appendix a

tmdl schedule

MICHIGAN

Waterbody Name: Dowagiac River **Location:** St. Joseph River confluence **County:** Cass
Parameter of Concern: Fish consumption advisory (FCA) for PCBs **TMDL Years:** 2010

Waterbody Name: Farmer's Creek **Location:** Pipestone Road upstream **County:** Berrien
Parameter of Concern: TDS exceed standards due to untreated sewage **TMDL Years:** N/A

Waterbody Name: Fawn River **Location:** St. Joseph River confluence **County:** St. Joseph/Branch
Parameter of Concern: FCA for PCBs **TMDL Years:** 2010

Waterbody Name: McKinsie Creek **Location:** Nieb concrete settling ponds NE of Niles **County:** Cass
Parameter of Concern: Fish community rated poor **TMDL Years:** 2006

Waterbody Name: Ox Creek **Location:** Paw Paw River confluence **County:** Berrien
Parameter of Concern: Macroinvertebrate community poor due to heavy metals **TMDL Years:** 2008

Waterbody Name: Palmer Lake **Location:** Vicinity of Colon **County:** St. Joseph
Parameter of Concern: Fish tissue – Mercury **TMDL Years:** N/A

Waterbody Name: Randall Lake (North Lake and Cemetery Lake Chain) **Location:** Vicinity NW of Coldwater **County:** Branch
Parameter of Concern: FCA for PCBs, fish tissue – Mercury **TMDL Years:** 2010

Waterbody Name: St. Joseph River **Location:** Lake Michigan to Sturgis Dam at Three Rivers **County:** Berrien/Cass/St. Joseph
Parameter of Concern: FCA for PCBs, water quality exceedances for PCBs **TMDL Years:** N/A

Waterbody Name: St. Joseph River **Location:** Benton Harbor navigational channel **County:** Berrien
Parameter of Concern: Water quality exceedances for mercury **TMDL Years:** 2011

Waterbody Name: Union Lake **Location:** Union City near Dunk Road dam **County:** Branch
Parameter of Concern: FCA for PCBs **TMDL Years:** 2005

Waterbody Name: Big Meadow Drain* **Location:** St. Joseph River confluence **County:** Berrien

Waterbody Name: Brandywine Creek* **Location:** North branch Paw Paw River confluence **County:** Van Buren

Waterbody Name: Coldwater Lake **Location:** South of Coldwater **County:** Branch
Parameter of Concern: Fish tissue- Mercury **TMDL Years:** N/A

Waterbody Name: Dorrance Creek* **Location:** Indian Lake confluence **County:** Kalamazoo

Waterbody Name: Dowagiac River* **Location:** Frost Street upstream to Decatur **County:** Berrien/Cass

Waterbody Name: Eau Claire Extension Drain* **Location:** Farmers Creek confluence **County:** Berrien

Waterbody Name: Fisher Creek* **Location:** Marble Lake to headwaters **County:** Branch

Waterbody Name: Four County Drain* **Location:** Rocky River confluence upstream **County:** St. Joseph

Waterbody Name: Garman Foster Drain* **Location:** Portage River confluence upstream **County:** St. Joseph

Waterbody Name: Goose Lake Drain* **Location:** Portage River confluence upstream **County:** St. Joseph

Waterbody Name: Hickory Creek* **Location:** St. Joseph River confluence upstream **County:** Berrien

Waterbody Name: Hog Creek* **Location:** Paw Paw River confluence upstream to 62nd Street **County:** Van Buren

Waterbody Name: Hog Creek, North Branch* **Location:** South Branch confluence upstream to headwaters **County:** Branch

Waterbody Name: Little Portage Creek* **Location:** St. Joseph River confluence upstream **County:** St. Joseph/Kalamazoo

Waterbody Name: Little Swan Creek* **Location:** Long Lake confluence upstream to headwaters **County:** Branch/St. Joseph

Waterbody Name: McCoy Creek* **Location:** St. Joseph River confluence upstream **County:** Berrien

Waterbody Name: McKinzie Creek* **Location:** Hoyt Street upstream of Nieb Concrete **County:** Cass

Waterbody Name: Mill Creek* **Location:** Hill Avenue upstream **County:** Berrien/Van Buren

Waterbody Name: Mud Creek* **Location:** Coldwater River/North Lake confluence upstream **County:** Branch

Waterbody Name: Mud Lake Drain* **Location:** Paw Paw River confluence upstream to Mud Lake **County:** Van Buren

Waterbody Name: Nottowa Creek* **Location:** M-66 at Athens upstream **County:** Calhoun

Waterbody Name: Osborn Drain* **Location:** Dowagiac River confluence upstream **County:** Cass

Waterbody Name: Paw Paw River, South Branch* **Location:** 64th Avenue upstream to Mud Lake outlet **County:** Cass

Waterbody Name: Pine Creek* **Location:** Paw Paw River confluence upstream to headwaters **County:** Van Buren

Waterbody Name: Pipestone Creek* **Location:** Old Pipestone Road upstream to headwaters **County:** Berrien

Waterbody Name: Portage River* **Location:** Indian Lake confluence upstream to Portage Lake **County:** Kalamazoo

Waterbody Name: Sand Creek* **Location:** St. Joseph River confluence upstream to North Sand Lake **County:** Hillsdale

Waterbody Name: Silver Creek* **Location:** Dowagiac River confluence upstream to Magician Lake **County:** Cass

Waterbody Name: Soap Creek* **Location:** St. Joseph River confluence upstream **County:** Calhoun/Branch/Hillsdale

Waterbody Name: Spring Creek* **Location:** M-66 upstream **County:** St. Joseph

Waterbody Name: Tekonsha Creek* **Location:** St. Joseph River confluence upstream **County:** Calhoun/Branch

Waterbody Name: Williams Drain* **Location:** Beebe Creek confluence upstream **County:** Hillsdale

INDIANA

Waterbody Name: Snow Lake **County:** Steuben
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Snow Lake **County:** Steuben
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2014-2021

Waterbody Name: Marsh Lake **County:** Steuben
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Marsh Lake **County:** Steuben
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2014-2021

Waterbody Name: Lake James **County:** Steuben
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2015-2022

Waterbody Name: Lake James **County:** Steuben
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Jimmerson Lake **County:** Steuben
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Jimmerson Lake **County:** Steuben
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2014-2021

Waterbody Name: Fawn River-- Orland **County:** Steuben
Parameter of Concern: Pathogens **TMDL Years:** 2010-2015

Waterbody Name: Dallas Lake **County:** LaGrange
Parameter of Concern: Impaired biotic communities

Waterbody Name: Pigeon Creek **County:** N/A
Parameter of Concern: FCA for mercury, PCBs, and dioxin **TMDL Years:** 2015-2020

Waterbody Name: Mud Creek **County:** N/A
Parameter of Concern: Aquatic life support-- total dissolved solids & chlorides

Waterbody Name: Long Lake **County:** Steuben
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Turkey Creek-- Stump Ditch **County:** Steuben
Parameter of Concern: Not supporting primary contact; E. coli **TMDL Years:** 2010-2015

Waterbody Name: Emma Creek **County:** LaGrange
Parameter of Concern: Impaired biotic communities; ammonia

Waterbody Name: Baugo Creek and tributaries **County:** Elkhart
Parameter of Concern: pathogens **TMDL Years:** 2010-2015

Waterbody Name: Little Elkhart River **County:** Elkhart/LaGrange
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2010-2017

Waterbody Name: Big Otter Lake **County:** Steuben
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2010-2017

Waterbody Name: North Twin Lake **County:** LaGrange
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2010-2017

Waterbody Name: St. Joseph River **County:** St. Joseph
Parameter of Concern: Pathogens **TMDL Years:** 2010-2015

Waterbody Name: Meserve Lake **County:** Steuben
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2011-2018

Waterbody Name: Messick Lake **County:** LaGrange
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2011-2018

Waterbody Name: Hackenburg Lake **County:** LaGrange
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2012-2019

Waterbody Name: Witmer Lake **County:** LaGrange
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2012-2019

Waterbody Name: Rock Run Creek **Location:** Including Hoover Ditch & Boyer Ditch **County:** Elkhart
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2013-2020

Waterbody Name: St. Joseph River tributary **County:** St. Joseph
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2013-2020

Waterbody Name: Elkhart River **Location:** North/South branches & tributaries **County:** Elkhart/Noble
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Juday Creek **County:** St. Joseph
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Pigeon Creek **County:** Steuben/LaGrange
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Fly Creek Headwaters **County:** LaGrange
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Turkey Creek **Location:** Skinner and Hoopingarner ditches **County:** Kosciusko/Elkhart
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Solomon Creek & tributaries **County:** Elkhart
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Stoney Creek & tributaries **County:** Elkhart
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Rock Run Creek & tributaries **County:** Elkhart
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Pine Creek **Location:** North & South forks **County:** Elkhart/LaGrange
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Little Elkhart River **County:** Elkhart/LaGrange
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Willow Creek & tributaries **County:** St. Joseph
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Wabee Lake **County:** Kosciusko
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Olin Lake **County:** LaGrange
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Oliver Lake **County:** LaGrange
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Hamilton Lake **County:** Steuben
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Crooked Lake **County:** Steuben
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: McClish Lake **County:** Steuben
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Lake Shipshewana **County:** Elkhart
Parameter of Concern: FCA for PCBs **TMDL Years:** 2015-2020

Waterbody Name: Juday Creek **County:** St. Joseph
Parameter of Concern: FCA for PCBs **TMDL Years:** 2015-2020

Waterbody Name: Elkhart River **County:** Elkhart
Parameter of Concern: FCA for mercury & PCBs **TMDL Years:** 2015-2020

Waterbody Name: Lake Wawasee **County:** Kosciusko
Parameter of Concern: FCA for mercury & PCBs **TMDL Years:** 2015-2020

Waterbody Name: Pigeon Creek **County:** Steuben
Parameter of Concern: FCA for mercury & PCBs **TMDL Years:** 2015-2020

Waterbody Name: St. Joseph River **County:** St. Joseph/Elkhart
Parameter of Concern: FCA for mercury & PCBs **TMDL Years:** 2015-2020

Waterbody Name: Knapp Lake **County:** Noble
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2015-2022

Waterbody Name: Hindman Lake **County:** Noble
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2015-2022

Waterbody Name: Village Lake **County:** Noble
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2015-2022

Waterbody Name: Wisler Ditch & tributaries **County:** Elkhart
Parameter of Concern: Impaired biotic communities; nutrients **TMDL Years:** 2015-2022

Waterbody Name: Croft Ditch (south branch of Elkhart River) **County:** Noble
Parameter of Concern: Pathogens **TMDL Years:** 2015-2020

Waterbody Name: Seven Sisters Lakes **County:** Steuben
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2015-2020

Waterbody Name: Pleasant Lake **County:** Steuben
Parameter of Concern: FCA for mercury & PCBs **TMDL Years:** 2015-2020

Waterbody Name: Lake of the Woods **County:** LaGrange
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Dewart Lake **County:** Kosciusko
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Barrel and Half Lake **County:** Kosciusko
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Spear Lake **County:** Kosciusko
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Shock Lake **County:** Kosciusko
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Lime Lake **County:** Steuben
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2015-2020

Waterbody Name: Gordy Lake **County:** Noble
Parameter of Concern: Impaired biotic communities **TMDL Years:** 2014-2021

Waterbody Name: Bixler Lake **County:** Noble
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Sylvan Lake **County:** Noble
Parameter of Concern: FCA for mercury **TMDL Years:** 2015-2020

Waterbody Name: Henderson Lake **County:** Noble
Parameter of Concern: FCA for mercury & PCBs **TMDL Years:** 2015-2020

Waterbody Name: Berlin Court Ditch* **Location:** From Nappanee sewage treatment plant 2 miles downstream **County:** Elkhart

Waterbody Name: Werntz Ditch* **Location: F**rom Wakarusa sewage treatment plant to Baugo Creek **County:** Elkhart

**The Michigan or Indiana water quality standard is not attained, but a TMDL is not scheduled because the primary impairment is not caused by a pollutant. These systems are highly modified streams/ditches with impaired habitat that are considered insufficient to support an acceptable biological community (channelized, maintained streams represent this category).*

appendix b

mechanisms for watershed protection

Task 8. Mechanisms for Watershed Protection

Task 4, Prioritization of Concerns, resulted in a subwatershed scoring technique which ranked each of the major drainage units and the 217 delineated subwatersheds for their preservation and mitigation potentials. The next step after identifying areas prioritized for various activities is to identify the mechanisms to encourage those activities. Because the watershed is so large, site specific information cannot be gleaned for the entire basin. Instead, land cover data and other spatial data were relied upon to model the watershed at its broad scale. Similarly, protection mechanisms and identification of practices already in place are largely broad, as the identification of specific land use planning activities and ordinances in every municipality was not possible under the scope of this project. Identification of those mechanisms were gleaned from stakeholder interviews and internet research. Therefore, they are not inclusive. Further, the identification of geographic regions to apply these measures are also not inclusive. This chapter should be viewed as an introduction to additional needed work in the implementation phase.

(Links to additional information are provided on the attached table.)

Preservation of forests and wetlands

The subwatersheds were scored based on the percentage of wetland and forest land cover in each. The highest average scores were identified in the northwest portions of the watershed, which include the Paw Paw River, Dowagiac River and Rocky River Watersheds. Beebee Creek in Hillsdale County also scored high. However, this does not indicate that preservation is not important in the Indiana portions of the watershed. An isolated wetland was identified in the Turkey Creek Watershed in the southern portion of Elkhart County. This score was lost in the major drainage unit scoring, but was identified in the scoring of the 217 subwatersheds.

The Steering Committee identified sediments, nutrients, habitat loss, wetland loss and animal waste as the top five watershed concerns. The preservation of intact forest, prairie and wetland areas can prevent an increase in the occurrence of those concerns, and other techniques discussed in this chapter can reduce those pollutants at the source.

In the Watershed…

Fabius Township, in the Rocky River Watershed, developed a Greenprint, which identified natural resources, such as wetlands and priority rural views, in the township and laid out a plan to preserve them through zoning. This includes protection of wetlands smaller than 5 acres.

Lands identified for preservation can be protected through a variety of mechanisms. Private landowners can voluntarily choose to protect their land. However, development pressures, which are moving further and further from urban cores, are making it difficult to preserve these lands.

Lands can be donated to each state's Department of Natural Resources to be incorporated into its parks systems. Each state has a trust fund established for the purchase of such lands. The Indiana Heritage Trust was established in 1992 to acquire land with "examples of outstanding natural resources and habitats or have historical or archaeological significance". Sales of special license plates (blue eagle and sun) contribute to the fund. For example, the Fawn River Nature Preserve in LaGrange County was acquired in 1999. It is composed of 135 acres of upland beech and maple woods and a rare lowland oak forest. The preserve protects riparian habitat bordering more than a mile of the Fawn River.

