in millions of dollars in lost production capability when valuable nutrients wash off the land with the soil. The Dust Bowl of the 1930s occurred largely due to poor farming practices that led to massive erosion. The Great Lakes Commission, a service organization of the eight states surrounding the lakes, estimates that 6 million tons of soil erodes from Indiana into the Great Lakes Basin each year.[1]

Across the United States, approximately 4 billion tons of soil is lost from 160 million hectares of cropland yearly, resulting about $27 billion in economic losses.[2]

Erosion Prevention and Control

a.) Definition

Erosion by wind or water is a natural process that can significantly change a landscape. Soil and plant cover, weather, and slope gradient all affect the potential for erosion. Agriculture, logging, and urban construction significantly increase erosion by removing protective plant cover and baring soil to the effects of wind, precipitation and surface runoff. Land conversion from woodland to light development – with no erosion control – increases the volume of sediment loss from 100 tons per square mile per year to 10,000 during the construction phase.[3] Wind erosion can also take up valuable topsoil from agricultural or construction areas, which leads to air quality problems.

Surface water runoff transports loose soil particles into local waterways. In streams, sediment reduces water quality and harms aquatic habitat. Nutrients, especially phosphorus, bind to soil particles and "fertilize" streams, contributing to increased algae growth and decreased dissolved oxygen levels. Sediment clouds the water, harms fish habitat, decreases the respiration ability of fish, reduces stream depth, and can lead to flooding. Unchecked, erosion on steep slopes creates gullies, sloughing and landslides.

b.) Indicators

The City of Bloomington sits atop a thick soil layer classified as the Crider-Caneyville unit by the U.S. Natural Resources Conservation Service (formally U.S. Soil Conservation Service).[4] Some areas near the city have thin, stony soils that overlay limestone or siltstone. The undulating terrain ranges primarily from 2 to 18 percent slope. Karst features are prevalent in the limestone bedrock, especially in the western part of the city. Windblown silt comprises a topsoil layer up to three feet thick in undisturbed, i.e. underdeveloped, areas. Red clay and unconsolidated rock is sandwiched between the upper layer of silt and the limestone bedrock. The Crider and Caneyville soils are extremely erosive when left bare during rain events. Soils on steeper slopes erode more quickly than soils on flatter terrain.

Soils in the watersheds of Griffy and Monroe Lakes differ from those of the city due to steeper slopes and underlying bedrock of sandstone, siltstone and shale. However, these soils share the high potential to erode. In a 1984 long range management plan for Griffy Lake, William Jones estimated the wooded northwest sub-basin lost 0.81 tons per acre (less than 0.01 cm) annually while the steeper wooded northeastern basin lost 1.37 tons/acre (0.02 cm) annually. Loss of woodland cover would result in soil losses of 15.4 cm annually, the report estimated.[5]

Jones' 1997 report on Lake Monroe estimates that the bottom of the lake fills with sediment at a conservative average of 0.03 inches per year (32,825 tons). This rate is three times higher than previous estimates from the 1970s.[6] The report notes that sedimentation does not occur evenly, with the upper basin experiencing sedimentation rates 2-4 times higher than the lower basin. The report did not draw conclusions about the sedimentation increase, but noted that conversion of forest land in the watershed to other land uses would likely increase erosion and sedimentation rates.

Developers can control erosion through the use and proper installation of best management practices (BMPs). Such practices include seeding and mulching disturbed areas, installing sediment traps and filter strips, and limiting soil disturbance to small areas.

The City of Bloomington passed its first erosion control ordinance in early 1992 to require developers to use best management practices and keep soil on building sites. Two events prompted its passage: 1.) sedimentation from development became a noticeable and measurable problem in waterways in and around the City and, 2.) federal and state regulations required stricter controls.[7]

After the ordinance went into effect, erosion and sedimentation continued with little improvement. Developers, local engineers and construction personnel were not educated

about efficient methods to prevent soil from washing off construction areas. In addition, the city did not have effective enforcement tools to prompt developers to follow the new rules. Starting in 1994, the Environmental Commission conducted an informal survey of developers' compliance with the erosion control ordinance at large scale developments. During the survey, a site was noted "out of compliance" if sediment was clearly leaving the site, or entering a storm drain, sinkhole or waterway. Between two-thirds and three-quarters of the sampled sites failed to comply with the erosion control ordinance at some point between 1994 and 1996.[8]

Negative impacts have been particularly troublesome and long-lasting at the upper end of Griffy Lake where a large sediment delta extends from the mouth of Griffy Creek into the lake. Development in the Jackson Creek watershed in southeast Bloomington is causing similar problems with water quality in the creek (See Chapter 5, Water Quality).

The Common Council formed an erosion control task force in 1997 after the Environmental Commission repeatedly questioned the effectiveness of the existing ordinance, developers complained about the lack of consistency and clarity, and city planning staff expressed a desire to improve the efficiency of enforcement.

The task force evaluated the existing ordinance and developed draft language for revised rules. The Common Council adopted the new ordinance in November 1997. It improved the enforcement provisions and required developers and city personnel to agree on an erosion control plan during a pre-construction conference.

Under the new ordinance, the City can fix a recurring erosion problem and require the developer to pay for the work after the fact. Developers who continue to ignore erosion control requirements will have a lien placed on the property to cover the cost incurred by the City to mitigate the problem.

In April 1998, the Environmental Commission (EC) conducted a study to see if the ordinance was being properly implemented. This study found that the new ordinance was being enforced, but recommended further study. Therefore, between March and December 1999, the EC surveyed 12 sites once a month to determine the effectiveness of the erosion control ordinance. In addition, a photographic record was created. However, because of a lack of comparison data from the City's Engineering department due to high staff turnover, the comparison study was impossible to complete. The largest source of information from the Engineering department was extensive notes taken by the main erosion control inspector for 1999. Therefore, it was determined that an audit of those notes would be the best way to determine how well the erosion control ordinance is being enforced.

