The lower portions of the East River and Fox River are located in urban areas and receive urban pollutants. Many heavy metals are closely associated with sediment and move by sediment transport. (Valvoussori, 1992). Heavy metals, including lead, copper and zinc, are higher in concentration than in rural runoff. Water quality monitoring identified heavy metal concentrations at high levels in runoff from many urban areas. The highest concentrations were in industrialized drainage basins, with the lowest levels in low density residential areas. Highest heavy metal concentrations occurred in runoff events following dry periods.

The Remedial Action Plan Toxic Substances Management Technical Advisory Committee recommended the following urban nonpoint practices: industrial lot and urban runoff control demonstration projects; chemical stockpile runoff prevention; establishment of storm water ordinances; and increased street sweeping (WDNR, 1988).

RURAL NONPOINT ANALYSES

OVERVIEW

Rural nonpoint sources investigated were animal lots, croplands and other uplands, streambanks and fields winter-spread with livestock manure. The inventory and evaluation procedures are described in Appendix B. The DNR, the DATCP, and the Brown and Calumet County Land Conservation Departments estimated the relative amount of sediment and phosphorus entering surface waters from these sources.

Most creeks in the East River Watershed suffer from sedimentation derived primarily from upland, gully and streambank erosion. Sediments have blanketed the streambed, filling in pools and riffles, and degrading reproductive habitat for cold and warm water fish species and associated fauna. Cattle have extensively trampled streambanks and stream bottoms along many of the streams in the watershed.

Also, organic pollutant loads from livestock waste runoff locally impact the creeks. It is suspected that loss of cover and vegetation, along with a shallower streambank, and oxygen-demanding organic inputs have caused in-stream temperatures to increase and dissolved oxygen levels to fall.

BARNYARD RUNOFF

Runoff carrying a variety of pollutants from barnyards and livestock feeding, loafing, and pasturing areas is a significant source of pollutants in the creeks of the East River Watershed. As shown in Table III-1 and Figure III-2, 452 livestock operations were identified as having a potential to deliver runoff to surface waters. Of these, 285 were active operations with livestock present. The remaining 167 sites contained barns and

related equipment but no livestock at the time of the inventory. The lots with livestock were estimated to produce 4,120 pounds of phosphorus during a four-inch rainfall (this storm has a 10-year, 24-hour recurrence period). The phosphorus value is used to compare the relative water quality impact from the barnyards.

An additional four animal lots are internally drained and the runoff waters do not reach a stream or lake. These sites will require further investigation to determine their susceptibility for groundwater contamination.

Runoff From Areas Winterspread with Livestock Manure

The 289 active livestock operations inventoried produce an estimated 100,000 tons of manure annually from late fall through mid-spring. The most significant water quality problems associated with land-spreading of livestock manure occur when wastes are spread on "critical" areas such as steeply sloped frozen ground, land in floodplains, and/or areas with shallow depth to groundwater. For the purposes of this analysis, "critical lands" were defined as lands with slope greater than six percent, a soil type rated as flood prone, and soils with less than 24 inches depth to bedrock. Estimates indicate livestock manure is spread on about 500 "critical" acres from which runoff has a high potential to convey pollutants to surface water and groundwater.

It was estimated that approximately 8,000 acres in the watershed are needed to safely spread the manure generated during this period. A combination of factors including climate, soil condition, and proximity of croplands suitable for spreading result in spreading on unsuitable (critical) areas. In addition, individual landowners may not have enough suitable land to properly spread livestock wastes.

Upland Erosion and Sediment Delivery

Intensive agricultural practices have caused considerable amounts of eroded soil to reach streams, lakes and wetlands in the East River Watershed. Nutrients and pesticides are also carried along with runoff. Sediment transported in the runoff from the uplands was quantified. Upland erosion is the major source of sediments to surface waters.

Upland sediment sources were evaluated for approximately 95,000 acres, or 70 percent of the watershed. The results of this inventory are summarized in Table III-2. An estimated 302,000 tons of soil erode annually from croplands, pastures, woodlots, grassland, and other lands. Only about four percent of this amount or 17,150 tons/year actually reach wetlands, streams, or lakes in the watershed. The rest of the sediment settles out on fields or dry channels.