(The Indiana Heritage Trust link in the attached table includes additional information about preserved lands in the watershed.)

The Michigan Natural Resources Trust Fund, established in 1976, provides grants to local governments and the state to purchase lands for outdoor recreation and for preservation of open space. It is supported by revenues from state-owned mineral interests.

Many land conservancies are active in the watershed. The Southwest Michigan Land Conservancy owns approximately twelve preserves in the St. Joseph River Watershed in Van Buren, St. Joseph, Cass and Berrien Counties. Land can be donated to the conservancy by interested landowners. Volunteers help manage the lands by performing activities such as removal of invasive species.

In the Watershed…

In October 2003 the Michigan Chapter of the Nature Conservancy acquired 139 acres of prairie fen habitat in the headwaters of the East Branch of the Paw Paw River. The fen is included in one of only 15 remaining locations in the world which provide habitat for the federally endangered Mitchell's satyr butterfly.

The Trillium Land Conservancy works to protect land in Elkhart County. The Wawasee Lake Conservancy Foundation has acquired over 419 acres of wetlands around the Wawasee Lake in Noble County. Townships can establish partnerships with land trusts to provide matching funds for fee simple ownership of lands or to purchase conservation easements or development rights.

Private landowners can receive tax incentives to protect their own land through conservation easements. A landowner may wish to sell the land to a buyer who has conservation goals for the land. However, it is expensive and time consuming to advertise these lands for sale through special avenues to find buyers. Similarly, it may be difficult for buyers to find large tracts of undisturbed land. A network of buyers and sellers interested in conservation is needed. This network should be used to conserve agricultural lands, as well.

Land use planning and zoning can be used to protect natural resources within a municipality. A natural features inventory is a good way to identify those lands. However, many townships do not have any planning mechanisms in place. This may occur in townships where municipal officials are employed in a part-time capacity, as the tax base is low. For example, Branch County has several townships, five of the sixteen, which are not zoned. These townships are rural and not located along a major transportation corridor. Therefore, it may be felt that development does not threaten the current land uses. However, these areas have many valuable natural resources. Further these townships with many natural resources have less tax revenue available for the development of a land use plan or natural features inventory. Townships should pool their resources to develop plans, especially within a watershed or where they share contiguous natural resources.

Sherwood Township in Branch County is unzoned and 95% agricultural. The St. Joseph River flows through the township and is primarily wooded along its banks. Protection measures should be implemented to help these buffers remain intact. Perhaps downstream property owners or municipalities who could be adversely affected by sedimentation could purchase these lands or easements on them to assure that the buffers remain intact.

In Indiana, zoning is implemented at the county level. Michigan law allows comprehensive planning to be conducted at the county, city, village or township level (Sea Grant, 2002). There are regional commissions in the watershed including the Michiana Area Council of Governments

(MACOG; St. Joseph, Elkhart, Marshall Counties) and the Southwest Michigan Commission. These organizations operate by county boundaries, not watershed boundaries. MACOG deals primarily with transportation issues. However, it has a water quality department and has been awarded some grants to fund St. Joseph River Watershed projects in Indiana.

Identification of areas to apply conservation measures

<u>Agricultural land</u>
Lands were identified for application of conservation measures and BMPs based on the percentage of agricultural and urban land cover and on the presence of identified impaired waters. This is not to imply that agricultural land uses are not desired in the watershed, quite the contrary. Numerous surveys have identified preservation of agricultural land uses as a high priority. In addition to the obvious benefits of food and fiber production, agricultural land uses provide an aesthetic characteristic to the watershed. A visual preference survey conducted by the Michigan Farmland and Community Alliance, Michigan State University and the Michigan Association of Realtors (2004), identified farmland, which provides wide, open green space, as highly desirable in Michigan. A 1998 "Examination of Challenges and Opportunities" in Hillsdale County recommended land use planning and a diversification of agricultural products as necessary to protect farmland. A 2000 resident survey in the county identified the loss of farmland as a critical problem.

The watershed is largely agricultural (70%). Agriculture occupies over 80% of the land use (by subwatershed) in the Pigeon and Elkhart River Watersheds (Indiana). Agricultural products include hogs, cattle, corn, soybeans, wheat and hay. Some fruits and vegetables are grown in the western portions of the watershed. Traditional farming methods are practiced by Amish communities in the eastern and central portions of the watershed.

The Farm and Ranch Land Protection Program, administered by the Indiana Natural Resources Conservation Service provides matching funds (up to 50% of the easement fair market value) to help eligible entities purchase development rights to keep productive farm and ranch land in agricultural use. The Farmland and Open Space Preservation Program, administered by the Michigan Department of Agriculture, has five programs to aid in preservation. One of these programs, the Agricultural Preservation Fund provides grants to local governments to purchase conservation easements through Purchase of Development Rights programs. Participating land owners commit to at least ten years.

In the Watershed…

In St. Joseph County (IN) agricultural land identified as prime land may not be split into parcels smaller than 20 acres nor have less than 600 feet of road frontage when the land use is changed from agricultural to residential. Prime agricultural land is found in the southern portions of the county. Similar ordinances are also found in Calvin and Wayne Townships in Cass County (MI.)

There are also programs to acknowledge farmers who employ practices to protect water quality and conserve soil. The Indiana River Friendly Farmer program is sponsored by the Indiana Association of Soil and Water Conservation Districts (and other organizations). A farmer who meets each of nine environmental criteria on his land can be nominated for the award. Winners are recognized annually at the Indiana State Fair. The Michigan Agriculture Environmental Assurance Program certifies farming practices under three program areas: Livestock, Farmstead and Cropping. Certification is available currently for the Livestock program, which includes implementation of a Comprehensive Nutrient Management Plan.

The Wood-Land-Lakes RC&D Council works to protect farmland in Northeast Indiana. It holds conservation easements on farms in Elkhart, LaGrange and Steuben Counties. Tax Incremental Funding has been used in Elkhart County to provide a rebate on tax increases for the purchase of development rights on agricultural land. The use of this mechanism for agricultural protection was unique because the funds are typically used for industry. The Land Information Access Association (Traverse City, MI) has developed websites for Hillsdale and VanBuren Counties and an informational CD for the Dowagiac River Watershed Project. These resources all contain valuable information on zoning methods to protect farmland including exclusive use zoning, slide scale zoning, open space (cluster) zoning and the requirement of buffers between agricultural land and residential development.

(More information on these and other zoning techniques can be found on the Hillsdale County web link in the attached table.)

Land use ordinances including agricultural land protection measures are developed on a township basis. Some Michigan townships have received assistance from the Dowagiac River Watershed Project to prepare new Master Plans. Calvin, Wayne and Marcellus Townships (Cass County) were noted as examples of municipalities with good land use planning in the interview process. Agricultural lands in these townships are zoned as prime or general. Prime agricultural land sold in the townships may only have one residence constructed on every forty acres. (Prime agriculture is defined by the USDA as land best suited to grow food, feed, forage, fiber and oilseed crops. Prime agriculture produces the best yields with minimal economic input and the least environmental damage.) In contrast, general agricultural areas allow smaller parcel divisions. Many of these forty-acre plots are being used for small horse farms. This ordinance has prevented the development of small residential lots in the Christiana Creek Watershed. In contrast, Newburg Township in Cass County has no land use zoning. Agricultural lands can also be protected with open space zoning, which uses cluster development to concentrate homes and leave the remainder of the property undeveloped.

Indiana has a filter strip law which allows for a $1/acre assessment for property taxes for farms having filter strips of a particular size. It appears that this would serve as a good incentive for landowners to use this practice. However, many still do not use them. One suggested reason is a reluctance to use federal funding, as the use of funds may include restrictions on property rights. It may be a good idea to incorporate a mechanism to provide mini-grants from the Friends of the St. Joe River Association for the installation of BMPs. Therefore, the direct connection in the funding is from a nonprofit agency, creating a buffer and alleviating potential concerns about infringements on private property rights through federal restrictions.

The Noble County Drain Surveyor distributes free seeds for replanting buffer strips on agricultural lands following work on drains that disrupt the buffer. According to the Soil and Water Conservation District, the program is quite popular within the county and helps to reduce sediment and nutrient loading to the watershed.

Lake communities

Lake communities located in rural areas face unique issues. They are typically in areas of lands valued for preservation (agricultural, forest, wetland) and are usually not connected to a regional sewer system. The remote beauty of the

In the Watershed…

In Cass County, sewers have been installed around Donnell Lake, the subject of a past Section 319 grant. This has reduced nitrate levels in the groundwater in that area. Sewers have also been constructed around Indian Lake, Barren Lake, Diamond Lake, Eagle Lake, Lake Garver, Paridixie Lake, the Sisters Lakes and in the Village of Vandalia. The Diamond Lake Association monitors coliform levels and has not found high levels since the construction of the sewer. Sewer construction is also planned or occurring around Baldwind-Long-Coverdale Lakes, Shavehead Lake, Birch Lake and Juno-Painter-Christiana Lakes.

lakes draws residents and summer visitors. Waterfront properties get disproportionate development compared to upland areas. However, the concentration of septic systems around the lakes can take a toll on surface water quality. The need for regional treatment systems or connections to a sanitary sewer system has been identified in many areas of the watershed.

For example, LaGrange County has several lakes and a large influx of visitors each summer. Some lake communities, such as Fish Lake and Stone Lakes in LaGrange County, Klinger Lake in St. Joseph County and part of Palmer Lake near Colon have been sewered recently. A comparison of aerial photographs of Klinger Lake illustrates the reduction in algal blooms following sewering, and improvements have been observed in Fish and Stone Lakes. Citizens groups around Fisher Lake near Three Rivers are interested in sewer installation and have approached the Branch-Hillsdale-St. Joseph District Health Agency to request an assessment of the lake. The cost of connection to the sewer system is a major drawback to resident buy-in at many lakes. When sewer connection is not plausible, septic pretreatment has been suggested. A sewer use assessment was recommended to fund maintenance of pretreatment equipment for lake residents.

Other requirements to protect lake resources can include a restriction on the installation of septic systems in new developments, which should only be constructed where they have access to the sanitary sewer. The Kalamazoo Metropolitan County Planning Commission recommends this in its policy statements. When a property with a septic system is sold, an inspection should be required. Further, information on proper septic system maintenance should be provided to the new property owner. The Michiana Council of Governments has produced a free educational video titled “Septic Systems 1-2-3”. It has been distributed to title companies within the jurisdiction. Wider distribution of this video throughout the watershed to Realtors and title companies should be sought.

The Indiana Office of the Commissioner of Agriculture Land Resource Council identified rural wastewater management as a priority for 2003 and hence established a Rural Wastewater Task Force. The task force met nine times in 2003 to recommend eight activities for facilitating proper wastewater treatment in rural areas. Recommendations included a tracking system to document system failures and a training and certification program for inspectors and regulators. The Elkhart County Commissioners received a Section 319 grant to identify problematic septic systems in the county. That project led to the development of a Watershed Management Plan for the Lower Yellow Creek Watershed.

Some states allow Clean Water Fund Revolving Loans to be used for nonpoint source pollution reduction projects, including maintenance of septic systems. Funds are traditionally used for upgrades and construction of wastewater treatment plants. This could include the construction of new plants for lake communities. Indiana funds may be used for wetland protection, erosion control, stormwater Best Management Practices and conservation easements. Michigan Revolving Fund monies may only be used for publicly owned facilities, which may include stormwater facilities. The state has created a Strategic Water Quality Initiatives Fund which can be use for the upgrade or replacement of failing on-site systems, or the removal of stormwater or groundwater from sewer leads.

According to “Funding Opportunities: A Directory of Energy Efficient, Renewable Energy, and Environmental Protection Assistance Programs” published by the U.S. EPA State and Local Capacity Building Branch (2004), Drinking Water State Revolving Funds can be used in some instances to support green infrastructure activities such as permeable pavement, rooftop gardens and other measures that help reduce the urban heat island effect and save energy. Grants are awarded to states to provide low-cost loans to public water systems to finance the costs of infrastructure projects. States are also authorized to use a portion of their funds for set-aside activities such as source water protection.

Urban land

The Baugo Creek, Elkhart River and Juday Creek Subwatersheds scored highest for implementation of conservation measures and BMPs. This is due to the developed nature (urbanized and agriculture) of the area, the presence of impaired water bodies and county-level agricultural statistics and population data. These scores are primarily based on land cover data, and not on field-scale characteristics of the subwatershed units.

The Juday Creek Subwatershed overlaps the South Bend/Mishawaka urban area. These cities are experiencing rapid suburban growth which spans the two cities, especially along the Grape Road and Main Street corridors. Juday Creek scored high for mitigation, however the scoring does not take into account the socio-economic factors at play in this watershed. First, Juday Creek flows through the Notre Dame campus and is, consequently, one of the most studied creeks in Indiana. The university's golf course was redesigned to incorporate trees to shade parts of the creek. Biological studies have also been performed on the areas along the golf courses to assess restoration projects.

In the Watershed…

The Riverfront Park in Niles, MI provides recreational access to the St. Joseph River, which includes a 5-mile hiking trail and a boat launch.

Further, the Juday Creek Task Force is active in protecting the creek from the impacts of new development. This includes requirements for infiltration of stormwater and riparian setbacks. The drain code in St. Joseph County (IN) also plays a large role in the protection of Juday Creek. In this and some other Indiana counties, property taxes assessed by the drain surveyor are kept within the watershed they were collected. Therefore, watersheds with a large amount of development and high property values also have more funds for drain projects. This allows funds to offset the impacts of development. Conversely, in Elkhart County, for example, drain funds are placed in a county-wide pool. This however, can benefit watersheds with a low tax base needing improvements.

Ordinances regulating the quantity and quality of stormwater can be implemented in urban areas to protect water quality. In Dane County, WI a ban on phosphorus containing fertilizer is being explored to protect sensitive lakes. In 2002, the State of Minnesota passed a bill to allow counties to locally ban phosphorus fertilizers on lawns. In April 2004, The Minnesota House of Representatives voted to make a state-wide mandatory ban. At the time of this writing, the Senate vote was pending.

Storm sewer utility fees are being used by some communities to fund improvement projects. The fees treat the storm sewer system as a utility provided by the municipality, similar to water and sanitary sewer utilities. Fees are paid by users, i.e., property owners, and are based on the level of use. Fees are determined by property size and amount of impervious surface. Reductions in fees can be sought through the use of measures to reduce runoff, such as use of pervious pavement and rain barrels. To distinguish a user fee from a tax, it must meet certain criteria. It must primarily benefit the user of the utility and not the general public. It must be voluntary, that is, the fee payer must be able to choose to not use the utility. It must be proportional to the service actually used. It must be used for the municipality to meet a regulatory requirement and not for generating revenue. Michigan law has allowed stormwater utilities since 1990. However, a 1999 Michigan Supreme Court decision in *Bolt v. City of Lansing* disallowed stormwater utility fees issued by the city to fund separation of combined sewers. Therefore, municipalities wishing to use a storm sewer utility fee must meet the issues raised by *Bolt v. Lansing*.