The main issue raised during this audit was the repeated use of verbal warnings and subsequent postponement of notice of violation issuance.[9] The easiest way for those enforcing the ordinance to ensure that the site gets cleaned up quickly was to call the supervisor of the site and ask them to clean it up. Notices of violation and subsequent citations were only issued in severe cases of non-compliance and after repeated verbal warnings. As a result, paper trails to document the history of each site do not exist.

c.) Interpretation and Evaluation

Soils in and around the city and in the watershed of the drinking water supply have a high potential for erosion. Urbanization and more intensive land use have likely increased erosion rates, compromising water quality. Development around Lake Griffy has increased the rate of erosion above the rate reported in the 1984 management plan. At Lake Monroe, erosion has created steep drop-offs in some areas and led to the loss of shoreline.

Without effective erosion control, development on slopes and around karst features will have long-term repercussions. Saturated soils can give way, taking hillsides

and roads as they go. In the Lake Monroe watershed, erosion causes siltation in Lake Monroe and reduces the reservoir's holding capacity. Over the long term, reduced capacity affects drinking water quality and flood control; capabilities for which the reservoir was created.

Siltation of karst areas will eventually lead to localized flooding. Karst features, such as sinkholes and underground streams, serve as natural drainageways. Allowed to fill in with sediment, sinkholes force stormwater elsewhere.

Despite major improvements since 1992, and the results and suggestions of the Environmental Commission's recent audit, erosion remains a problem in Bloomington and Monroe County. Much of the problem stems from an attitude that "soil" cannot possibly be a pollutant. This attitude is changing as more developers and the public learn how erosion affects water quality.

The Environmental Commission's audit of the erosion control enforcement suggested several ways to improve the process: 1.) Simplify and streamline the notice of violation process. Roy Aten, Engineering Field Specialist for the city, estimates that it currently takes approximately three hours to file a notice of violation. The current process requires the site inspector to find out who the site contractor is, write up the paperwork, and send two copies out via certified mail. Often figuring out who is in charge of the site is difficult and time-consuming task, which involves finding the permit that was issued for the site. 2.) Give the inspectors ticketing authority. This would allow them to write a ticket on site and eliminate the time-consuming notice of violation process. 3.) Write erosion control measures into the building codes. Since the building department maintains the permits, knows the location of all of the developments, and makes routine inspections on every site, it is efficient for them to be an additional source of erosion control enforcement. 4.) Increase contractor education and awareness of the importance of erosion control and the most effective way to achieve it. 5.) Conduct stream sediment studies prior to, during and after development to ascertain the effectiveness of erosion control measures.

d.) Linkages

Soil erosion is linked to water quality, air quality, aquatic habitat, silting in rivers and reservoirs, and decreased land productivity.

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VII. Wildlife and Natural Areas

Introduction

Natural areas and ecosystems provide the world with many benefits and services. Natural systems support recreational activities, filter air and water pollutants, prevent flooding, provide resources for manufacturing, pharmaceuticals, and energy, regulate climate, provide nutrients, and supports habitat for wildlife. Life depends on the presence of natural systems throughout the world.

Forest cover has been reduced from 50 percent to 17 percent of the earth's land surface and 39 percent of what remains is threatened by human activities including logging and agricultural clearing. Agricultural land, second-growth forests, and development have replaced much of the original forestland in the United States. Over 50 percent of the original wetlands have been destroyed in the continental United States.[1] In 1997, an estimated 105.5 million acres of wetlands existed in the country, constituting just 5 percent of the landscape. From 1986 to 1997, a net total of 644,000 acres of wetlands were lost in the United States. Approximately 30 percent of the wetland losses were attributed to urban development and 26 percent were attributed to agriculture. Those data indicates that the country has not yet met the goal of "no net loss" of wetlands.[2] Human activities such as deforestation, wetland destruction, and habitat fragmentation have led to a rapid rate of species extinction and decline in biodiversity. As of January 2001, a total of 1244 plants and animals were listed as endangered or threatened species in the United States. The number of listed endangered or threatened U.S. species increased almost 30 percent since 1995.[3]

1. Natural Areas, Habitats, and Botanical Resources

a.) Definition

Natural areas provide habitat for native species to flourish and reproduce at a level that is sustainable in the long term. They allow interactions between populations that facilitate plant production and nutrient cycling. Plant and animal species adapt to local conditions and therefore have specific habitat requirements. Some species require large, contiguous areas of forest. Others live in wetland ecosystems while still others are adapted to the moist and dark environment of caves.

Human alteration of the landscape in Indiana has degraded natural ecosystems to such an extent that less than 1 percent of the land represents high quality examples of pre-settlement conditions. Indiana's original habitat types included tall grass prairies, burr oak savannas, limestone glades, cypress swamps, upland forest, sand dunes and marshes. Some communities are still represented but others have disappeared.[4]

Development and agricultural clearing contributed to the landscape changes. Habitat fragmentation is the breakup of one continuous habitat into several smaller ones. Fragmented areas have more "edges" and less "interior" space. As a result, local conditions such as temperature and moisture levels change. Predation from "edge" species increases. This form of habitat degradation negatively affects many species.

Fragmentation, habitat degradation, and pollution put stress on natural systems. The ability of natural areas to provide basic ecosystem functions and values is decreased. Biodiversity and community structure declines and resistance to natural disasters or exotic species invasions is reduced as a result of disturbances and alterations to the natural ecosystems.

b.) Indicators

Of the original 20 million acres of forestland in Indiana, only 2000 acres of old-growth forest remain. Prior to settlement, 15 percent of Indiana was made up of prairie lands. Most was lost due to drainage, agriculture and development.[5] Indiana has lost 4,849,370 acres or 87 percent of its original wetlands. It ranks fourth in percentage of wetland loss among all of the states.[6] Many of the remaining sites are now protected as part of the state's nature preserve system. Approximately 23,000 acres of land in Indiana are now protected in 176 state nature preserves. Other protected sites include those managed as State Fish and Wildlife Areas, Wetland Protection Areas, National Wildlife Refuges, State Forests and the National Park.