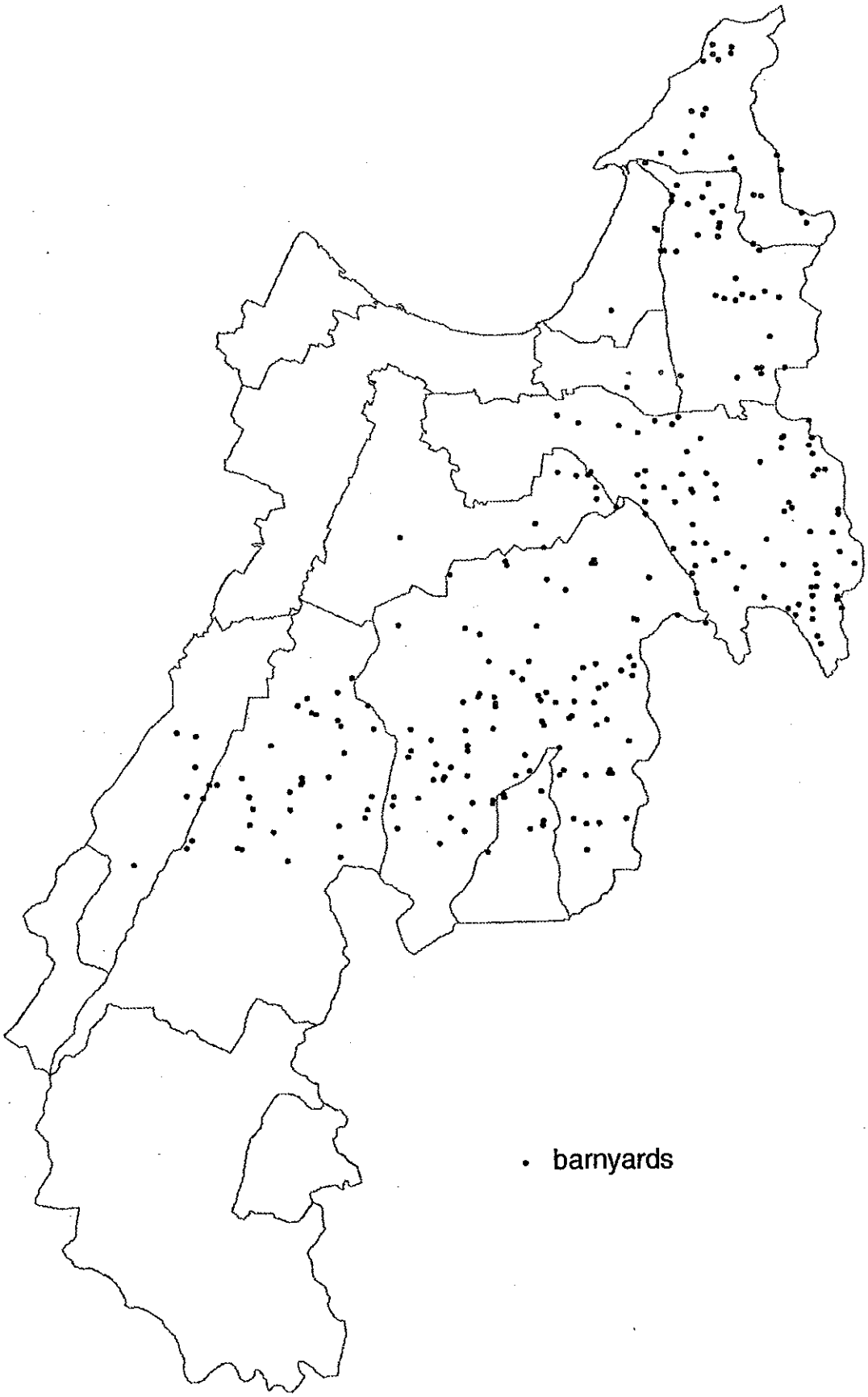

Figure III-2. Barnyards and subwatersheds in the East River watershed.

Table III-1. Inventory Results: Barnyard Summary

Subwatershed	Barnyards with Surface Runoff: Total # of Yards	Phosphorus Load (lbs)**	% Total of Watershed
East River	154	1,401.8	34%
Bower Creek	128	1,591.1	39%
Baird Creek (1)	73	574.3	14%
Fox River	28	211.4	5%
Holland Wildlife (2)	15	103.7	3%
Green Bay Direct Drainage			
Wequiock Creek	31	131.0	3%
Red Banks	20	66.3	2%
Mahon Creek (3)	3	40.3	1%
Totals	*452*	*4,119.9*	*100%*

1) Excludes 1 internally drained yard with a phosphorus load of 16.7 lbs.
2) Excludes 2 internally drained yards with a phosphorus load of 29.5 lbs.
3) Excludes 1 internally drained yard with a phosphorus load of 22.5 lbs.