(The "Authority for Local Stormwater Fees in Indiana" link in the attached table provides guidance to Indiana municipalities wishing to explore stormwater fees.)

Post-construction ordinances identify the maintenance practices needed to maintain stormwater utilities. These practices may include street sweeping, cleaning of catch basins and pervious surfaces, visual inspections, monitoring of outflow of retention basins, limits on the use of deicing materials and education of residents regarding stormwater issues. Other suggestions include requiring all general purpose floor drains to be connected to the sanitary sewer.

Ordinances are also used to protect water bodies from streambank degradation and overland runoff. Riparian setback rules exclude development in riparian areas. They typically specify a distance (e.g., 100 feet) from the shorelines and streambanks in which development cannot occur. The ordinances can also specify that native vegetation be maintained in riparian areas to provide habitat and shade the water. Buffer ordinances may also include protection of steep slopes, floodplains and adjacent wetlands. A process for recording the location of the buffer in legal documents (e.g., land deeds) and the authority who will maintain the buffer should also be included in the ordinance. Buffers can also be labeled in the field with signs, so that their location is delineated and their importance is communicated.

In the Watershed…

The City of South Bend is conducting a river use survey to assess residents' use of the St. Joseph River and willingness to pay to protect it. The results of this survey can help shape public education campaigns and plan water quality improvement projects.

Combined sewer overflows (CSOs) from 12 cities in Indiana and 2 in Michigan impact the water quality of the St. Joseph River. All Indiana municipalities with CSOs are required to conduct a "Stream Reach Characterization" which assesses the health of the stream flowing through or adjacent to that municipality. The characterization is followed by a "Long Term Plan for Controlling Discharges from CSOs". The regulations also specify that no new combined sewers may be constructed. Therefore, new developments may connect sanitary sewers to existing combined sewer systems. But the stormwater from the development must be handled in another way. Elkhart County and City of Elkhart policies call for stormwater to be retained on-site. However, these policies are currently not ordinances.

Phase II Stormwater Rules are requiring municipalities and educational institutions in urban areas, as defined by the 2000 U.S. Census, to obtain permits for stormwater discharges. The permit process includes a watershed management plan, education/outreach activities and an illicit connection detection and elimination program. A Lower St. Joseph River Watershed has been delineated and is the subject of a Watershed Management Plan being developed by the municipalities in Berrien and Cass Counties regulated by the Phase II rules. These municipalities are working together and sharing resources to meet their Phase II obligations.

Ordinances for soil erosion and sedimentation are important to minimize runoff from construction sites. The Phase II Stormwater Rules specify that construction activities that disturb one acre or more of land require a stormwater control permit. Noble County adopted a stormwater drainage and erosion ordinance for disturbances greater than one acre in size prior to the update of the Indiana Rule 5, which previously required permits for projects disturbing over five acres, as required by Phase I Stormwater Rules.

Erosion control plans should be adjusted as site conditions change or as observations during construction identify on-site needs. Various drawings for different stages of development should be used, as different erosion control measures will be needed at different times. Exposed soil should be vegetated as soon as possible. This may follow rough grading, as opposed to waiting for the whole project to be completed. In areas with storm sewers, inlet protection should be used to prevent soils from entering area surface waters. Site access should be restricted to a minimum number of entry/egress points to prevent tracking of sediment off-site. These points should have stones to shake soils off of vehicle tires or tire washing stations. Soil stockpiles should be covered at the end of each workday.

The Indiana Department of Natural Resources has guidance for small sites. The guidance indicates that placement of site structures should be based on the lot's natural features. Sensitive areas, such as trees, should be protected during construction. A 20- to 30-foot vegetative buffer, mowed no shorter than 4 inches, should be maintained around the perimeter of the site. Stockpiled soils should be temporarily seeded with annual rye or winter wheat immediately following stockpiling.

(Example language for the ordinances described can be found through the Center for Watershed Protection link in the attached table.)

Total impervious area

Land can also be classified based on the percent of impervious surfaces in a given area. Impervious surfaces are caused by development related items such as roads, buildings, parking, lots and lawns. These surfaces can significantly alter the hydrology of a water body. In the St. Joseph River Watershed, the greatest imperviousness was identified along the river corridor from the mouth upstream to the western side of Elkhart County. These areas are located in the Cities of St. Joseph, Benton Harbor, Niles, South Bend, Mishawaka and Elkhart.

Zoning ordinances typically identify these urban areas as industrial, commercial and residential (single family, multi-family). However, they also allow the surrounding areas to support these land uses. Transportation infrastructure allows this development to move further and further from urban areas into lands previously used for agriculture or supporting valuable habitat. There are many causes and consequences of sprawl that are extensively studies by land planning experts. A Michigan Sea Grant study (2002) of land use planning in coastal communities indicated that Michigan, as a whole, is following a low-density development pattern which is highly land consumptive. The state has one of the highest ratios of urbanized land per person in the country.

Traditional zoning allows sprawl to continue unchecked. One cause is that watersheds lie in multiple political jurisdictions, each with its own zoning code. For example, the St. Joseph River Watershed includes over 170 townships in both states. In Michigan, land use planning and zoning falls to the authority of each township, some of which lack monetary resources to protect their valuable natural features. In Indiana, land use planning is conducted at the county level, which allows more broad recommendations to be implemented. However, site specific details and needs of constituents can be lost, similarly to watershed planning at the large scale.

In the Watershed…

Fabius Township's Ordinance 95 establishes an Open Space Residential Zoning District in which 50-80% of the development must remain as open space or farmland.

Overlay zoning has been used in many communities to add additional restrictions to traditional zoning areas. This can be used where significant natural features, such as riparian areas and wetlands, have been identified. It can also be used to protect cultural resources such as drinking water or historical features. Overlay zoning based on current imperviousness can also be used. This targets specific types of development to areas already impacted by past and current land uses. For example, areas currently having 20% or greater imperviousness, such as inner city areas, are targeted for redevelopment and highly dense development. Abandoned industrial lands (brownfields) should be redeveloped to suitable uses. If commercial land is built in new areas, it should be clustered with shared drives, as opposed to spread into strips.

Lands with low imperviousness should be targeted to only allow future developments at total low density. This does not imply that houses be constructed on large lots, because when the total density is considered, which includes extensive roads, that development pattern can result in more imperviousness. This zoning technique calls for low impact development or conservation development. This can include clustering homes in a central area and leaving the remaining land for agricultural or preservation purposes. This can include conserving open spaces, clustering buildings and decreasing paved areas by narrowing road widths, placing sidewalks on only one side of roads, installing shared driveways, relaxing setback standards, using pervious paving and reducing cul de sac radii or installing plantings in the centers (to create a donut shape).

In the Watershed…

Longmeadow, a Planned Unit Development in Niles, MI, combines residential living, commercial development and open space.

These communities may also use incentives or requirements for individual on-site measures, such as rain gardens or rain barrels. The community includes open space to be used as parks, stormwater treatment or habitat. For example, long shallow vegetated depressions can be dug in open areas for stormwater infiltration. During dry weather, they appear to be a part of the landscape. Low impact development saves money for developers through a reduction in the amount of roads, sidewalks and storm sewers, which can amount to ½ half the cost of the subdivision.

The Kalamazoo Metropolitan County Planning Commission Policy Statements (1999) encourages Planned Unit Developments and discourages the development of residential property units in rural areas. A municipality can provide density bonuses to developers who protect open space and keep development away from sensitive areas, which should be preserved as assets to the property.

Protection of the watershed as a whole

Watershed management planning should also include mechanisms to consider and protect the watershed as a whole. Currently, the Indiana portion of the watershed is considered in planning decisions through the St. Joseph River Basin Commission, which was established by the Indiana General Assembly in 1988 (Indiana Code 14-30-3). It includes representation from municipalities and counties within the watershed and the Indiana Department of Natural Resources. A formal mechanism within the Michigan portion of the watershed or across the watershed boundaries would be beneficial to the watershed. The watershed also has regional planning commissions, such as MACOG, the Southwest Michigan Commission (Region 4) and the South-Central Michigan Planning Council (Region 3). However, it does not appear that these commissions work together on a watershed basis.

There are examples of multi-state watershed commissions throughout the nation. For one, the Connecticut River Joint Commissions were created in 1989 by combining New Hampshire's Connecticut River Valley Resource Commission, created by legislature in 1987, and Vermont's

Connecticut River Watershed Advisory Commission, similarly created in 1988. The role of the commissions is advisory to assure public involvement in the protection of the river and valley.

(The Connecticut River Joint Commissions can be found at http://www.crjc.org/.)

Some multi-state watersheds, such as Lake Champlaign, have been assigned special designations. Others, like the Chesapeake Bay Watershed, have become the focus of divisions of the U.S. Environmental Protection Agency (USEPA).

The USEPA has encouraged the use of watershed based NPDES permits to monitor and reduce pollutant loading. These have been done in the context of a TMDL and may have application with the St. Joseph River *E. coli* TMDL. With these permits, point sources are regulated collectively to meet a maximum load to the river. Watershed based permits have been used for nutrients in the Long Island Sound, CT; the Neuse and Tar-Pamlico River, NC; and the Tualatin River, OR. A general stormwater permit is available for all watersheds in the State of Michigan. This process stemmed from the court-mandated cleanup of the Rouge River. The permit is available as an alternative to the traditional six minimum measures permitting option under the Phase II Stormwater Program.

(See the Watershed Based Permit links in the attached table for more information.)

The Ohio River Valley Sanitation Commission (ORSANCO) was established in 1948 to control and abate pollution in the Ohio River Basin. ORSANCO is an interstate commission representing eight states and the federal government. Member states, including IN, IL, KY, NY, OH, PA, VA, WV, entered into a compact to establish the commission.

(ORSANCO can be found at http://www.orsanco.org/.)

The Miami Conservancy District was established in 1913 in response to a devastating flood. It is a political subdivision of the State of Ohio that provides flood protection and water resource monitoring for the Great Miami River Watershed in Ohio and Indiana. The State of Ohio has 23 conservancy districts, all organized at the watershed level.

(More information can be found at http://www.miamiconservancy.org/.)

The Tip of the Mitt Watershed Council works to protect watersheds in Northern Michigan. It administers the Great Lakes Aquatic Habitat Network and Fund. The Network has a hub in each Great Lakes state which provides information and assistance on issues within the Great Lakes portion of that state. The Fund provides small grants to grassroots organizations to install BMPs and protect local water resources.

(More information can be found at http://www.watershedcouncil.org/.)

Short of a special designation or commission, a permanent watershed coordinator position should be funded to assure continued work to protect the watershed. Funds could come from watershed assessments (as a part of property taxes), membership dues to the Friends organization or grant funding, such as the grant which supported this project.

appendix c

scoring of major subwatersheds

Scoring of Major Subwatersheds

<u>Introduction</u>

The St. Joseph River Watershed was delineated using a 30-meter Digital Elevation Model into 217 subwatersheds. GIS-data, such as land cover, impaired water bodies and trout lakes and streams, are available for the subwatersheds. County level data, such as population, number of animal units and acres harvested, are available for the basin. These types of spatial data were used to score the subwatersheds for preservation priorities and to determine which subwatersheds were impacted (mitigation priorities). A nonpoint source model was also run for the subwatersheds to determine the expected loading of total suspended solids and total phosphorus contributed to Lake Michigan annually from each subwatershed.

<u>Mapping Major Subwatershed Units</u>

A series of preservation scoring scenarios were developed for the 217 subwatersheds of the basin in order to identify those with large percentages of remaining forest and wetland land cover. Attachment 1 contains the detailed subwatershed scoring report. Because the St. Joseph River Watershed is quite large and objectives developed in the Watershed Management Plan will focus on large-scale implementation efforts, scores were determined for major subwatersheds. Each named surface water body flowing into the St. Joseph River was used as a major subwatershed unit. Subwatersheds within that unit were grouped and scores were averaged for those units. Subwatersheds along the main stem, delineated by overland flow to the river, were grouped into three units (upper, middle and lower). This initial grouping resulted in 32 watersheds. Six resulting watersheds, such as the Elkhart River, were quite large, while others, along the main stem, consisted of only one subwatershed each. Therefore, the large subwatersheds were divided into smaller units. (For example, the Coldwater River unit contained the Hog Creek Subwatersheds in the first iteration because the Hog Creek flows into the Coldwater River before the confluence with the St. Joseph River. The Hog Creek was then grouped as its own subwatershed, separate from the Coldwater/Sauk Subwatershed.) This resulted in 42 subwatersheds for the basin, shown in Figure 1.

<u>Scoring for Preservation and Mitigation</u>

The detailed subwatershed scoring report describes four preservation scoring scenarios. Preservation Scenario 4 was chosen for the major subwatershed scoring and is based on the percent of wetland/open water land cover, the percent of forest land cover and trout lakes and streams (discounted by 1/3, as the presence of wetland and forest cover should indicate a watershed which provides trout habitat.) Table 1 lists the subwatersheds and their average preservation and mitigation scores. Trout Creek, Mill Creek, Upper Paw Paw River and Upper Dowagiac River scored the highest for preservation. (Trout Creek and Mill Creek consist of only 1 subwatershed each.) Baugo Creek, Lower Elkhart River and Little Elkhart River scored the lowest. Figure 2 illustrates these scores. Mitigation was scored by the percent urban land cover, percent agricultural land cover, presence of impaired waters [as identified by each state's 303(d) list], and county level statistics (2000 population, 1997 animal units and 1997 atrazine use). Pine Creek, Juday Creek and the Lower Elkhart River scored the highest for mitigation, while the Upper Fawn River and Upper Pigeon River scored lowest. Figure 3 illustrates these scores.

<u>Land Cover Analysis</u>

The total percent imperviousness was also averaged for each subwatershed grouped into the larger drainage units. A watershed with greater than 10% imperviousness is considered impaired, while those with 5-10% are considered threatened. Imperviousness is calculated by multiplying an imperviousness factor for each land use type by the area of that land use type. Those values are summed and divided by the total land area of the unit. One unit was considered impaired: the Lower Main Stem. Four were considered threatened: Lower Elkhart River, Hickory Creek, Yellow Creek and Juday Creek. Figure 4 illustrates these percentages.

Table 1 also lists the average percent wetland, forest, agriculture and urban land cover. Trout Creek, Portage River and Christiana Creek contained the greatest percentage of remaining wetlands, while Trout Creek, Mill Creek and the Upper Paw Paw River contained the greatest percentage of remaining forest cover.