Some of the natural ecological communities currently represented in Monroe County include upland forest systems, floodplain forest communities, wetlands, and cave systems. Native upland forests in southern Indiana include communities of Beech-Maple-Poplar trees or Oak-Hickory tree combinations. Slope and soil type generally dictate which communities become established in a certain area. Several examples of these communities are found in natural areas around Bloomington.[7]

The natural regions in Monroe County support a variety of vegetation including some endangered and threatened species. A species is classified as "endangered" when it is in danger of becoming extinct within its habitat range in the near future. A "threatened" species is at risk of becoming endangered within the foreseeable future. The State endangered or threatened plants that are documented in Monroe County include: Lake Cress (*Armoracia quatica*), Northern Catalpa (*Catalpa speciosa*), Butternut (*Juglans cinerea*), Narrow-leaved Puccoon (*Lithospermum incisum*), Green Adder's Tongue (*Malaxis unifolia*), Blackfruit Mountain-Ricegrass (*Oryzopsis racemosa*), Illionois Woodsorrel (*Oxalis illinoensis*), Illinois Blackberry (*Rubus centralis*), and Golden Alexander (*Zizia aptera*).[8] (See Figure 7.1)

Figure 7.1

Endangered, Threatened, or Rare Plant Species for Monroe County, Indiana			
State Endangered	**State Threatened**	**State Rare**	**Watch List**
Lake Cress	Blackfruit Mountain-Ricegrass	Northern Catalpa	Butternut
Narrow-Leaved Puccoon		Illinois Woodsorrel	
Green Adder's Tongue		Golden Alexander	
Illinois Blackberry			

Source: Indiana Department of Natural Resources

Bloomington residents have access to many large natural tracts that they can enjoy in the surrounding region.

Morgan-Monroe State Forest and Yellowwood State Forest.
Both state forest areas support valuable hardwood forests typical of southern Indiana. Located north of Bloomington near Martinsville, Morgan-Monroe Forest extends over 24,000 acres. Prior to the State's acquisition of the land in 1924, the area had been cleared for agriculture. The steep ridges and valleys of the landscape had been abandoned and left to erode because agricultural development proved too difficult in such rocky terrain. Yellowwood Forest is made up of 23,326 acres in Brown County. Along with hardwood species, Yellowwood Forest contains non-native pine species such as red and white pine. Yellowwood Lake (133 acres) is contained within the area. Managed by the Department of Natural Resources, both forest systems offer extensive recreational opportunities and support endangered plants and animals.[9]

Griffy Woods Nature Preserve
This 1,200-acre site is managed by the City of Bloomington Parks and Recreation Department. The area is just north of Bloomington and offers a woodland area complete with trails and recreational opportunities surrounding Lake Griffy. The state endangered plant, green adder's tongue, has been found in the preserve.[10]

Indiana University has recently dedicated 200 acres of its campus adjacent to Griffy Woods as a teaching and research preserve.

Hoosier National Forest
This large area of protected forestland extends over 197,974 acres and is managed for multiple uses. It provides habitat that supports a variety of wildlife. Approximately 50 species of mammals, 142 bird species, 36 reptilian species and 28 amphibian species are located within the region. The Hoosier National Forest is within the ranges of four federally endangered and threatened species including the Indiana bat, gray bat, bald eagle and fan shell mussel. The area also contains caves and unique karst features, which provides habitat to unusual cave species. Hardwood forest stands such as oak and hickory are predominant but the forest also features non-native pine trees that were planted to prevent erosion. The extensive forest system protects and maintains the health of the Lake Monroe watershed. Forty-one different forest types have been inventoried.

Timber harvest is used as a management method in the Hoosier National Forest to enhance the biological diversity of the area. The allowable timber sale quantity is 4.4 million board feet per year. Since 1990, the average amount sold has been approximately 1 million board feet per year.[11]

McCormick's Creek
Indiana's first state park, McCormick's Creek, contains unique limestone and karst features as well as scenic waterfalls. The park is located 14 miles northwest of Bloomington. The wooded area offers a variety of recreational activities to Bloomington residents.[12]

Leonard Springs
This 90-acre site contains karst topography and at least three caves, a series of springs, sinkholes, and a forested landscape. A variety of flora communities are contained within the property. One state listed rare species, the limestone adder's tongue fern was identified during a site investigation. The diversity of plant species in the area was noted in a 1999 floristic and management report. Unfortunately, trash problems have plagued the area in the past. Management recommendations have indicated a need to improve the potential of the site and protect its sensitive character as a natural area park.[13]

Bean Blossom Bottoms Nature Preserve
Managed by the Sycamore Land Trust and located in northern Monroe County, the Bean Blossom Bottoms site is an example of a high quality hardwood wetland region. The Dept. of Natural Resources has designated the area as an Indiana Nature Preserve. Together with the adjacent land managed by the U.S. Fish and Wildlife service the Bean Blossom Bottoms complex encompasses a total of 520 acres. The unique environment provides habitat for a variety of endangered and threatened species.

The Sycamore Land Trust is a non-profit organization in the area dedicated to preserve and conserve natural systems. According to the most recent property update, the Sycamore Land Trust owns 779 acres and 14 properties. From 1999-2000 the Trust acquired 145 acres. The Land Trust has made strong efforts to expand the Bean Blossom Bottoms Nature Preserve complex into a large, contiguous protected unit of land.[14]

The Indiana Chapter of the Nature Conservancy, the Indiana Department of Natural Resources, the Land Trust Alliance, and the local chapter of the Center for Sustainable Living are other organizations in the area involved in land preservation.

Cave and karst systems are among the unique natural environments located in Monroe County. The system formed as a result of natural drainage and erosion of the region's limestone bedrock. Precipitation percolates into the ground and dissolves the calcium carbonate in the rock. This chemical process creates openings and natural drainage ways for runoff. These systems formed over thousands of years and characterize what is known as karst terrain. The topography of these areas features sinkholes, sinking streams, large springs and caves. This landscape also provides important habitat for rare species, including the federally endangered Indiana bat. Most of the karst terrain in Monroe County is privately owned, creating challenges for protecting the resource. Other threats to the health of these sensitive systems include excessive sediment from runoff, failing septic systems that introduce bacteria and nutrients into the system, vandalism, and pollutant infiltration.[15]