* Phosphorus loads calculated for a single 10-year, 24-hour storm.
** Active operations (285) have the potential to deliver pollutants to surface waters. No livestock were present in 167 barnyards.

Source: Brown County Land Conservation Department and Department(s) of Agriculture, Trade and Consumer Protection and Natural Resources.

Croplands are the major source of sediment that reaches surface waters. Croplands comprise 77 percent of the rural land uses and are the source of about 87 percent of the sediment attributable to upland erosion. The highest sediment delivery rates are found in the East River, Bower Creek and Baird Creek Subwatersheds. These areas together account for more than 12,100 tons or 80 percent of the sediment loading attributed to cropland erosion.

GULLY EROSION AND SEDIMENT DELIVERY

Gully erosion occurs when surface runoff concentrates into small streams and flows over upland areas. The type of vegetative cover, topography and soil conditions are among the factors influencing the severity of gully erosion. A combination of county Farmland Preservation Plans, installation of nonpoint source control practices, the Brown County Soil Erosion Control Plan, aerial photographs, field work and knowledge of the watershed were used to determine the extent of gully erosion.

The results of this evaluation, summarized in Table III-3, identify 174 sites where gully erosion is occurring. Gully erosion was determined to be a significant source of sediment loading to the East River and its tributaries. An estimated 10,400 tons of soil is eroded annually from these sites. This accounts for about 30 percent of the rural sediment load in the watershed. The greatest amount of gully erosion occurs in the East River and Bower Creek Subwatersheds.

STREAMBANK EROSION

The streambank erosion inventory for perennial streams in the rural portions of the watershed is summarized in Table III-4 and shown in Figure III-3. This evaluation determined that streambanks were eroded, slumping or trampled by livestock at 117 sites. Livestock access to streams was recorded at 51 locations, or about 50 percent of these sites.

The investigations showed that streambank erosion is an important source of sediment to surface waters in the project area, accounting for 3,000 tons or 10 percent of the sediment attributable to rural nonpoint sources. Uncontrolled access degrades streambank and stream bed habitat and results in direct deposition of waste materials to streams. The East River Subwatershed, with 95 sites identified as eroded or trampled, has the most serious streambank erosion problems in the watershed.

Table III-2. Summary of Upland Sediment Loading by Land Use

Subwatershed		Cropland	(%)	Grassland	(%)	Pasture	(%)	Woodlot	(%)	Developed[1]	(%)	Other (2)	(%)	*Totals*	*(%)*
East River	Acres	28,558	77%	1,287	3%	281	1%	4,848	13%	1,533	4%	652	2%	*37,159*	*39%*
	Sediment (tons/yr)	6,375	90%	20	0%	19	0%	145	2%	547	8%	7	0%	*7,113*	*41%*
Bower Creek	Acres	18,273	80%	852	4%	203	1%	1,845	8%	1,360	6%	383	2%	*22,916*	*24%*
	Sediment (tons/yr)	3,940	88%	15	0%	16	0%	72	2%	440	10%	10	0%	*4,493*	*26%*
Baird Creek	Acres	8,885	75%	483	4%	73	1%	751	6%	843	7%	789	7%	*11,824*	*12%*
	Sediment (tons/yr)	1,794	82%	11	1%	6	0%	39	0%	328	15%	16	1%	*2,194*	*13%*
Fox River	Acres	4,944	81%	241	4%	44	1%	444	7%	368	6%	66	1%	*6,107*	*6%*
	Sediment (tons/yr)	977	86%	5	0%	3	0%	18	2%	125	11%	3	0%	*1,131*	*7%*
Holland Wildlife	Acres	1,709	68%	61	2%	22	1%	548	22%	93	4%	63	3%	*2,496*	*3%*
	Sediment (tons/yr)	344	87%	1	0%	2	0%	12	0%	36	1%	2	1%	*397*	*2%*
Green Bay Direct Drainage															
Weiquiock Creek	Acres	5,071	71%	128	2%	54	1%	1,190	71%	389	5%	348	5%	*7,180*	*8%*
	Sediment (tons/yr)	704	79%	3	0%	4	0%	50	17%	122	14%	7	1%	*890*	*5%*
Red Banks	Acres	2,277	60%	190	5%	15	0%	1,112	15%	158	4%	23	1%	*3,775*	*4%*
	Sediment (tons/yr)	353	79%	4	1%	1	0%	34	4%	55	12%	1	0%	*448*	*3%*
East Bay	Acres	1,524	91%	54	3%	14	1%	63	4%	16	1%	0	0%	*1,671*	*2%*
	Sediment (tons/yr)	283	97%	1	0%	1	0%	3	2%	5	2%	0	0%	*293*	*2%*
Mahon Creek	Acres	1,193	79%	17	1%	8	1%	58	4%	88	6%	153	10%	*1,517*	*2%*
	Sediment (tons/yr)	176	90%	0	0%	1	1%	0	0%	18	9%	0	0%	*195*	*1%*
Totals	*Acres*	*72,434*	*77%*	*3,313*	*4%*	*714*	*1%*	*10,859*	*11%*	*4,848*	*5%*	*2,477*	*3%*	*94,645*	*100%*
	Sediment (tons/yr)	*14,946*	*87%*	*60*	*0%*	*53*	*0%*	*373*	*2%*	*1,676*	*10%*	*46*	*0%*	*17,154*	*100%*