<u>Nonpoint Source Model</u>

An empirical nonpoint source model using land cover and average annual rainfall was run to determine the annual loading of total suspended solids and total phosphorus from each subwatershed of the basin. The report is included in Attachment B. An average loading for each major subwatershed was calculated from the individual loads of each subwatershed in that unit. These values are also listed in Table 1. Trout Creek, the Lower Main Stem and Hickory Creek were determined to contribute the greatest sediment loading. Hickory Creek, Lower Main Stem and Yellow Creek were determined to contribute the greatest phosphorus loading. These data are due to the urban nature of these areas and the greater amount of rainfall at the western end of the St. Joseph River Watershed.

<u>Discussion</u>

This averaging scheme was used to characterize the watershed and identify critical areas at the large scale. It identifies regions where preservation should be recommended and regions largely impacted by development and agricultural uses. However, averaging the scores over a broad area tends to result in many units scoring in the middle range, as site specific characteristics are lost. It is evident in the fact that most of the highest and lowest scoring units are those composed of only one subwatershed (i.e., Hickory Creek, Trout Creek, Juday Creek). These single subwatersheds were not combined with other units because they directly flow into the St. Joseph River Watershed. (An exception was made for Soap and Sand Creeks in the headwater area because they are small, contiguous subwatersheds.)

The detailed scoring scenario in Attachment A largely illustrated subwatershed scores being clustered in geographic locations. However, a few isolated scores were noted in which the subwatershed score did not match those surrounding it. An example is Turkey Creek (of the Elkhart River Watershed) which scored high for preservation because 25% of its land cover is wetland. These fine details are not seen in the scoring of the major units, but is preserved in the Attachment A report. The scores in Table 1 can be used for broad watershed characterizations.

Table 1. Major Subwatershed Scores

Name	Area (square meters)	Nonpoint Source Loading Model		Percent Land Cover Type				Score		Percent Total Impervious Area
		TSS (lb/acre)	TP (lb/acre)	Wetland	Forest	Agriculture	Urban	Preservation	Mitigation	
Lower Elkhart River	27088.1	105.0	0.2372	2.1	8.1	77.5	9.1	1.10	13.98	6.19
Middle Elkhart River	31878.5	97.9	0.2074	5.5	6.4	81.7	4.9	1.33	12.60	3.06
Turkey Creek Elkhart River	41762.7	96.2	0.1903	6.3	6.3	84.8	1.8	1.42	12.89	1.31
North Branch Elkhart River	42355.7	87.0	0.1880	11.5	10.0	75.6	2.0	2.43	9.48	1.68
South Branch Elkhart River	29174.3	85.5	0.1727	9.4	12.1	77.6	0.7	2.38	9.28	0.45
LIttle Elkhart River	29733.6	97.0	0.1793	2.8	8.5	87.4	0.7	1.19	10.89	0.81
Lower Pigeon River	47158.6	89.6	0.1805	8.3	11.5	78.7	1.2	2.19	9.36	0.89
Upper Pigeon River	35784.5	88.1	0.1750	7.3	11.8	79.5	1.0	2.10	6.53	0.92
Turkey Creek Pigeon River	18696.4	87.0	0.1705	8.1	11.2	80.2	0.5	2.15	6.68	0.26
Lower Fawn River	22342.5	95.2	0.2040	6.2	11.8	76.0	3.9	2.04	10.38	3.41
Upper Fawn River	27206.5	82.5	0.1803	13.4	14.0	71.0	1.0	3.05	6.37	1.07
Coldwater/Sauk Rivers	48689.7	83.1	0.1740	8.2	17.1	71.8	2.3	2.80	9.21	1.27
Hog Creek	27946.1	82.4	0.1602	6.3	17.9	74.9	0.6	2.64	8.34	0.45
Lower Dowagiac River	28308.0	95.0	0.2002	9.1	21.3	67.4	1.6	3.62	9.16	1.11
Upper Dowagiac River	37300.2	88.8	0.1998	13.5	21.4	63.3	1.5	4.05	8.12	0.96
Lower Paw Paw River	46178.2	101.0	0.2409	9.2	21.8	61.2	6.0	3.60	7.15	3.89
Upper Paw Paw River	58990.1	85.7	0.1782	0.0	27.9	62.4	1.0	4.13	7.07	0.78
Beebe Creek	10851.8	74.5	0.1545	10.4	23.6	65.8	0.2	3.65	7.35	0.10
Soap Creek, Sand Creek	8762.8	80.0	0.1530	5.6	21.4	72.6	0.4	2.85	7.80	0.20
Tekonsha Creek	5625.0	77.0	0.1490	6.2	24.8	68.9	0.0	3.30	9.00	0.12
Nottawa Creek	45818.4	78.9	0.1601	9.3	22.7	67.6	0.2	3.49	9.11	0.19
Little Portage Creek	11432.4	91.5	0.1680	2.8	16.2	80.4	0.6	1.95	9.10	0.33
Portage River	50662.3	83.2	0.1891	14.4	16.3	66.9	2.1	3.42	8.79	1.01
Swan Creek	22462.4	85.0	0.1703	8.1	15.5	75.4	0.9	2.90	8.87	0.39
Prairie River	60721.6	84.7	0.1778	11.1	14.1	73.5	0.9	2.90	8.09	0.70
Rocky River	43481.8	85.1	0.1843	11.1	20.5	66.4	1.5	3.69	8.31	0.72
Mill Creek	11312.1	73.5	0.1615	12.9	30.3	56.6	0.2	5.30	7.85	0.10
Trout Creek	7928.0	124.0	0.1660	17.3	32.9	48.7	1.0	6.50	9.70	0.49
Pine Creek	7996.0	95.0	0.1830	3.3	12.3	81.9	1.9	1.60	14.30	1.01
Baugo Creek	19959.3	104.8	0.1928	1.8	5.7	90.5	1.2	0.80	12.73	1.11
Peterbaugh Creek	4261.0	97.0	0.2250	7.0	13.7	69.5	7.7	2.20	11.30	4.48
Christiana Creek	25681.6	84.6	0.2070	13.7	22.6	57.8	4.3	4.04	9.10	2.87
Cobus Creek	9151.0	95.0	0.2060	5.5	19.0	69.1	5.0	2.60	12.10	3.13
Juday Creek	9252.0	110.0	0.2680	0.7	12.8	69.0	14.5	1.40	13.40	8.38
Brandywine Creek	6134.0	95.0	0.2100	5.4	26.7	61.7	5.4	4.00	8.40	2.79
McCoy Creek	6063.0	106.0	0.2450	8.1	22.7	62.1	5.4	3.60	8.80	3.51
Pipestone Creek	12869.7	107.0	0.2025	3.9	20.1	74.9	1.1	3.35	7.90	0.51
Yellow Creek	13023.0	111.0	0.2850	3.6	22.0	58.2	14.6	4.00	7.40	7.01
Hickory Creek	13022.0	111.0	0.2850	3.6	22.0	58.2	14.6	4.00	7.40	7.01
Middle Main Stem	29351.7	91.0	0.1996	7.5	17.1	69.8	4.2	2.66	10.89	2.85
Upper Main Stem	52601.7	81.9	0.1804	9.6	18.7	67.6	3.4	3.08	8.89	2.01
Lower Main Stem	62466.6	116.0	0.3345	6.2	18.3	51.1	18.0	2.96	11.20	12.85

Figure 1. Major Subwatershed Units.

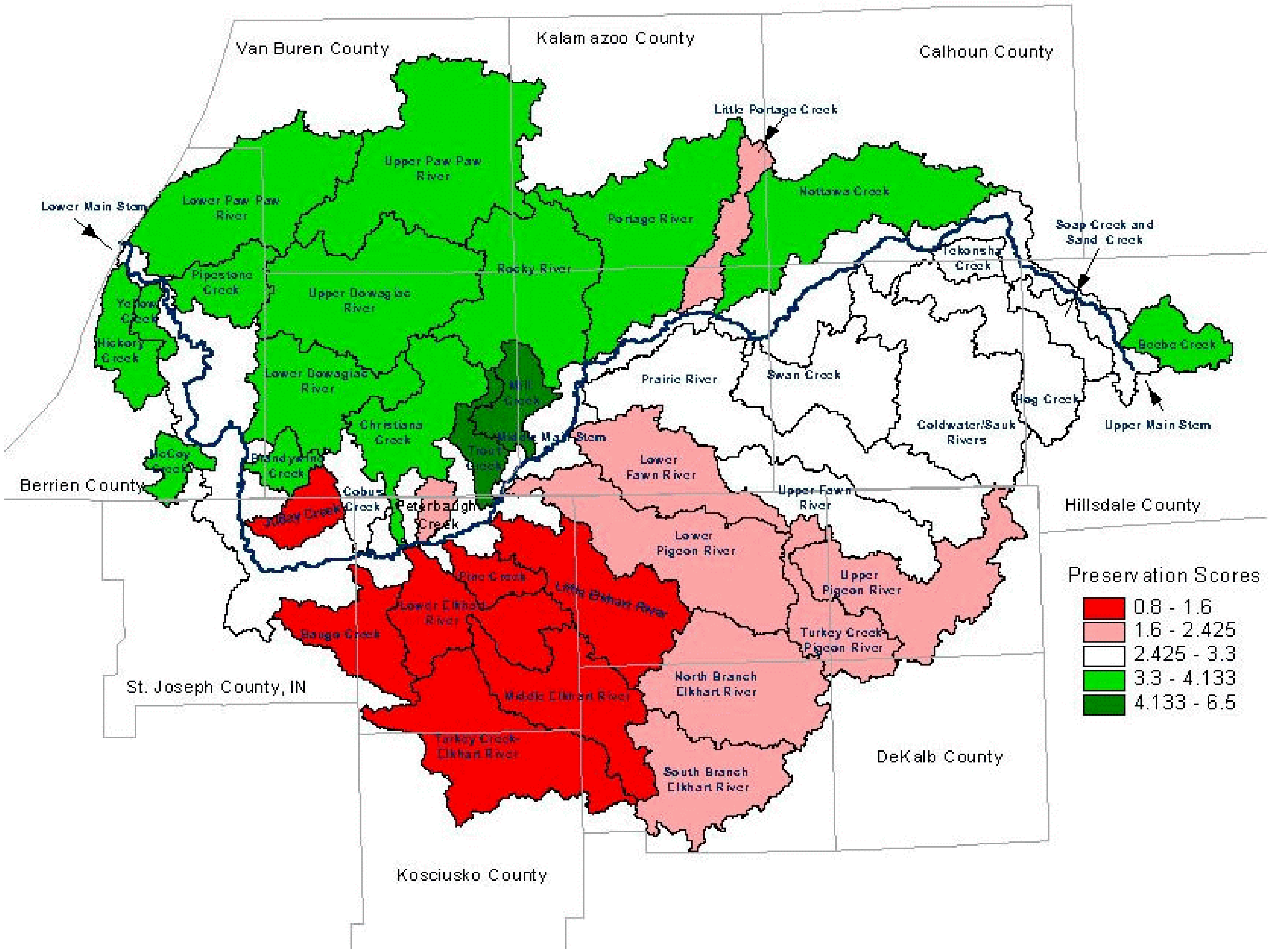


Figure 2. Major units scored for preservation.

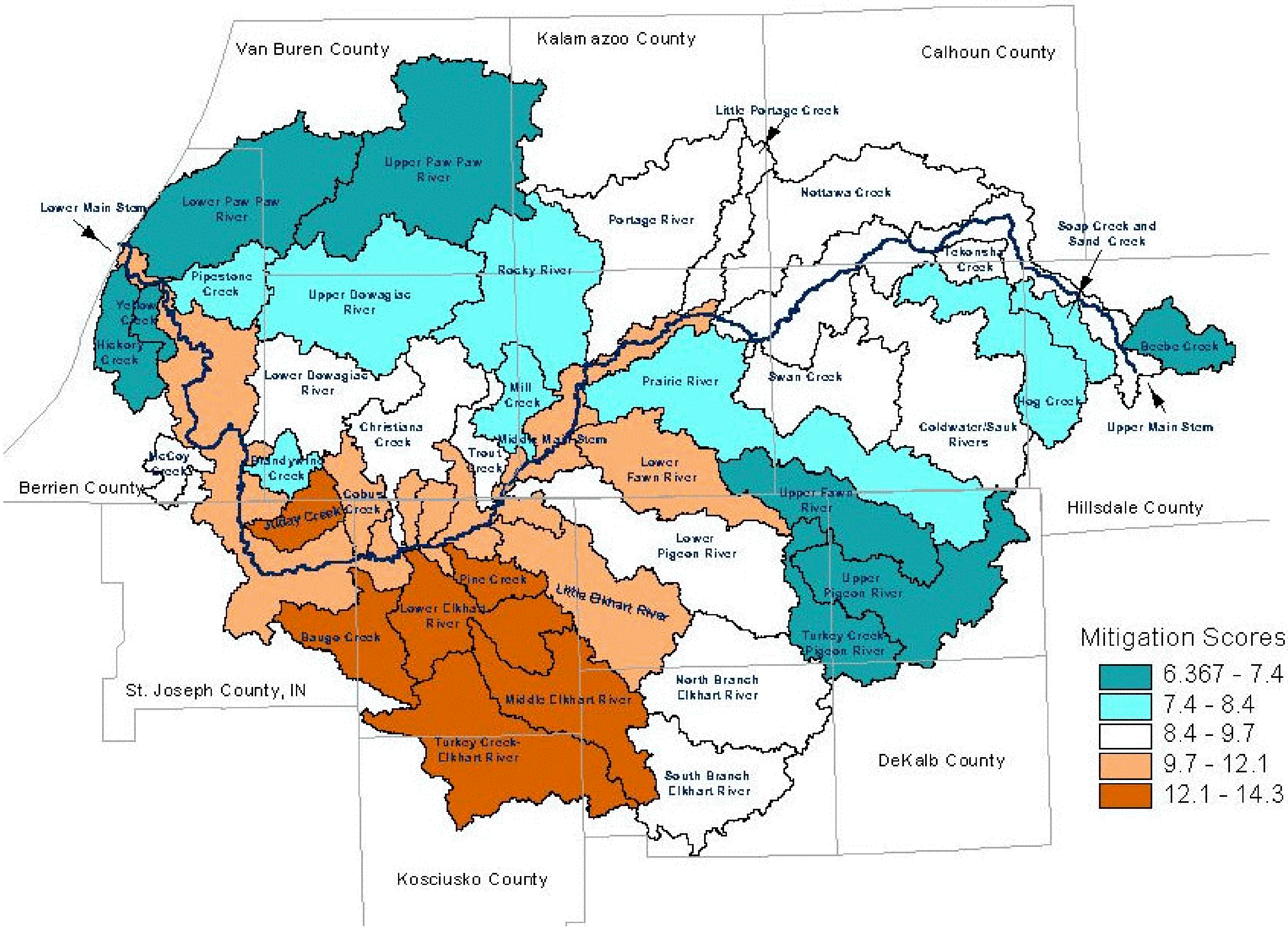


Figure 3. Major units scored for mitigation.