Although Bloomington's stream systems have the potential to be valuable natural systems and to support quality habitat, they show signs of degradation (see Chapter V). The riparian zones along rivers and creeks can provide many benefits to a community. In addition to their aesthetic and recreational value, riparian zones have the capacity to buffer waterways from non-point source runoff originating from agricultural, urban, or other areas. Healthy riparian zones can absorb sediments, chemical nutrients, and other substances contained in non-point source runoff. Currently, the Bloomington Parks and Recreation Department is restoring riparian regions and developing recreational trails along Jackson Creek and Clear Creek.[16]

c.) Interpretation and Evaluation

Bloomington residents benefit from living within a wide range of natural areas and habitats. The Hoosier National Forest, the state forests and parks, and protected natural areas provide residents with the opportunity to enjoy the natural areas of the region. Conservation of these areas protects the important functions and values of the natural ecosystems. The region's forested areas are representative of southern Indiana's hardwood forest systems. They clean the air, serve as carbon dioxide sinks, protect the local watershed, and support endangered wildlife

habitat. Wetlands provide flood control, filter nutrients and pollutants from surface water, and support high levels of wildlife biodiversity. The intensive destruction of wetlands in Indiana in the past emphasizes the need to protect the remaining natural systems and restore degraded systems.

The karst areas of the region require special consideration and protection due to their sensitivity and native importance. They are unique systems that provide important habitat for local wildlife. Water quality maintenance is also important for the protection of these systems. Private property rights often prompt difficulties for conservation efforts. Increased development pressure in karst areas also threatens the integrity of the system. The Leonard Springs site is an example of an important natural area in Bloomington that exhibits karst topography. Previous evaluations of the site have recommended that this area be protected and managed as a state park.

Habitat destruction and fragmentation threaten the natural ecosystems of the region. Increased pollution due to a growing population and irresponsible activities also damages these systems. In natural stream and riparian systems, PCB contamination and non-point source pollution inhibit diversity and degrade the waterways. Urban sprawl and development in the regions surrounding Bloomington destroys and fragments many natural areas. These activities also increase the sources of pollution. Construction of the additional roads in Bloomington indicates that natural areas were fragmented to accommodate these roadways.

State and federally protected regions and the areas conserved by land trusts such as the Sycamore Land Trust represent efforts to maintain and preserve the region's natural areas. These efforts to increase the protection of natural areas should continue in order to maintain the unique and valuable landscape of the Bloomington area. Thus far, protection of the cave systems has consisted of working with local cave preservation organizations and landowners to manage the surrounding areas to protect the cave and karst systems. Given the sensitive nature of these systems, initiatives to conserve such areas from pollution and development should be expanded.

d.) Linkages

The quality of natural areas is linked to water quality and air quality. Population growth, development, and erosion also affect natural environments. Regional wildlife depends on the quality of habitat provided by these natural areas.

2. Wildlife

a.) Definition

Wild animals are those species not bred for domestic or agricultural uses. They depend on the natural environment to provide the habitat necessary for their survival. Urbanization and habitat fragmentation threaten the survival of many species. Officials closely watch the populations of many species experiencing declines within the state. Wildlife managers track other species for their value to hunters and anglers. The status of wildlife is often an indicator of the quality of the natural environment that encompasses their habitat.

b.) Indicators

Of the state listed endangered, threatened or rare wildlife, Monroe County supports 11 bird species, 6 mammal species, 4 reptile species, and 2 amphibian species (See Figure 7.2).[17] Five species that were state listed as threatened in 1997 have been reclassified as endangered. These species are the Four-toed salamander, Northern crawfish frog, Kirtland's snake, Timber rattlesnake, and the American badger. This indicates that the populations of these species have continued to decline.

Destruction of the bald eagle's habitat contributed to that species disappearance from Indiana in 1897. The Bald Eagle Reintroduction program was initiated after study results showed that restoration of bald eagles to Indiana was feasible. The first phase

Figure 7.2

Endangered, Threatened, and Rare Animal Species for Monroe County, Indiana	
State Endangered	**Species of Special Concern**
Four Toed Salamander	Rough Green Snake
Northern Crawfish Frog	Western Ribbon Snake
Kirtland's Snake	Sharpshinned Hawk
Timber Rattlesnake	Redshouldered Hawk
Bachman's Sparrow	Broadwinged Hawk
Upland Sandpiper	Cerulean Warbler
Bald Eagle*	Wormeating Warbler
Least Bittern	Black and White Warbler
Northern River Otter	Hooded Warbler
Bobcat	Least Weasel
Indiana Bat**	
American Badger	
	*Federally Threatened
	**Federally Endangered

Source: Indiana Department of Natural Resources

of the program released 73 bald eagle chicks at Monroe Reservoir from 1985 to 1989. Bald eagles return to within 50-100 miles of where they fledged when they reach adulthood at 4-5 years old. In 1991, the first successful bald eagle nest was established at the Monroe Reservoir. Since then, the population has been carefully monitored as nesting sites increase. In 2000, 16 successful nests were established and 35 young fledged. This is an increase from 17 young fledged in 1995. The number of young fledged is expected to steadily increase into the future.[18]

The Indiana bat (*Myotis sodalis*) is both a federally endangered species and a state endangered species. The Indiana bat serves as a good indicator species for cave habitat, water quality, and mature riparian forests because all three parameters affect its population. The bats hibernate in caves during the winter and occupy dead or dying trees of mature forests in the summer. Monroe County cave systems are hibernation locations for the Indiana Bat. The species was originally listed as endangered in 1967. Their population decline is attributed to human-induced disturbance of their hibernating habitats and to the deforestation and fragmentation of summer forest habitats. Although populations continue to decline in other states, Indiana populations are steady and possibly increasing slightly.[19]

In 1999, Indiana joined the North American Amphibian Monitoring Program (NAAMP) when Indiana University's School of Public and Environmental Affairs initiated a pilot study in Bloomington and expanded it state-wide in 2000. NAAMP was created to involve states in monitoring amphibian populations. National concern has been growing about the declining amphibian populations and the substantial gaps in research on amphibian populations. Indiana's crawfish frog is a state endangered species and three additional frog species are considered rare. The monitoring program uses volunteers to study amphibian populations by random-route calling surveys. 243 trained volunteers surveyed 43 of 56 random routes in 2000 and the program is expected to expand to 100 percent coverage of the routes for the 2001 season. The 2001 season is currently underway at the time this report was printed.[20] Amphibians have specific habitat requirements and can be good indicators of habitat fragmentation and wetland quality.