* Sediment measured in tons/year.

1) Includes urban land uses.
2) Includes wetlands and ponds.

Source: Brown County Land Conservation Department and Wisconsin Department(s) Agriculture, Trade and Consumer Protection and Department of Natural Resources.

Table III-3. Inventory Results: Gully Erosion

	Slight		Moderate		Severe	
Subwatershed	# Sites	Tons/yr**	# Sites	Tons/yr**	# Sites	Tons/yr**
East River	33	2,475	37	1,295	10	1,000
Bower Creek	12	900	14	490	2	200
Baird Creek	6	450	7	245	2	200
Fox River	6	450	6	210	3	300
Holland Wildlife	2	150	2	70	0	0
Green Bay Direct Drainage						
Wequiock Creek	5	375	6	210	1	100
Red Banks	5	375	5	175	2	200
East Bay	2	150	2	70	1	100
Mahon Creek	1	75	1	35	1	100
Totals	*72*	*5,400*	*80*	*2,800*	*22*	*2,200*

* Does not include subwatersheds with no gully erosion.
** Tons of sediment delivered per year.

Source: Brown County Land Conservation Department.

Table III-4. Inventory Results: Rural Streambank Erosion

Subwatershed*	Segment Length	# of Eroding Sites (ft)	Length of Eroding Sites (ft)	Sediment Loss (tons/yr)	Streambanks with Livestock Access (ft)
East River	223,890	95	58,100	2,675	91,575
Bower Creek	51,800	10	10,550	188	8,550
Fox River	35,200	12	7,800	162	0
Totals	*310,890*	*117*	*76,450*	*3,025*	*100,125*

* Does not include subwatersheds with no stream erosion.

Source: Brown County Land Conservation Department.