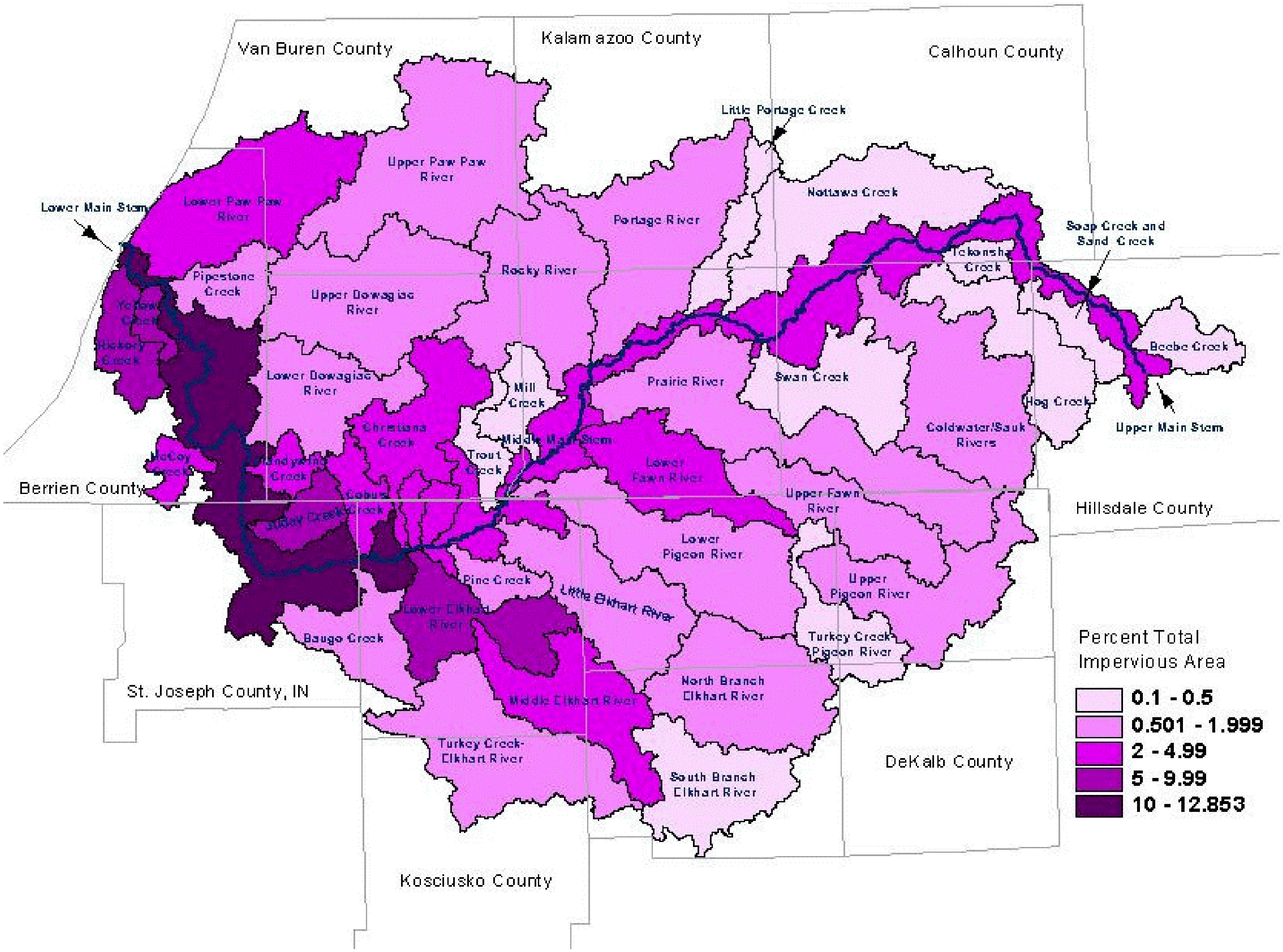
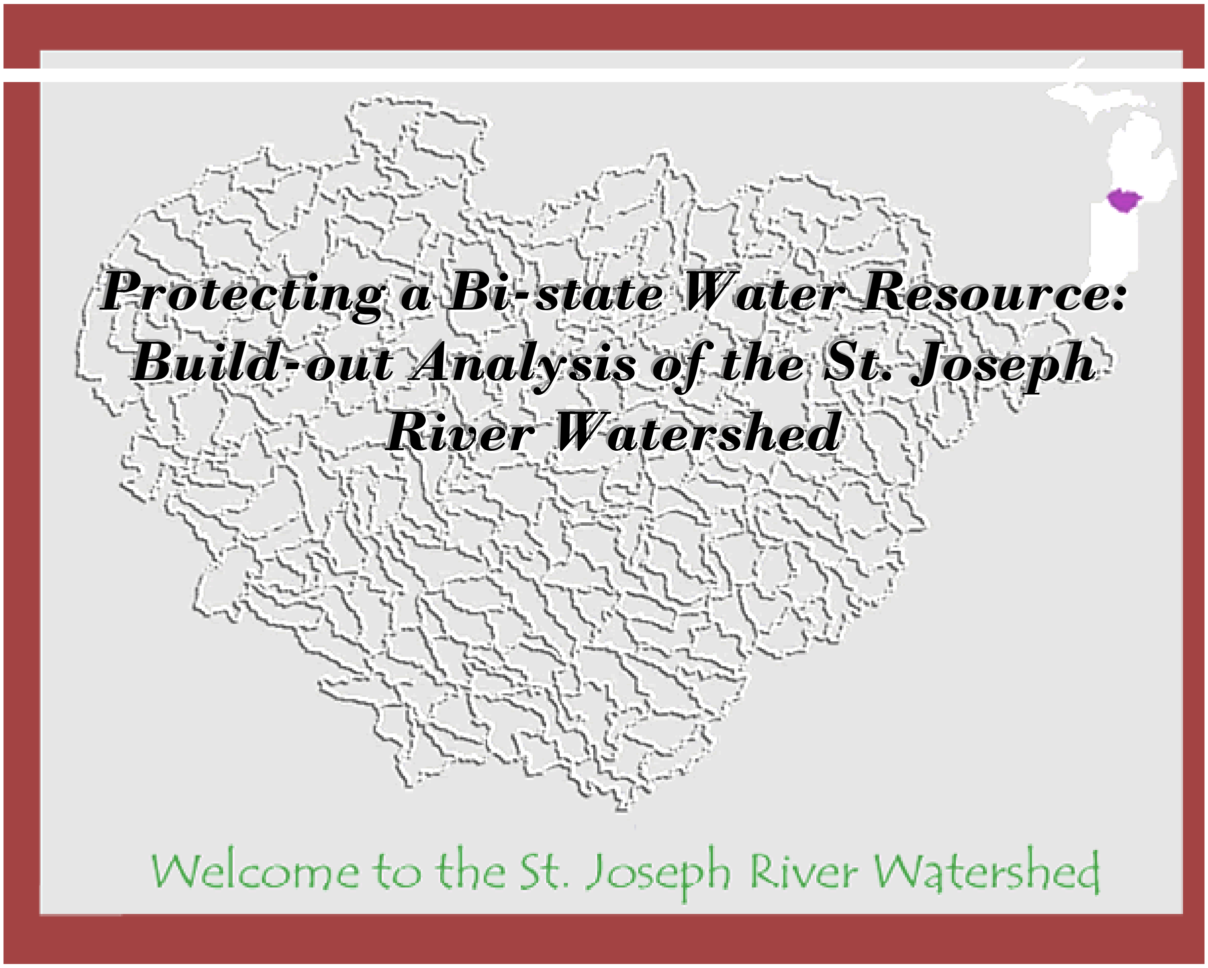


Figure 4. Total percent imperviousness for major units.

appendix d

protecting a bi-state water resources: build-out analysis of the st. joseph river watershed

Protecting a Bi-state Water Resource: Build-out Analysis of the St. Joseph River Watershed



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Project Background

The U.S. Environmental Protection Agency (USEPA) issued new requirements for watershed management plans funded through Section 319 grant monies in late 2003. All watershed management plans must meet the new requirements (known as the Nine Elements) to be eligible for implementation funds through the Section 319 grant program. These requirements call for additional quantification of sources of nonpoint source pollutants and expected reductions in pollutants with recommended Best Management Practices. The St. Joseph River Watershed Management Planning Project was initiated in December 2002. New efforts are being completed to quantify sources of impact in the basin including nonpoint source modeling of agricultural and urban land covers. This report addresses the latter.

The St. Joseph River Watershed is a large (4,685 square miles), bi-state watershed (Figure 1). Field scale data collection and analysis are not feasible at such a large scale. Therefore, GIS-based models are necessary to understand current nonpoint source loading conditions and to characterize pollutant sources. Predictive tools are necessary to model watershed changes and the associated water quality threats. The Great Lakes Commission awarded a $6,000 grant to the Friends of the St. Joe River Association, Inc. to conduct limited build-out analyses using the ArcView extension, Landscape Analyst as a tool to help the Watershed Management Plan (currently in development) meet the Nine Elements. Under contract to the Friends of the St. Joe River Association, Kieser & Associates (K&A) used Landscape Analyst to project future development in the watershed and to model potential threats to existing open space. Identification of threats to open space and loss of farmland is used here to signal the need for preservation and smart growth, as well as implementing the Watershed Management Plan. This effort was also designed to illustrate the impacts on water quality from unplanned growth with no stormwater management. A nonpoint source loading model for sediment and phosphorus was used to estimate loads to the St. Joseph River from future potential development in these regards. It is envisioned that these exercises will also underscore the importance of ongoing land use planning efforts.

Model Overview

Landscape Analyst, developed by the Canaan Valley Institute (West Virginia), is an ArcView 3.2 GIS extension designed for watershed simulations. The development model within the extension, was used to simulate potential future changes to the landscape. The model identified areas where future development can occur in the watershed based on physical constraints such as topography. These results were used to identify where preservation may be needed and where increased stormwater runoff may be expected. Those new areas of potential development identified by Landscape Analyst were used as inputs to adjust the empirical nonpoint source load model run for current land cover conditions for the Watershed Management Planning Project (K&A, 2003). The adjusted nonpoint source load model predicted associated changes in stormwater runoff and loading of sediments and phosphorus to the St. Joseph River with new development assuming no stormwater management practices are applied.

Landscape Analyst also includes many indicators of watershed conditions. Indicators were used to identify forested areas to confirm preservation priorities developed through subwatershed scoring in the Watershed Management Planning Project.

In addition to modeling potential threats to the watershed, a goal of this effort was to assess the use of Landscape Analyst as a tool for watershed planning and analysis in the St. Joseph River Watershed. The Watershed Management Planning Project is unique in the fact that it encompasses a large geographic unit that includes two states. This modeling project therefore presents an innovative method for identifying and quantifying potential watershed threats at a large scale.

Methods

This section discusses the approach used by K&A to use the Landscape Analyst model for projecting future development and the associated water quality impacts in the St. Joseph River Watershed. Documentation of the Landscape Analyst extension is included in Attachment A. In this section, we discuss:

- predicted watershed level development
- model limitations
- county-scale analysis of future development
- nonpoint source loading
- indicators of forested land use

<u>Predicted Watershed Level Development</u>

Future development in the St. Joseph River Watershed was predicted with the development model within Landscape Analyst. The development model utilizes land cover, roads, streams and elevation spatial data in a fuzzy logic technique with GIS to identify areas where development can occur. A 30-meter digital elevation model from the U.S. Geological Survey (USGS, 1999) and 2000 land cover data (Figure 2a) from the National Oceanic and Atmospheric Association (NOAA, 2000) were used in the model. The stream network from the USGS National Hydrography Dataset (USGS, 1997) was also utilized, while road data were derived from U.S. Census TIGER files (U.S. Census, 1995). The geographic extent of the modeling was defined by a watershed delineation completed for the Watershed Management Planning Project (K&A, 2003).

The development model allows users to define maximum thresholds for locations of development and a minimum suitability for development. User defined inputs are detailed in Table 1.

Table 1. User-defined input parameters for Landscape Analyst.

Input Parameter	**Value**
Distance from roads (miles)	10.9
Distance from current development (miles)	10.9
Slope threshold (%)	2.5
Minimum suitability (range 0-1, 1 is most suitable)	0.75

The minimum threshold values allowed by the model were 10.9 miles for both distance from roads and distance from current development. This is due to the fact that the model adjusts the available user inputs based on the size of the geographic area. Because the study area, i.e., the St. Joseph River Watershed, is so large, the model did not allow smaller user inputs. In order to verify this, the model was also run for Elkhart County alone to refine predictions and to evaluate the utility of the model at a smaller scale for possible use by land use planners. A minium threshold of 2.2 miles was allowed by the model at this refined geographic scale.

Model Limitations

The model allows users to define the current land cover type on which development can occur. Two scenarios were attempted: one in which agricultural lands were developed, and one in which forested lands were developed. However, a visual review of the grid file output of the model revealed that both scenarios resulted in the same areas being predicted for development. This was confirmed by an area analysis in which the 2000 land cover grid file was intersected with each development prediction scenario. The two scenarios projected development on the same absolute areas and ratios of land cover type, regardless of the user input. The model also predicted development on all land cover types, including wetlands, open water and currently developed lands, even though the user input specified only forest land or only agricultural lands to be developed. This type of issue was identified by another user of the model (Fongers, personal communication, 2004). Assistance from the Canaan Valley Institute did not result in a correction of this issue. Assistance was limited due to a lack of funding support for the extension (Kemlage, personal communication, 2004). Therefore development projected on wetlands, open water and currently developed lands (i.e., approximately 25% of the total) was disregarded, and the following data analysis was applied to the model output to produce representative results for this exercise.

County-scale Analysis of Future Development

Landscape Analyst simply identifies areas in which development is expected based on physical constraints within the watershed. Further analysis is therefore necessary to place that projection in the context of actual population growth. This section discusses the application of U.S. Census data and land development patterns within jurisdictional units, i.e., counties, to the development model output.

For each county in the St. Joseph River Watershed, the areas of projected development (output of the development model) on each current land cover type were tabulated using the Spatial Analyst extension in ArcView 3.2 (for example, the acres of forested land cover expected to be developed in Branch County). The areas in which development was projected on currently developed lands, wetlands and open water were disregarded, as discussed above in the Model Limitations section. The areas in which development was projected on cultivated land and grassland were summed as agricultural land, and the areas projected on forested and scrub-shrub land were summed as forest land. Those areas projected for these two land use categories were used as future development in further calculations.