The Hoosier National Forest may serve as an important breeding area and habitat for bird species. However, the continued decline of migrating songbirds may be attributed to overall habitat fragmentation of the region's landscape. The edge effects associated with fragmentation degrade habitat quality and

increases cowbird parasitism and predation on songbirds. Migrating songbirds have suffered from reproduction declines and reductions in survival rates as a result.[21] Continued development in the areas surrounding Bloomington creates more disturbance and fragmentation within the natural environment.

c.) Interpretation and Evaluation

The efforts of public and private organizations to conserve wildlife habitat and natural areas is a step in the right direction to slow or reverse declining wildlife trends for some species. Habitat destruction and fragmentation are major factors in the decline of wildlife populations across the country. Protected areas such as the Hoosier National Forest in the Bloomington area are extremely valuable to wildlife. Bald eagle reintroduction is an example of a wildlife conservation project that was made feasible because of the habitat provided by the Hoosier National Forest and the natural land surrounding Monroe Reservoir. Other regions such as the Bean Blossom Bottoms Reserve serve as an important wetland habitat for many species. The protection of wildlife habitat and large contiguous land areas should be considered a priority in conserving the species of the Bloomington region. Increased development and urban sprawl will destroy wildlife habitat and fragment the landscape further. The development of new housing developments, shopping centers and more roads cuts through the landscape and harms local wildlife.

Increased pollution is also detrimental to the wildlife in the region. Sources of pollution include PCBs and toxic contamination in the local waterways. Many fish found in Bloomington streams cannot be consumed due to PCB and mercury contamination. As discussed in previous sections, sedimentation is a major problem in the surface waters of the region. Excessive sedimentation is destructive to the stream ecosystems and inhibits riparian and aquatic wildlife.

The karst areas of Monroe County serve as important wintering habitat for the Indiana bat. The Indiana bat and many other species require that the sensitive karst and cave systems remain healthy and intact. Since water percolates through the system, it is necessary that water pollution be minimized. Nonpoint source pollution and storm water flow damages these ecosystems. Sedimentation from erosion is also destructive to the system. The increased development occurring west of Bloomington is encroaching on the sensitive karst region and threatens the health of the unique ecosystems associated with the landscape.

Large-scale destruction of wetlands in Indiana negatively affected the wildlife that depended on these habitats. Species such as amphibians depend on healthy wetland ecosystems for their survival. The NAAMP program is an innovative program centered in Bloomington that compiles valuable data on local amphibian populations and involves the public in a cooperative conservation effort.

Many natural lands, including karst regions, are privately owned, making land and wildlife management challenging. Small landowners have different values and ideas regarding land use and wildlife. Unfortunately for the wildlife, private uses may not be compatible with their needs. Conservation education and public interest in wildlife and their habitat is important to increase Bloomington's and Monroe County's potential to support wildlife.

d.) Linkages

Wildlife diversity is linked to habitat quality of natural areas, fragmentation and development. Population growth and pollution also affect the regional wildlife. Water quality and air quality directly influence the quality of wildlife habitats.

3. Urban Greenspace

a.) Definition

Urban greenspace is made up of undeveloped natural areas, agricultural land, and parcels set aside as parkland. Such places enhance urban regions with natural beauty, provide places for

play and relaxation, and help protect the surrounding environment. Their presence provides human connection with natural processes. Depending on size, greenspace can filter some urban pollutants and lower city temperatures via shading.

Most urban parks do not serve as habitats for sensitive species. Only those species that can withstand constant interaction with humans make these areas home. Therefore, undeveloped grassy and forested areas are a very important part of the city's greenspace.

b.) Indicators

During the fall of 2000, the Environmental Commission undertook a project to map all of Bloomington's greenspace using Geographic Information Systems (GIS). Using the broad definition of greenspace as any area containing some kind of vegetation that is not developed, the final map identified approximately 9.4 square miles of greenspace within the municipal boundaries of Bloomington (See GIS Greenspace map at the end of this report). The mapping was completed using the most recent aerial photgraphs, which were taken in 1998. This map is intended to provide baseline data on the city's greenspace so that the rate of city's greenspace loss or gain can be evaluated. Information on developments that have occurred since 1998 show that the city has already lost some of the greenspace identified on the map.

Residents cite Bloomington's 21 parks and the green landscape as one of the city's attractions. Trees, grassy areas, playgrounds, and trails break up the visual monotony of miles of paved streets, houses and buildings, especially in the city core. The City's Parks and Recreation Department manages almost 1700 acres of park land, biking trails, and developed athletic areas. They range from the 1200 acre Griffy Nature Preserve to the 0.5-acre People's Park in downtown Bloomington. In addition, Monroe County manages one developed park, Karst Farm, near the fairgrounds. The 1859-acre Indiana University campus also provides Bloomington residents with access to park-like, or natural, spaces with its many native deciduous trees and open areas.
Forested areas are an important part of Bloomington's greenspace. In 1999, the Environmental Commission undertook a tree cover survey of the city. Using aerial photographs from 1992 and 1998, the survey estimated that 3.25 percent of the tree cover was lost in that time period (41.98 percent in 1992 and 38.73 percent in 1998).[22]

Large trees and other distinctive vegetation are not limited to forest or parks. In 1992, Bloomington adopted a tree code to guide how the City manages the trees on public rights-of-way. In addition, the city zoning ordinance requires landscaping for any development other than single family construction. Under guidance from the city forester, the City plants roughly twice as many trees as it removes. In 1996, 78 trees were removed and 288 planted. Removals become necessary when trees are diseased or dying, when they are hazardous to electrical lines or traffic, or when road widening projects require removal. As tracked in an inventory, the City had approximately 10,522 trees in public rights-of-way in 1994. In 1997, about 12,000 trees were listed with many more to be inventoried in the newly annexed areas.[23]

c.) Interpretation and Evaluation

The City of Bloomington is losing greenspace to development. Future studies will determine the exact rate of loss, but if the community wants to maintain some of these undeveloped and often forested areas along with its traditional parks, immediate action needs to be taken to preserve them.