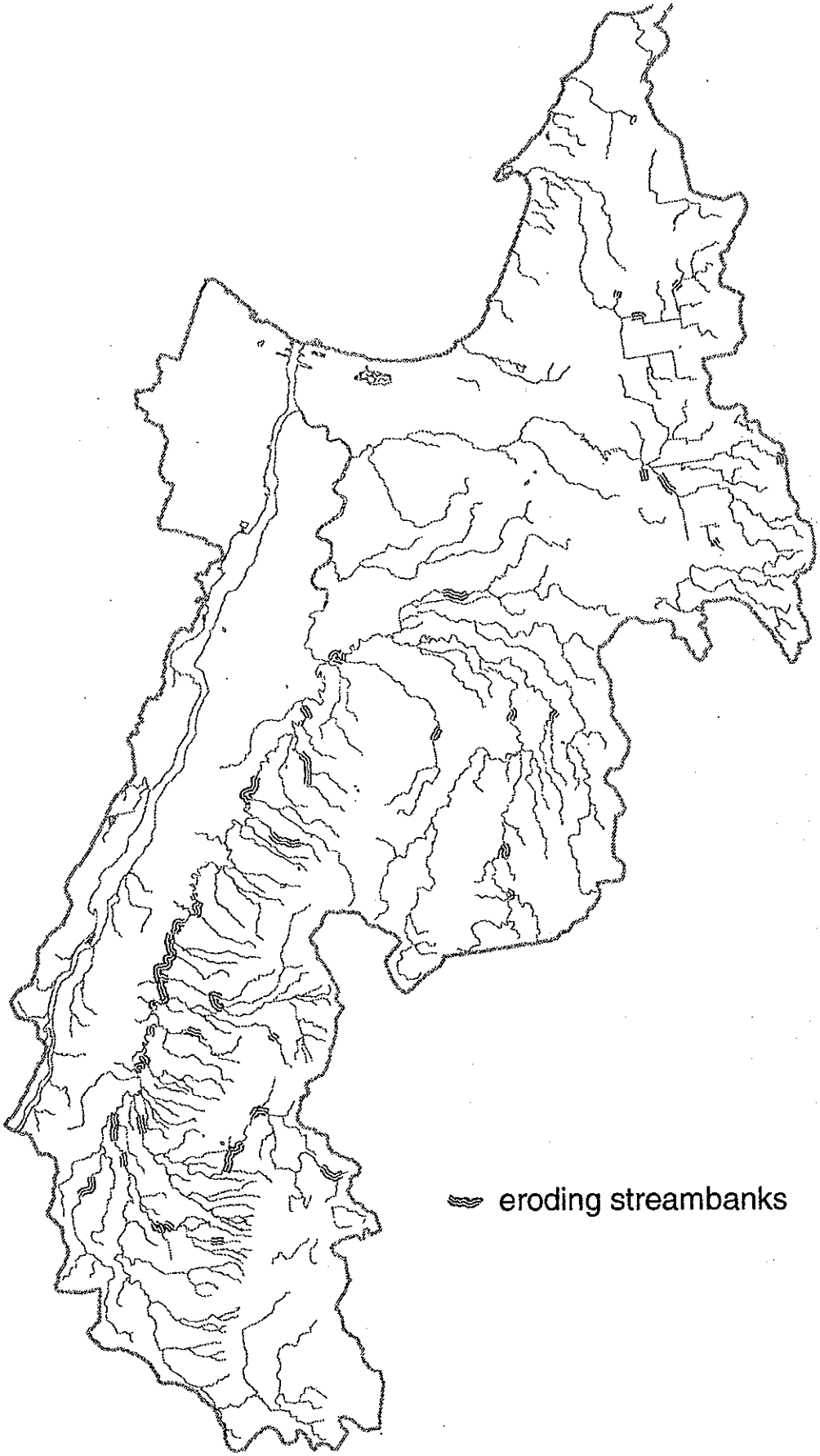

Figure III-3. Streambank erosion in the East River watershed.

URBAN NONPOINT SOURCE ANALYSES

OVERVIEW

Urban runoff carries a wide array of pollutants to surface water. Some pollutants are unique to urban runoff, while others also are contained in runoff from agricultural areas. Urban stormwater runoff was recently (June 1989 to July 1990) monitored by the Department and the U.S. Geological Survey at five locations in Milwaukee and Madison, Wisconsin. Problem pollutants (those above detection limits in 10 percent of samples and which exceed state water quality standards in at least one runoff event) included lead, copper, zinc, silver, cyanide, volatile organic compounds, PCBs, and several insecticides.

Substances in urban runoff that are also contained in runoff from rural areas include sediment (especially from construction sites), nutrients, bacteria and other pathogens, and pesticides. While acres of urban land may be small compared with rural lands, urban areas can contribute more pollutants on a per-acre basis because they are often connected to storm sewers which convey runoff directly to lakes and/or streams.

Runoff from urban areas also impacts stream hydrology. As the landscape becomes urbanized, runoff volume increases in magnitude and is produced in a short time period creating large increases in peak stream flows. In some areas, groundwater recharge is significantly reduced as concrete and other impervious surfaces prevent rainwater and snowmelt from soaking into the ground. This can reduce base stream flows needed to sustain fish and aquatic life during periods of low rainfall. Uncontrolled urban runoff can produce "flashy" streams with temperatures and chemical characteristics that limit animal life and recreational uses. Streambank erosion may increase as the stream tries to cut a channel in equilibrium with widely variable stream flows. Flooding of adjacent property may also occur, sometimes requiring channel modifications to accommodate flood flows or prevent flood damage. This often destroys the natural stream system and speeds the transport of pollutants downstream.

Runoff from new urban development has the potential to impact stream water quality in several ways. First, constructing roads, utilities and buildings disturbs large areas, exposing large amounts of soil to erosion. Sediment is easily carried by runoff to drainage ways, storm sewers and ultimately streams. An estimated 25 percent of the sediment delivered to surface waters in the watershed is attributable to construction site erosion.