The total acreage of projected developed land (agricultural and forested land) in each county was compared to the acreage of currently developed land identified by the 2000 land cover. The projected acreage to be developed in each county was reported as a percentage of that county's current (2000) development. To gauge the time to reach the projected development build-out at current trends, the population growth rate (from 1990 to 2000) was identified for each county from U.S. Census data (U.S. Census, 2000, Attachment B). The relationship of land development to population growth was derived from a study of sprawl by the Brookings Institution (2001). The average Midwest urban area develops land at a rate 4.5 times that of population growth. The publication also identified these sprawl factors for metropolitan areas in the watershed including Kalamazoo, MI; South Bend-Mishawaka, IN; and Elkhart-Goshen, IN. Specific rates were applied to the counties containing these metropolitan areas (see Table 2).

Table 2. Sprawl factors (rate of change in urbanized land area/rate of population growth, 1982 - 1997) for metropolitan areas (Brookings Institution, 2001).

Metropolitan Area	Sprawl Factor
Elkhart-Goshen, IN	1.37
Kalamazoo, MI	3.11
South Bend-Mishawaka, IN	4.03

Benton Harbor, MI was also included in the report. However, it reported a decrease in population from 1982 to 1997. Therefore, the average rate (4.5) was applied to Berrien County.

The following formula was used to calculate the time, in years, for each county to reach full development as predicted by the development model:

$$\text{Time to reach development (years)} = \frac{\text{percent development projected * 10 years}}{\text{sprawl factor * percent population growth from 1990-2000}} \qquad \textit{Equation 1}$$

Based on the current (2000) and projected development from Landscape Analyst, the percentage of total future developed land as a portion of total land area was also calculated for each county by:

$$\text{Total future developed land (\%)} = 100^* \frac{\text{current developed acreage + projected developed acreage}}{\text{total acreage of portion of county within the watershed}} \qquad \textit{Equation 2}$$

Nonpoint Source Loading

An empirical nonpoint source phosphorus and sediment loading model using USGS 1992 land cover data was run in 2003 for the Watershed Management Planning Project to identify critical subwatersheds (K&A, 2003). The model output identified annual runoff volumes, annual sediment loading and annual phosphorus loading from each geographic unit (subwatershed). A rudimentary calibration to published loading data for the basin in the 1990s was completed for this empirical model.

For this report, the load model was updated using the 2000 land cover data and run at the subwatershed and county levels to be consistent with the Landscape Analyst model run. The area of expected urban land development in each subwatershed and in each county was calculated in GIS. These land areas were used to adjust the land cover input in the nonpoint source load model. The area of projected developed land in each unit was used to increase the area of residential land cover (by 75% of future developed land) and the area of the commercial/industrial/transportation (referred to as commercial) land cover (by 25% of the future developed land) in the model (Equations 3 and 4, respectively). These percentages were based on a Brookings Institution (2004) study that indicates that the majority of new development from 2000 to 2030 will be residential. The projected developed land in each county was used to decrease the agricultural and forested land uses in the loading model (Equations 5 and 6, respectively).

Future residential land area = projected development area * 0.75 + current residential land area *Equation 3*

Future commercial land area = projected development area * 0.25 + current commercial land area *Equation 4*

Future agricultural land area = current agricultural land area - projected development area (ag/grassland) *Equation 5*

Future forested land area = current forested land area - projected development area (forest/shrub) *Equation 6*

At the subwatershed level, the total acres of projected development were subtracted from the current forest and agricultural land area at an average watershed percentage of 10% and 90%, respectively. That is, 10% of the new development was projected to occur in forested areas, and 90% was projected to occur in agricultural areas. These percentages were derived from the county level analysis as the average distribution of land types in which development was projected to occur. The new runoff volumes and loads were calculated for each county and each subwatershed. For planning purposes, the county each subwatershed is predominantly located within was also determined using GIS.

Indicators of Forested Land Use

Indicators in the Landscape Analyst extension were used to identify areas of interior forest land, percentage of forested areas, forest edge habitat, forested land uses along riparian areas and agricultural land uses along riparian areas using 2000 land cover data. The extension identified these areas by the production of a new GIS grid file and by reporting a total watershed percentage. The work plan for this project also called for an identification of the largest forest patch in the watershed. However, the Landscape Analyst extension failed to run this indicator.

Results and Discussion

The predicted areas of development and estimated times to reach development for each county are discussed in this section. Times to reach full build-out levels, as predicted by the Landscape Analyst, vary from 26.4 years to 2,197 years. The greatest time was calculated for counties with little development in the watershed and a large land area of predicted development. These larger values present crude projections which should be updated with year 2010 census data, as population growth trends are not expected to remain constant. The predicted changes in runoff and nonpoint source loading by county and subwatersheds are also discussed and represent the potential water quality impacts of uncontrolled development with no stormwater management.

Development Model by County

The build-out analysis (future acres developed and time to reach development) was conducted for each county in the St. Joseph River Watershed (i.e., the portion of those counties within the watershed). The counties predicted to have the most future development within the shortest time period are discussed in this section.

St. Joseph, IN; St. Joseph, MI; Kalamazoo, MI; Kosciusko, IN and Elkhart, IN counties were predicted to have the most future developed land (as a percentage of total land area). Of these counties, St. Joseph, IN and Elkhart County were projected to reach this level of development in the shortest period of time (26.4 and 66.3 years, respectively). St. Joseph County (IN) also has the greatest current developed area, at 30%, and a sprawl rate of 4.03. Elkhart County is expected to reach its future level of development based on a 17% population growth rate from 1990 to 2000 and a land development rate at 1.37 times the population growth rate. Of those counties with the greatest future developed land, Kalamazoo County has the potential to increase its developed land by the greatest percentage (959%) from current development. However, it is expected to take the longest time to reach this level of development (1,400 years) due to its relatively low population growth (6.8%) and rate of sprawl (3.1) below the Midwest average (4.5). St. Joseph County (MI) is predicted to have the greatest number of acres developed (104,507). This development is predicted to be reached in 300 years, based on current population growth rates.

Figure 2b illustrates the projected land cover with the future developed areas as predicted by the Landscape Analyst development model. Table 3 identifies the expected development within the watershed by county in relation to developed land in 2000. It also identifies from which land uses the development is expected to occur. VanBuren County was projected to have the greatest percentage of new development in forested areas (19.32% of 57,916 acres or 11,178 acres). Kosciusko County was predicted to have the greatest percentage of new development on agricultural lands (95.9% of 17,201 acres or 16,341 acres).

Development by Subwatersheds

In order to identify future build-out and water quality impacts at the subwatershed scale, the acres expected to be developed in each of 217 St. Joseph River subwatersheds were calculated from the watershed scale model run (see the table and figure in Attachment C). For planning purposes, the county in which each subwatershed predominantly falls was identified. Two subwatersheds, #42 in VanBuren County (a 32,900-acre subwatershed in the Dowagiac River drainage) and #65 in St. Joseph County, MI (a 23,500-acre subwatershed at the mouth of Portage River) each have over 9,000 acres of projected development.

For the Watershed Management Planning Project, subwatersheds were scored for preservation based on mapped attributes (K&A, 2004). Those subwatersheds were grouped into larger subwatershed units, and the scores were averaged. Two units scored the highest for preservation (primarily because they were small drainages in which the preservation score was not averaged over many units). They drain directly to the St. Joseph River in St. Joseph, MI, and Cass Counties and are known as Mill Creek (Subwatersheds #89 and #104) and Trout Creek (Subwatershed #124). These subwatersheds are shaded in the Attachment C table. The model did not predict much development in these units, compared with development predicted in other subwatersheds. It did, however, identify over 1,200 acres in each that could be developed based on the model constraints.

The scoring procedure conducted for the Watershed Management Planning Project also identified the eight drainage units (in bold in Attachment C) which scored highest for preservation at the individual subwatershed level. A high preservation score means that the watershed has a high percentage of forested and wetland land cover, according to the USGS 1992 land cover dataset used for the nonpoint source model and the subwatershed scoring. Two of these subwatersheds have over 4,700 acres projected for development (#51 in Cass County, Dowagiac Creek and #12 in Kalamazoo County, Gourdneck Creek).

Development in Elkhart County

The development model was also run on Elkhart County alone because it is almost entirely within the St. Joseph River Watershed and it was projected to have one of the greatest percentages of future developed land. With the smaller geographic scope, the model allowed for a distance threshold of 2.2 miles from current development and roads. The model was again attempted with two different user inputs: forested land as developed and agricultural land as being developed. The outputs (acres of future land developed on all current land cover types) were quite different between the two scenarios (approximately 50,000 acres vs.

Table 3. Projected development within the St. Joseph River Watershed by county using the 2000 land cover data.

County	Acres to be Developed	Acres Currently Developed	% Developed	% Development Change	% Population Change 1990-2000	Estimated Time to Reach Development (years)	Future % Developed	% of Development Occurring in Each Land Use	
								forest	agriculture
Berrien	22,338	27,650	11.1	80.8	0.7	253.9	20.0	15.0	83.9
Branch	86,956	8,951	2.7	971.5	10.3	207.5	29.1	11.5	87.9
Calhoun	39,393	2,630	1.8	1498.0	1.5	2197.0	29.3	12.5	87.1
Cass	51,382	13,857	4.3	370.8	3.3	247.2	20.2	12.8	86.9
DeKalb	908	146	2.1	622.1	14	**97.8**	15.0	8.9	91.1
Elkhart	52,335	33,899	11.6	154.4	17	**66.3**	**29.6**	9.9	89.6
Hillsdale	13,363	3,699	3.5	361.3	7.1	111.9	16.1	13.6	85.8
Kalamazoo	47,088	4,912	3.0	958.6	6.8	1409.8	**31.8**	11.1	87.9
Kosciusko	17,201	2,937	4.8	585.6	13.4	451.1	**33.2**	4.0	**95.9**
LaGrange	61,436	4,751	1.9	1293.3	18.4	**96.1**	26.7	10.0	89.9
Noble	28,597	5,542	2.8	516.0	22.2	**51.1**	17.1	9.5	90.4
St. Joseph, IN	25,513	32,185	**29.7**	79.3	7.5	**26.4**	**53.2**	13.6	86.1
St. Joseph, MI	**104,807**	12,885	3.9	813.4	6	298.3	**35.5**	8.8	90.6
Stueben	18,888	5,911	3.8	319.6	21	**33.5**	15.9	13.6	86.3
VanBuren	57,916	10,074	4.0	574.9	8.9	142.1	27.3	**19.3**	79.5

Bold figures are the highest or lowest values for those categories, depending on category.
Elkhart County and St. Joseph, IN County figures are shaded because they have the greatest predicted future development in the smallest amount of time.

61,000, respectively). When the model was run at the whole watershed level, approximately 78,000 acres were predicted to be developed in Elkhart County on all land cover types. [The model predicted 52,335 acres to be developed on the appropriate land cover types, as discussed in the Model Limitations section (see Table 3).] However, the county-scale model run also projected future development in wetland areas, open water areas and areas where development is currently located, as did the watershed scale run.

The county level run of the model with forested land selected for future development projected 3,800 acres to be developed on forested and shrub lands. The scenario in which agricultural land was selected to be developed predicted 36,000 acres of agricultural land to be developed. Therefore, 39,800 acres are projected to be developed (95% of which is on agricultural land) when the distance threshold is 2.2 miles in contrast to 10.9 miles with the watershed-scale model run. Table 3 illustrates that when the model was run at the whole watershed level, 90% of the 52,335 acres of new development were predicted to occur in agricultural areas. This exercise illustrates that running the model on a smaller geographic scale allows smaller distance thresholds to be used. However, the model outputs must still be carefully considered because development is projected in more places than on the specified land uses.

Nonpoint Source Load Model

The nonpoint source load model run for the Watershed Management Planning Project (K&A, 2003) was updated with the NOAA 2000 land cover data. The new development predicted by the Landscape Analyst based on 2000 land cover data was used to adjust the model to calculate associated increases in stormwater runoff and nonpoint source loading of sediments and phosphorus at the county level (Table 4).

Table 4. Increases in stormwater runoff and nonpoint source loads by county related to projected development.

County	Increase from Baseline Loads (2000)		
	Runoff	**TP**	**TSS**
Berrien	12.5%	20.6%	6.3%
Branch	35.1%	69.7%	18.7%
Calhoun	32.3%	73.5%	21.0%
Cass	21.3%	42.4%	11.9%
DeKalb	20.2%	35.3%	8.4%
Elkhart	23.6%	37.9%	10.9%
Hillsdale	17.7%	33.6%	9.1%
Kalamazoo	36.1%	77.3%	21.9%
Kosciusko	35.4%	67.9%	17.3%
LaGrange	33.1%	65.8%	16.9%
Noble	18.7%	37.6%	9.9%
St. Joseph, IN	25.0%	36.9%	13.9%
St. Joseph, MI	**43.6%**	**82.5%**	**21.6%**
Stueben	13.3%	30.2%	9.2%
VanBuren	30.4%	63.8%	19.7%

TP = total phosphorus
TSS = total suspended solids

St. Joseph County (MI) is expected to increase in stormwater runoff and pollutant loading by the greatest percentages. This is due to the fact that it is largely undeveloped and was predicted to have 104,807 acres of additional development. Only 3.9% of the county land area, all of which lies within the St. Joseph River Watershed, is currently developed. It is also expected to have the greatest percentage of future developed area (35.5%) after St. Joseph County, IN, which is currently 30% developed. However, it is predicted to take almost 300 years to reach this level of development.

Expected changes in runoff and loading by subwatershed are tabulated in Attachment C for the 217 drainage units used in the empirical loading model. The attachment includes the percent change from current levels to projected levels. These projections can be used with planning tools by municipalities and county governments to identify areas threatened by development (based on topography and distance to roads and current development).

Table 5 lists the total St. Joseph River Watershed calculated runoff volume and nonpoint source loads in relation to the original values (2000). The future development increases signal impacts to the watershed from future development. The increase in phosphorus loading is the greatest because the future predicted development is primarily residential (75%), which produces the highest concentration of phosphorus in runoff of all land cover types, according the estimated mean concentrations.

Table 5. Annual watershed runoff and loads with projected development.

	2000 Land Cover (baseline)	**Future Development**	**Increase from Baseline**
Runoff (acre-feet/year)	13,424,289	17,071,834	27%
Sediment (tons/year)	131,712	151,088	15%
Phosphorus (tons/year)	318	483	52%

Land cover data available from the USGS (1992) was used in the nonpoint source model conducted during the Watershed Management Planning project (K&A, 2003). More current land cover data (2000) has since become available (from NOAA) and was used to update the nonpoint source model and as a baseline for the development predictions. A 1995 land cover dataset was also available from NOAA. The land cover changes seen among these datasets and the associated watershed nonpoint source loading are discussed in Attachment D.