While the number of trees in Bloomington's public places may have grown by 14 percent between 1994 and 1997, the percent tree cover of the city dropped 2.35 percent between 1993 and 1998. This loss runs contrary to the 1991 Growth Policies Plan, which calls for a 20 percent increase in tree cover by 2001. While new trees may be planted to replace ones that are lost to development, newly planted trees tend to be much smaller than the ones they replace. It takes a significant amount of time

for these small trees to grow large enough to contribute to the overall tree cover of the city. Therefore, overall tree cover in Bloomington has decreased with development and urban sprawl.

Stronger incentives need to be established to encourage developers to leave older trees standing. Currently, developers are encouraged to retain large trees on the land they develop but many large trees left standing have died soon after completion of the project due to damage and stress.[24] The mixed success observed from this practice suggests that improvements in protection are necessary. Tree preservation as a means to increase tree canopy cover should be addressed in addition to planting new trees.

Any visitor to Bloomington will notice the presence of parks, tree-lined streets, and a few remaining forested areas. The amount of parkland provides residents easy access to natural areas. This diversity helps make Bloomington an enjoyable place to live, work and visit. It illustrates how vital natural areas and greenspace is to the quality of life in a community. City planners work with developers to maintain as many trees as possible on new building sites during preliminary plan reviews. However, without a tree preservation ordinance, there is no legal basis for the city to require compensation when a large area of trees is cleared for development. Bloomington must act quickly to preserve its valuable, but dwindling, areas of mature trees.

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Appendix A

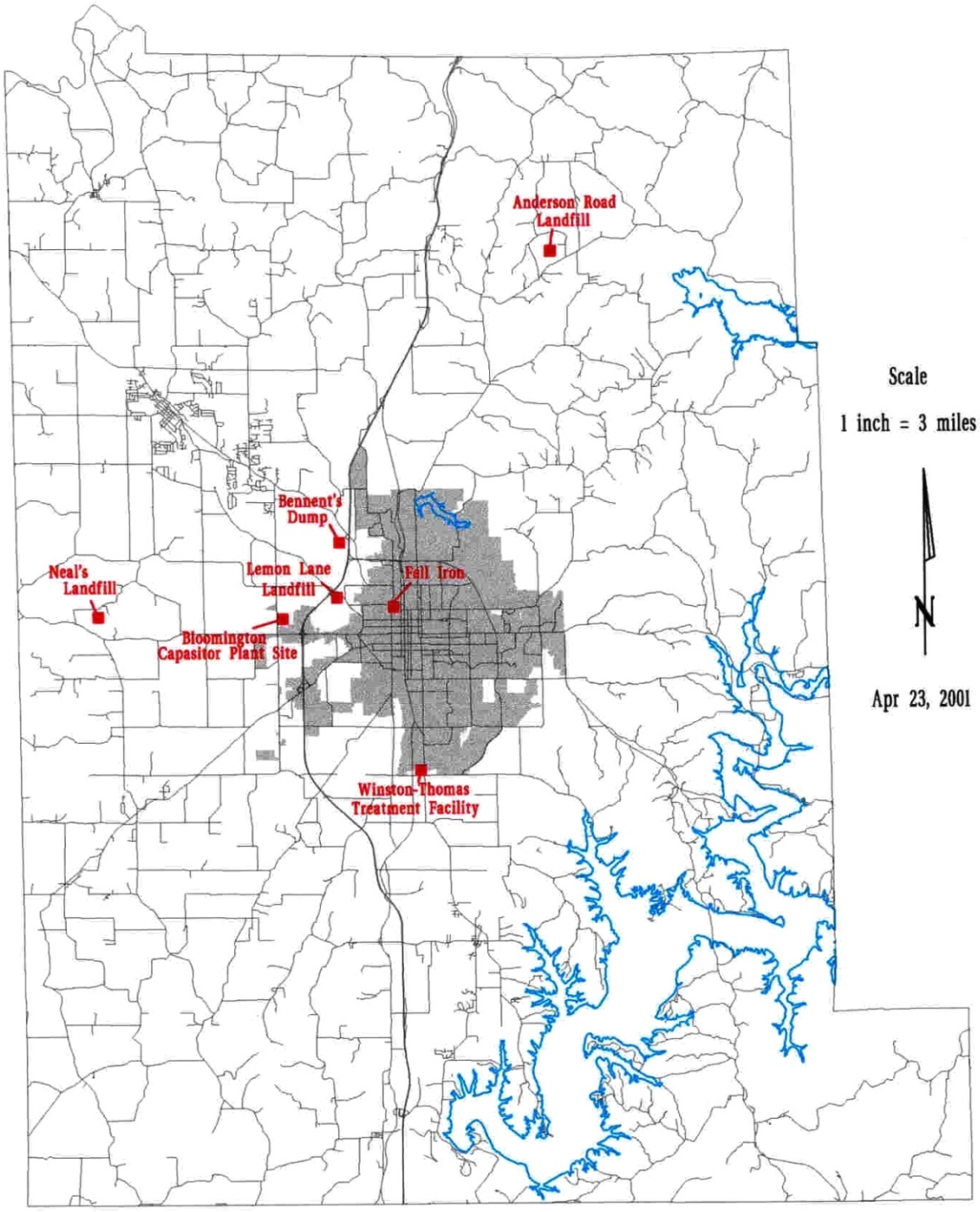
1999 Toxic Release Inventory - Reported Releases (in pounds), Monroe County Source: 1999 Toxic Release Inventory - U.S. Environmental Protection Agency				
Source	**Fugitive Air**	**Stack Air**	**Surface Water Discharge**	**Total On-Site Releases**
ABB Power T&D, Co., Inc.	n/a	n/a	n/a	n/a
N. Curry Pike, Bloomington				
Copper	.	.	.	.
Xylene	.	.	.	.
Cook Inc.	**20,615**	**206,320**	**0**	**226,935**
N. Matthews Dr., Ellettsville				
2-Chloro-1,1,1,2-Tetrafluoroethane	20,400	206,300	0	226,700
Ethylene Oxide	215	20	0	235
GE Appliances Inc.	**54,422**	**510,941**	**0**	**565,363**
N. Curry Pike, Bloomington				
1,1-Dichloro-1-Fluoroethane	162	383,830	0	383,992
1,2,4-Trimethylbenzene	0	25,937	0	25,937
Certain Glycol Ethers	31,331	52,118	0	83,449
Copper	0	206	0	206
Manganese	2	0	0	2
N-Butyl Alcohol	1	33,648	0	33,649
Nitrate Compounds	0	0	0	0
Sodium Nitrite	0	0	0	0
Toluene-2,4-Diisocyanate	0	39	0	39
Toluene-2,6-Diisocyanate	0	10	0	10
Xylene (mixed Isomers)	22,787	15,153	0	37,940
Zinc Compounds	139	0	0	139
Independent Packaging	**8,848**	**228**	**0**	**9,076**
N. Curry Pike, Bloomington				
Certain Glycol Ethers	8,848	228	0	9,076
Indiana Metal Craft, Inc.	**509**	**0**	**0**	**509**
Enterprise Ct., Bloomington				
Copper	509	0	0	509
Otis Elevator Co.	**3,165**	**25,110**	**1,000**	**29,275**
S. Curry Pike, Bloomington				
Chromium Compounds	5	5	250	260
Copper Compounds	250	250	250	750
Manganese Compounds	5	250	250	505
N-Hexane	1,300	11,700	0	13,000
Nickel Compounds	5	5	250	260
Xylene (mixed Isomers)	1,600	12,900	0	14,500
Total	**87,559**	**742,599**	**1,000**	**831,158**