Construction site erosion can have catastrophic impacts on urban rivers and streams, clog storm sewers causing local flooding, and accumulate on road surfaces and sidewalks. Second, newly established urban surfaces accumulate pollutants until they are carried in runoff to streams. Consequently, as new areas become urbanized, water quality problems caused by urban pollutants and excessive storm water runoff can worsen.

Water quality improvements resulting from implementation of nonpoint source control practices for existing urban areas can be negated by these additional pollution sources.

The urban nonpoint source inventory and evaluation techniques are presented in Appendix B. The Brown County Planning Commission and the Bay Lake Regional Planning Commission conducted the inventory of existing 1986 and planned year 2010 urban conditions. Three key characteristics were assessed: the type of urban land use; the type of storm water conveyance system; and urban housekeeping practices including but not limited to street sweeping and leaf collection. Each is discussed below. The DNR used the information to determine urban nonpoint source loading to streams. The pollutants assessed were sediment, phosphorus, lead, copper, zinc and cadmium.

URBAN LAND USES

Existing 1986 land use conditions are summarized in Table III-5 and Table III-6, and shown in Figures III-4 and III-5. Urban land uses occupied approximately 49 square miles, or 23 percent of the watershed in 1986. The majority of the urbanized area (58 percent) is in the city of Green Bay. The watershed's predominant existing urban land uses include residential (35 percent) and parks and open space undeveloped areas (48 percent).

As shown in Table III-6, an additional 8,700 acres of planned urban development is anticipated to occur in the watershed over about the next 20 years. Much of this 22 percent increase in urban development will occur in the city of Green Bay. Residential, park/open space, and industrial areas are planned to show the greatest increases.

STORM WATER CONVEYANCE

Urban storm water is most commonly conveyed to streams through storm sewers either separately or in combination with grassed swales or roadside ditches. Storm sewers transport runoff rapidly with no "treatment" or filtering of the runoff before it enters streams. Properly designed grassed swales generally transport lesser amounts of runoff. Infiltration and vegetation serve to remove some pollutants from the runoff before it flows into streams or storm sewer systems.

The types and amounts of pollutants transported by runoff, depend on the extent to which pollutant-producing surfaces are hydrologically "connected" to the storm sewer system. For example, automobile traffic density -- a prime determinant in the production of lead, asbestos, cadmium, and street dirt -- is highest for street surfaces in commercial areas and freeways. Normally, these areas are connected to storm sewers which may transport runoff directly to streams, lakes or wetlands. Developing sites in urban areas are often already connected to storm sewers before construction begins. Storm water conveyance systems were identified during the East River urban inventory process.

Table III-5. Existing 1986 Land Use in the East River Watershed

Municipality	Residential			Commercial (acres)	Industrial (acres)	Highway (acres)	Misc. (acres)	Parks/ Open (acres)	Total (acres)	Percent of Total Urban Acres
	Low (acres)	Medium (acres)	High (acres)							
C. of Green Bay	56	6,163	533	1,030	1,818	662	341	7,787	18,390	59
C. of De Pere	145	1,433	44	171	201	44	120	2,670	4,828	15
T. of Bellevue	4	390	39	87	135	123	0	2,660	3,438	11
V. of Allouez	28	1,642	30	90	17	71	77	980	2,935	10
T. of Scott	56	84	0	11	6	0	0	897	1,054	3
V. of Ashwaubenon	1	196	81	77	136	16	3	252	762	2
Totals	*290*	*9,908*	*727*	*1,466*	*2,313*	*916*	*541*	*15,246*	*31,407*	*100*

Source: Brown County Planning Department.

Table III-6. Anticipated increases in Urban Land Uses by the Year 2010 in the East River Watershed

Municipality	Residential			Commercial (acres)	Industrial (acres)	Highway (acres)	Misc. (acres)	Parks/ Open (acres)	Total (acres)	Percent of Total Urban Acres
	Low (acres)	Medium (acres)	High (acres)							
C. of Green Bay	0	1,732	129	147	728	0	1	1,258	3,995	46
T. of Bellevue	3	812	106	244	403	0	0	330	1,898	22
C. of De Pere	17	1,053	3	26	438	0	0	220	1,757	20
V. of Allouez	0	291	24	23	0	0	21	118	477	6
T. of Scott	3	33	0	2	5	0	0	317	360	4
V. of Ashwaubenon	0	6	0	29	133	0	0	18	186	2
Totals	*23*	*3,927*	*262*	*471*	*1,707*	*0*	*22*	*2,261*	*8,673*	*100*

Source: Brown County Planning Department.