Forest Indicators

The model indicated that the watershed contains 11.3% upland forest and that 9.9% of this forested land is edge habitat. It also identified 8% of the watershed as forest interior, based on a 52-hectare moving window which identified areas that are at least 50% forested. Figures 3 and 4 illustrate forested areas within the watershed. Riparian areas (lands bordering streams) were found to border agricultural land on 40% of the stream length and to border forests on 35% of that length. By visual observation of the maps, the majority of forested land uses and forest interiors were identified in the northwest portion of the watershed. A large area of interior forest land was also identified in northeast LaGrange County.

Conclusions

The Landscape Analyst ArcView extension was used to conduct a build-out analysis of the St. Joseph River Watershed. This analysis predicted areas where future development can occur based on topography, distance to roads and distance to current development. The model results were used with U.S. Census data to predict the rate at which each county could be developed. The extension and other modeling tools were also used to determine on which current land use types development is predicted to occur. Changes in land cover were then used to examine potential stormwater load increases.

The Landscape Analyst model was developed by the Canaan Valley Institute through a federal grant, but is not supported nor updated through any continual funding. It is offered at no charge through an online download of the extension. Available technical assistance and help documents are limited. The institute was contacted regarding several model issues, though the large distance threshold (10.9 miles) allowed as a minimum and the placement of projected development on areas not specified by the user were of primary concern. The distance threshold could be corrected by running the model at a smaller geographic scale, as evidenced by the Elkhart County level run. Therefore, the whole watershed level run could be considered a screening tool by which Elkhart County was identified as a critical county (Table 3). The projection of future development on areas not specified by the user could not be corrected in the model. Those land areas were simply ignored and only the development projected on agricultural land and forested areas is reported. However, the future land cover map (Figure 2b) shows all development predicted by the model. Further, the largest forest patch indicator could not be executed. Though visual observation of the forest interior indicator (Figure 4) produced a similar outcome for the project. Despite these shortcomings, output from the Landscape Analyst extension has provided useful information to illustrate the potential impacts of future development in the watershed.

Elkhart County was identified as a critical county because it was predicted to have one of the greatest percentages of future developed land (29.6%), as a proportion of total land area, in a relatively short period of time (66.3) years. This is based on a 17% growth rate from 1990 to 2000. However, the relatively low sprawl rate of 1.37 (identified in Table 2) extends the time frame needed to reach the future predicted development (from the Midwest average sprawl rate of 4.5). This sprawl rate indicates the development in the Elkhart-Goshen metropolitan area is much more dense than most Midwest areas. Therefore, less land is used for development. Denser development requires innovative stormwater management techniques, such as permeable pavement and other Low Impact Development techniques. It is desirable because it actually results in less watershed imperviousness due to less extensive road and driveway networks to access sprawl development. During the Watershed Management Planning Project, subwatersheds were scored for BMP implementation priority based on the presence of identified impaired water bodies [inclusion on the 303(d) list] and the percentage of developed land uses (urban and agriculture). Of the six major subwatersheds scoring highest in this analysis, five fell partly or wholly in Elkhart County. (A higher score means the area is more impacted.) Three of these drainage units are parts of the Elkhart River Watershed. Analysis of USGS water quality monitoring data revealed the Elkhart River to be a large contributor of suspended solids and phosphorus to the St. Joseph River Watershed (analysis conducted for the Watershed Management Planning Project).

St. Joseph County (IN) was also identified as a critical county due to a high potential for future developed land (53.2% of the land in the watershed). However, the portion of this county in the watershed is already 29.7% developed. It also has the highest sprawl factor of the three metropolitan areas (4.03) in the watershed. (This value is below the Midwest average of 4.5.) This analysis indicates that the county is currently largely developed, but has the potential to add even more developed land. This is supported by current growth trends in areas spanning South Bend and Mishawaka. A watershed group in this area, the Juday Creek Task Force, is active in encouraging stormwater management at new developments. St. Joseph County (IN) and Elkhart County are the most developed counties in the watershed and are both continuing to grow, based on Census data. Therefore, they are assigned the greatest priority for stormwater management and land use planning. Berrien County is the third most developed county in the watershed, but has the lowest growth rate of any county in the watershed. Therefore, Berrien County is assigned the lowest priority in the watershed, based on this analysis.

During the Watershed Management Planning Project, subwatersheds were also scored on mapped attributes for preservation potential (K&A, 2004). Scoring was based on forested and wetland land cover, and on the presence of identified trout streams. The preservation scoring identified major drainage units and individual subwatersheds having the greatest amount of natural resources, based on current land cover. It was rationalized that those with large areas of intact, undisturbed lands should be preserved. The development model in Landscape Analyst was used to determine which of these areas with the greatest remaining natural resources have the potential to be developed and, thus, have threatened resources. It also addressed the consequences of doing nothing (a "no-action scenario for land use planning) to protect these natural resources.

St. Joseph County, MI, which scored highly for preservation due to its forested land, was actually predicted to have over 90% of its development occur in agricultural lands. VanBuren County, also prioritized for preservation, was predicted to have the greatest percentage of development in forested areas (19.3%). Subwatersheds in the Dowagiac River Watershed (which lies in VanBuren, Cass and Berrien Counties) were identified as having the most potential for development (#42, VanBuren County) of all of the subwatersheds and as having the one of the greatest acres of potential development of those prioritized for preservation (#51, Cass County). (Subwatershed 12 in Kalamazoo County was predicted to the have the greatest number of acres developed, of those subwatersheds prioritized for preservation. However, Subwatersheds 12 and 11 contain the Gourdneck State Game Area, which is protected by the MI Department of Natural Resources.)

Further, VanBuren County is predicted to have most of its new development on forested land. This points to the need for preservation and strengthens the importance of the ongoing efforts in the Dowagiac River Watershed. This particular watershed was the subject of a 2002 watershed management planning project and is undergoing hydraulic restoration activities by the Army Corp of Engineers. VanBuren County is also drained by the PawPaw River Watershed, which contains rare prairie fen habitats (Friends, 2002-2004). Subwatershed #2 in the PawPaw River Watershed was also prioritized for preservation. The development model predicted that 3,624 acres in this subwatershed could be developed. The PawPaw River joins the St. Joseph River in Berrien County. Although Berrien County was assigned the lowest priority in this analysis, the portions of that county drained by the PawPaw River Watershed should remain a priority. The PawPaw River Watershed is a critical area based on preservation scoring and prioritization of VanBuren County.

The development model predicts future development based on physical constraints, i.e., topography and location in relation to current development and roads. It does not account for economic and social impacts on development, nor for land use planning policies. The model simply identifies areas that could be developed at some time in the future. Further, the nonpoint source load model assumed that no stormwater BMPs are installed with the future development. It simply predicts the runoff and load based on rainfall depth and land use types. It also does not account for transport to and within the stream network. These values are meant to be used for comparison purposes to illustrate the potential impacts of unplanned development and to compare geographic units within the watershed. Based on this analysis at the county level, Elkhart County is prioritized for urban BMP implementation and VanBuren County is prioritized for land use planning related to preservation.

Landscape Analyst is a powerful tool that was developed with limited funding. Therefore, resources are currently not available to update or debug the program or to provide technical support. However, the development model outputs could be manipulated and utilized with published data on land development patterns and population growth to predict potential future impacts to the St. Joseph River Watershed. When the outputs are carefully considered, they provide useful insights into future land use pressures and potential water quality threats. The development model is also applicable at a smaller geographic, such as the county or subwatershed levels, for land use planning efforts.

Landscape Analyst is useful for future watershed management planning efforts in light of the quantitative requirements associated with USEPA's Nine Elements. Additional refinements, as noted here, would be useful. Funding for updates to the extension and technical support should be a priority to aid watershed planning efforts using this tool. Calibrating the development model output with U.S. Census data and sprawl factors further supports the utility of the model at the local level. A linkage between the model and population statistic databases could result in a powerful land use planning tool. Further, use of the extension indicators to identify agricultural land in riparian areas could be useful for targeting appropriate BMPs such as buffers, livestock exclusion and drainage protection. Although there were issues encountered using this tool, we believe the results to be reasonable and reliable for the purposes of this effort. When coupled with Census data, the development model is useful for predicting watershed threats.

Lastly, the model works with ArcView 3.2 only. This version, however, is no longer supported by ESRI, the software developer. New GIS software, ArcGIS, is now available for mapping. Ideally, two versions of the extension software could be updated/developed to allow compatibility with ArcGIS and ArcView 3.2.

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ATTACHMENT A

Landscape Analyst Documentation

Community Assistance

How can we help you?

Highlighted Projects

Watershed News

CVI Grant Program

Other Grant Opportunities

Community Tools

Online Mapping

Highlands Profiler

Watershed Calculators

Landscape Analyst

- Landscape_Analyst
- Flow Chart
- Developers
- Functionality
- Screen Shots
- Secure Login

Landscape Analyst

Description

The **Landscape Analyst** is an ArcView GIS (version 3.x) 3rd party extension. ArcView extensions add more functionality to the core software.

The **Landscape Analyst** allows users to assess the current conditions of watersheds, counties and/or regions both visually and quantitatively. It also allows users to simulate potential impacts of future changes to the **landscape**. The **Landscape Analyst** depends on users of ArcView having the ESRI created Spatial **Analyst** Extension loaded on their system.

Many of the tools, models and processes in the **Landscape Analyst** can be performed using the core ArcView software with the Spatial **Analyst** extension alone but the expertise, time and complexity required to perform such actions would be prohibitive. The **Landscape Analyst** simplifies and organizes such specialized functions into an interface that can be used by the intermediate ArcView users to make policy decisions regarding the Earth's **landscape**.

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Developers:

The Landscape Analyst was developed as a cooperative agreement between the Canaan Valley Institute and the Natural Resource Analysis Center at West Virginia University.

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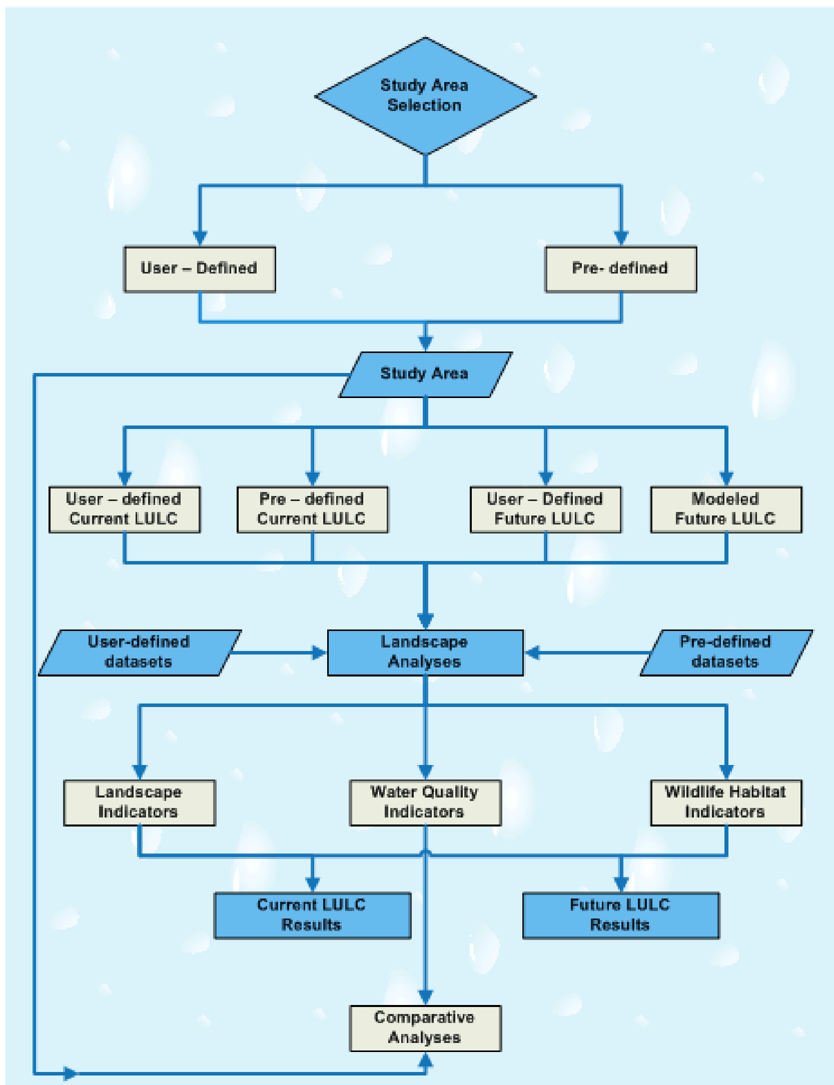
Landscape Analyst Flow Chart



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Some of the Landscape Analyst functions include:

Expected mean concentration - Estimate concentrations and loadings in the stream based on expected mean concentrations from land use/cover classes.

Fate transport - Estimate pollutant concentrations and loadings based on changing flow conditions using a weighted mass balance approach.

Potentially affected streams - Potential stream locations can be found where pollution may flow during a precipitation event.

Delineate watersheds - Automatically create watersheds at set sizes.

Erosion model - Estimate how land use changes influence the amount of runoff in a watershed.

Trace raindrop path - Trace the path of steepest descent across the landscape.

Estimate drainage area - Query a stream location and report back an estimate of the drainage area.

Stream flow query tool - Estimate the Cubic Feet Per Second of water flowing through a stream at a specified point.

Riparian forest - Estimate the percentage of stream length with adjacent forested land cover.

Agriculture near streams - Estimate the proportion of total stream length with adjacent agricultural land cover.

Stream/road intersections - List the number of stream/road intersections and the number of intersections per unit stream length.

Development model - Identify areas that are more likely to be developed in the future based on a fuzzy logic approach.

Tabulate Land Use/Land Cover Area - Compute the total area in square meters, hectares, acres, and square miles for different land cover types.

Land Use/Land Cover Histogram - Computes a histogram depicting the total area of different land cover types.

Derive slope - Calculate the higher elevation, lower elevation, elevation change, length, percent slope, and slope for a line.

Report elevation - Elevation is returned in meters and feet.

Percent forested - Estimate the percentage forested land cover.

Forest edge habitat - Estimate approximate amount of forest edge habitat.

Largest forest patch - Estimate the single largest contiguous forested patch.

Forest interior - Estimate the proportion of the study area above a user-specified percent forested threshold.

Road density - Compute the total length of roads per unit area.

Relative Road density - Compute the relative road density.

Human use index - Estimate the percentage of human-influenced land uses.

Agriculture on steep slopes - Estimate the proportion of agricultural areas that are found on steep slopes.

Cropland on steep slopes - Estimate the proportion of cropland that is found on steep slopes.

Bird community index - Estimate the overall ecological condition by relating the types of birds inhabiting an area with the surrounding land cover.

Louisiana Waterthrush - Estimate the amount of suitable and less suitable riparian habitat available for Louisiana Waterthrush (Seiurus motacilla).