Appendix B - Wastewater Treatment in Bloomington

Dillman Road Wastewater Treatment Plant												
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Million Gallons Treated per Day	10.4	12.7	12.2	11.0	10.0	14.1	11.6	11.9	14.4	14.1	12.2	10.2
Influent:												
Suspended Solids (mg/L)	153	164	189	192	188	181	200	224	200	200	232	215
Biochemical Oxygen Demand (mg/L)	205	200	187	196	192	124	148	165	148	148	184	153
Effluent:												
Suspended Solids (mg/L)	1.0	1.5	1.6	1.1	1.4	2.1	2.2	<1.0	1.1	2.0	1.0	1.3
Biochemical Oxygen Demand (mg/L)	3.3	3.5	2.7	2.6	3.1	3.2	2.5	3	3.8	3.0	4.0	4.7
PCBs (ug/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorus (mg/L) *Annual Average*	1.2	1.2	1.0	1.3	1.3	1	1.2	1.1	1.1	1.4	1.7	1.5
Phosphorus (mg/L) *Summer Average*	0.7	0.7	0.6	1.0	0.7	0.5	0.8	0.6	0.7	0.9	0.7	0.8
Ammonia (mg/L) *Annual Average*	2.1	0.7	0.3	0.2	0.2	0.3	0.3	0.2	0.3	0.4	0.2	0.5
Ammonia (mg/L) *Summer Average*	1.6	0.1	0.2	0.1	0.3	0.2	0.2	<0.1	0.2	0.1	<0.1	<0.1
Fecal Coliform/100ml	11	12	26	63	13	12	3	12	8	4	13	20
NPDES limit exceeded (week)	-	-	-	0	0	0	2	2	6	0	1	4

Blucher Poole Wastewater Treatment Plant											
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Million Gallons Treated per Day	2.1	2.7	2.7	2.3	2.2	2.4	1.7	2.0	2.6	2.5	2.0
Influent:											
Suspended Solids (mg/L)	235	181	165	215	205	149	212	208	222.1	308	221
Biochemical Oxygen Demand (mg/L)	121	106	105	105	129	110	130	155	153.3	215	170
Effluent:											
Suspended Solids (mg/L)	10	9	13	8	8	6	7	8	8.1	10	8
Biochemical Oxygen Demand (mg/L)	4	3	3	3	2	3	3	3	2.7	4	4
NPDES limit exceeded (week)	2	0	2	2	1	1	0	0	0	0	0

Source: City of Bloomington Annual Reports
Personal Communication - Bill Bardes, CBU



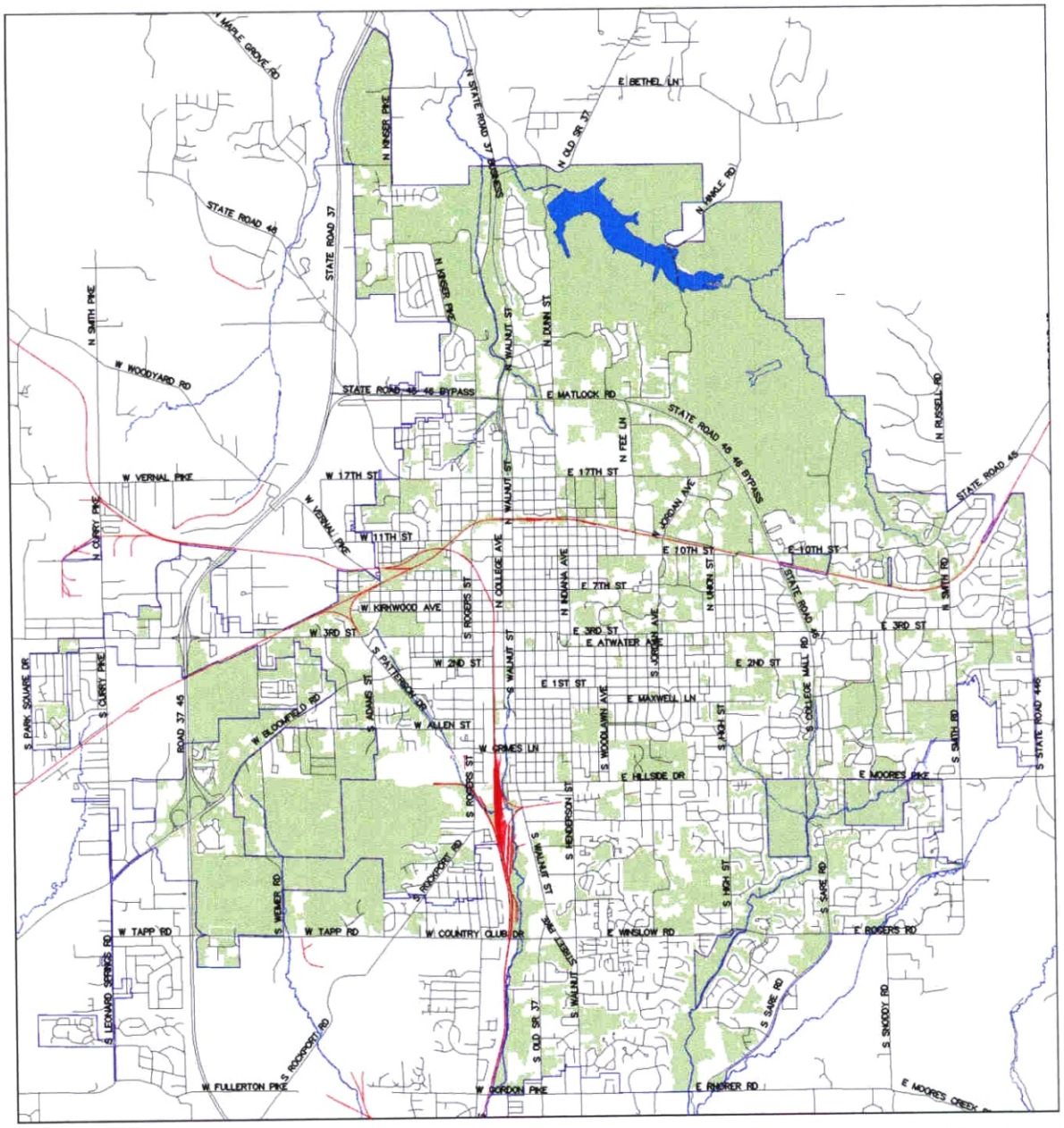
Monroe County PCB Clean Up Sites

Bloomington Environmental Commission

City of Bloomington

Geographic Information System

TmcpcbLP



City of Bloomington, Indiana

Bloomington Greenspace

Apr 23, 2001

Scale: 1inch = 1 mile

1 0 1 2 3

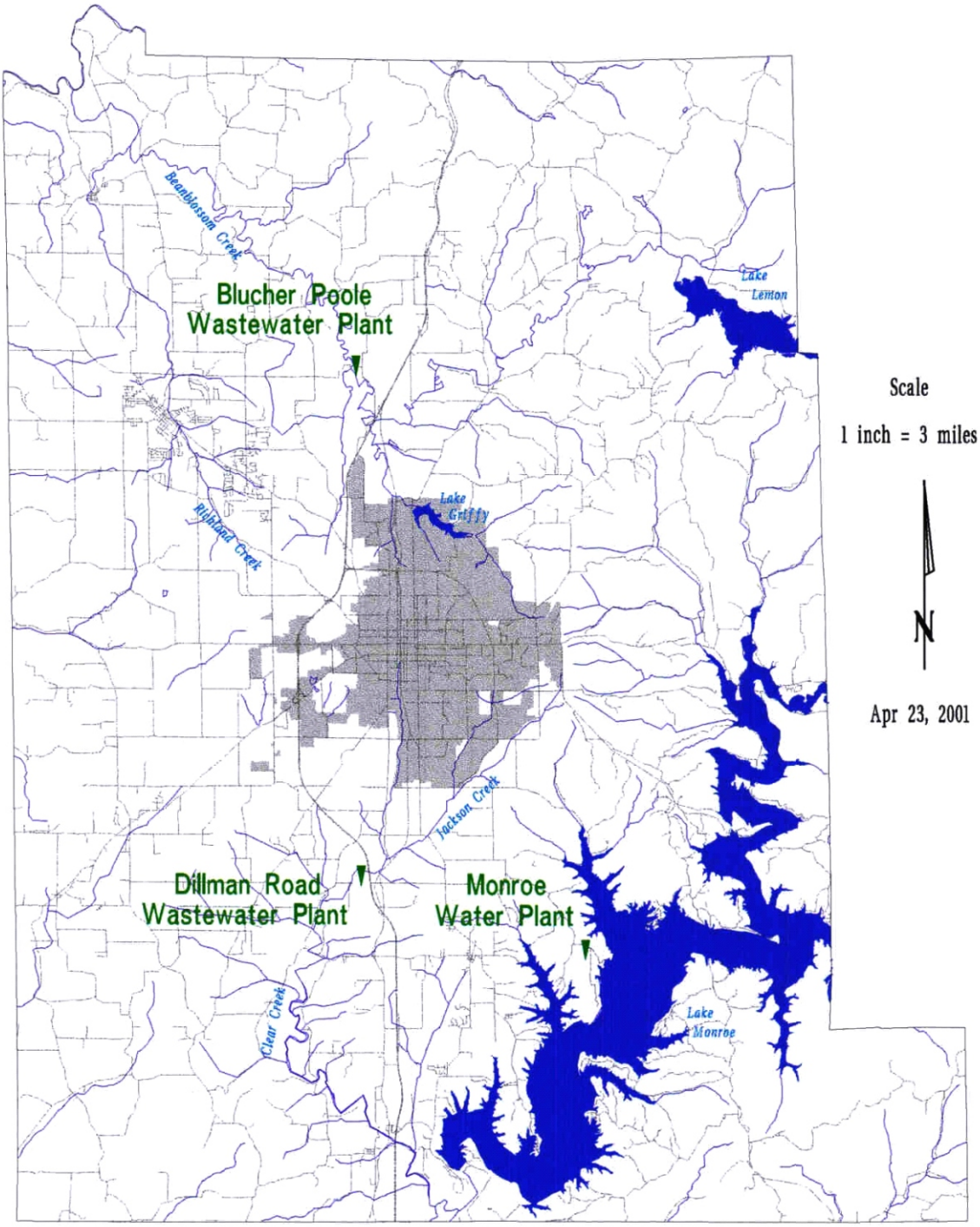
N

City of Bloomington
ITS Department

Geographic Information System

For use as map information only, information is NOT warranted.

TecgsLP



Monroe County Waterways

Bloomington Environmental Commission

City of Bloomington

Geographic Information System

TmcwwLP