Select Study Area - Define a study area based on the spatial coordinates of a center point, a graphical point, line, or polygon, or a dataset feature.

Clip GRID to polygon - Clips a GRID theme with a polygon theme.

GRID Re-class - Change the land cover GRID cells interactively.

Measure distance - Measure distance in Feet, Meters and Miles.

Report polygon area - Report the area of a polygon.

Coordinate display - Report the UTM coordinates of a point.

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ATTACHMENT B

1990-2000 Population Growth Rates

County Level Population Growth Rates (1990-2000),
as identified by the U.S. Census
(http://www.census.gov)

County	**Growth Rate (%)**
Berrien	0.7
Branch	10.3
Calhoun	1.5
Cass	3.3
DeKalb	14.0
Elkhart	17.0
Hillsdale	7.1
Kalamazoo	6.8
Kosciusko	13.4
LaGrange	18.4
Noble	22.2
St. Joseph, IN	7.5
St. Joseph, MI	6.0
Stueben	21.0
VanBuren	8.9

ATTACHMENT C

Projected Development and Associated Nonpoint Source Loading Increases by Subwatershed

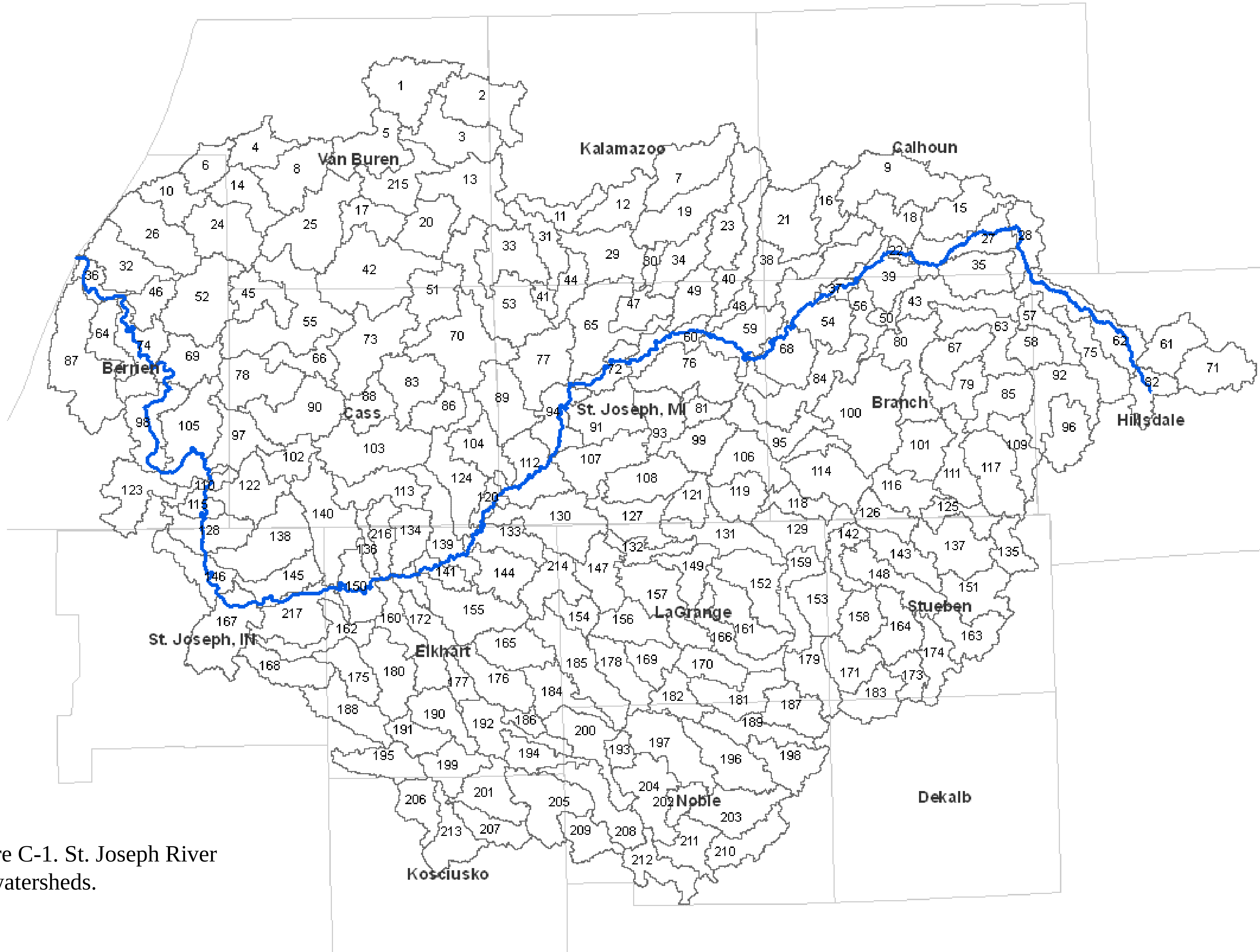

Figure C-1. St. Joseph River Subwatersheds.

			Annual Runoff (acre-feet/year)			Annual TSS Loading (tons/year)			Annual TP Loading (tons/year)		
Number	County	Acres to be Developed	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase
1	VanBuren	3,240	92,939	113,265	21.87	894	999	11.70	2.08	3.00	43.92
2	**VanBuren**	**3,624**	**102,066**	**124,278**	**21.76**	**631**	**745**	**18.11**	**1.75**	**2.75**	**56.98**
3	VanBuren	3,185	83,781	103,456	23.48	710	811	14.25	1.72	2.60	51.50
4	VanBuren	2,142	52,302	66,513	27.17	446	520	16.38	1.08	1.72	59.38
5	VanBuren	4,173	100,627	127,221	26.43	680	817	20.13	1.78	2.97	67.31
6	Berrien	1,098	62,006	69,431	11.97	384	422	9.94	1.17	1.51	28.43
7	Kalamazoo	6,095	92,276	127,366	38.03	829	1010	21.78	1.94	3.52	81.37
8	VanBuren	2,087	93,024	106,729	14.73	810	881	8.70	2.02	2.64	30.47
9	Calhoun	7,248	117,510	157,113	33.70	906	1110	22.49	2.23	4.01	79.84
10	Berrien	604	54,676	58,816	7.57	532	553	4.00	1.44	1.63	12.91
11	Kalamazoo	2,636	48,247	63,968	32.58	334	415	24.22	0.98	1.69	72.29
12	**Kalamazoo**	**4,777**	**80,591**	**108,467**	**34.59**	**446**	**589**	**32.20**	**1.39**	**2.64**	**90.32**
13	VanBuren	4,118	91,114	116,364	27.71	896	1026	14.49	2.18	3.31	52.18
14	VanBuren	2,196	65,915	80,637	22.33	624	700	12.14	1.55	2.21	42.66
15	Calhoun	4,008	64,265	85,920	33.70	637	748	17.50	1.42	2.40	68.38
16	Calhoun	1,043	48,840	54,735	12.07	336	366	9.04	0.86	1.13	30.74
17	VanBuren	2,581	42,388	58,827	38.78	487	572	17.37	1.04	1.78	70.82
18	Calhoun	2,032	54,888	65,992	20.23	347	404	16.48	0.93	1.43	53.84
19	Kalamazoo	4,997	100,206	128,923	28.66	757	905	19.52	1.91	3.20	67.76
20	VanBuren	3,350	60,668	81,486	34.31	584	692	18.33	1.39	2.33	67.37
21	Calhoun	2,746	97,982	113,569	15.91	719	799	11.15	1.82	2.52	38.48
22	Calhoun	714	9,662	13,583	40.58	92	112	21.88	0.21	0.39	82.99
23	Kalamazoo	3,295	72,466	91,285	25.97	785	882	12.33	1.70	2.55	49.69
24	VanBuren	2,800	85,114	104,120	22.33	1039	1136	9.42	2.29	3.14	37.39
25	VanBuren	4,942	131,225	163,517	24.61	1278	1444	13.00	2.99	4.44	48.63
26	Berrien	1,043	98,544	105,768	7.33	1114	1151	3.34	2.59	2.92	12.53
27	Calhoun	5,985	77,845	110,123	41.46	649	815	25.58	1.60	3.06	90.55
28	Calhoun	4,173	53,755	76,101	41.57	386	501	29.81	1.00	2.01	100.27
29	Kalamazoo	5,766	93,134	126,888	36.24	738	912	23.53	1.90	3.42	80.01
30	Kalamazoo	1,647	14,342	23,844	66.26	136	185	35.92	0.32	0.74	135.35
31	Kalamazoo	4,777	31,599	60,165	90.41	529	676	27.81	1.04	2.32	123.64
32	Berrien	1,922	98,265	111,702	13.68	1067	1136	6.48	3.15	3.76	19.19
33	Kalamazoo	4,612	72,907	100,691	38.11	700	843	20.43	1.59	2.84	78.65
34	Kalamazoo	2,416	52,884	66,750	26.22	459	530	15.54	1.08	1.70	57.89
35	Calhoun	2,636	60,355	74,553	23.52	525	598	13.93	1.23	1.86	52.12
36	**Berrien**	**769**	**50,276**	**55,677**	**10.74**	**354**	**382**	**7.85**	**1.43**	**1.67**	**17.01**
37	Branch	988	18,800	24,278	29.14	126	154	22.38	0.37	0.62	66.28
38	Calhoun	4,612	75,988	101,887	34.08	674	808	19.76	1.59	2.75	73.32
39	Calhoun	2,910	48,538	64,530	32.95	522	604	15.77	1.15	1.87	62.34
40	Kalamazoo	1,977	56,914	68,153	19.75	532	589	10.88	1.21	1.72	41.75
41	St. Joseph MI	933	10,665	16,209	51.98	146	175	19.53	0.30	0.55	82.73
42	VanBuren	9,829	124,221	186,659	50.26	1601	1922	20.07	3.36	6.17	83.71
43	Branch	4,558	58,675	83,312	41.99	582	709	21.77	1.31	2.42	84.60
44	Kalamazoo	2,965	36,681	54,216	47.80	338	428	26.70	0.82	1.61	96.57
45	Cass	2,636	76,098	93,831	23.30	529	620	17.24	1.50	2.30	53.11
46	Berrien	494	30,420	33,888	11.40	440	458	4.06	0.92	1.07	17.02
47	St. Joseph MI	3,075	38,314	56,061	46.32	391	482	23.37	0.88	1.67	91.19
48	St. Joseph MI	1,702	17,311	26,976	55.83	206	255	24.17	0.44	0.88	97.91
49	St. Joseph MI	1,812	33,682	44,040	30.75	486	539	10.97	0.97	1.44	47.90
50	Branch	879	12,152	16,968	39.64	125	150	19.76	0.27	0.49	79.01
51	**Cass**	**4,173**	**91,952**	**117,671**	**27.97**	**592**	**724**	**22.35**	**1.62**	**2.78**	**71.24**
52	Berrien	1,702	111,408	123,178	10.57	1275	1335	4.75	2.79	3.32	19.00
53	St. Joseph MI	5,326	136,742	168,830	23.47	1141	1306	14.47	2.76	4.20	52.34
54	Branch	8,456	115,138	162,251	40.92	1203	1446	20.15	2.65	4.77	79.97
55	Cass	8,895	203,214	262,250	29.05	1593	1897	19.07	4.16	6.82	63.78
56	Branch	1,592	30,647	39,430	28.66	295	340	15.34	0.67	1.06	59.19

			Annual Runoff (acre-feet/year)			Annual TSS Loading (tons/year)			Annual TP Loading (tons/year)		
Number	County	Acres to be Developed	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase
57	Hillsdale	1,647	26,749	35,578	33.00	351	397	12.93	0.72	1.11	55.35
58	Branch	1,153	36,282	42,463	17.04	348	379	9.15	0.78	1.06	35.43
59	St. Joseph MI	4,063	67,378	90,387	34.15	639	757	18.53	1.47	2.50	70.51
60	St. Joseph MI	3,404	39,402	58,905	49.50	451	552	22.24	0.99	1.87	88.23
61	Hillsdale	1,373	46,251	53,664	16.03	458	496	8.34	1.02	1.36	32.58
62	Hillsdale	3,020	79,750	96,015	20.40	865	949	9.68	2.00	2.73	36.65
63	Branch	4,063	59,373	81,289	36.91	634	747	17.79	1.42	2.40	69.62
64	Berrien	1,098	40,457	48,236	19.23	601	641	6.66	1.26	1.61	27.82
65	St. Joseph MI	9,829	94,367	151,663	60.72	1087	1382	27.13	2.42	5.00	106.44
66	Cass	1,318	50,802	59,394	16.91	461	505	9.59	1.21	1.60	31.90
67	Branch	2,196	53,315	65,243	22.37	578	639	10.62	1.50	2.04	35.77
68	Branch	2,581	59,123	73,608	24.50	604	679	12.33	1.34	1.99	48.76
69	Berrien	494	65,887	69,364	5.28	745	763	2.40	1.76	1.92	8.89
70	Cass	2,691	124,016	140,278	13.11	1021	1105	8.20	2.50	3.23	29.24
71	Hillsdale	1,647	59,003	67,914	15.10	595	641	7.70	1.34	1.74	29.99
72	St. Joseph MI	2,471	34,671	48,960	41.21	323	397	22.73	0.79	1.43	81.72
73	Cass	3,185	91,648	111,704	21.88	1095	1198	9.42	2.33	3.24	38.67
74	Berrien	988	80,953	87,961	8.66	910	946	3.96	2.15	2.46	14.69
75	Hillsdale	1,263	49,969	56,785	13.64	515	550	6.81	1.14	1.44	27.00
76	St. Joseph MI	5,875	74,773	108,220	44.73	994	1166	17.31	2.03	3.53	74.30
77	St. Joseph MI	3,350	75,854	95,541	25.95	759	860	13.34	1.82	2.71	48.57
78	Cass	3,075	96,435	117,228	21.56	864	971	12.38	2.09	3.03	44.72
79	Branch	1,922	42,610	53,085	24.58	462	516	11.68	1.08	1.56	43.46
80	Branch	3,789	91,172	111,910	22.75	778	884	13.72	1.94	2.87	48.16
81	St. Joseph MI	1,373	15,117	22,893	51.44	230	270	17.39	0.46	0.81	76.52
82	Hillsdale	329	34,617	36,402	5.16	351	361	2.61	0.95	1.03	8.49
83	Cass	1,483	68,309	77,378	13.28	684	731	6.82	1.56	1.97	26.19
84	Branch	4,393	76,245	100,676	32.04	916	1041	13.73	1.91	3.01	57.49
85	Branch	3,185	52,516	69,684	32.69	493	582	17.91	1.16	1.93	66.54
86	**Cass**	**439**	**45,364**	**47,998**	**5.81**	**340**	**354**	**3.99**	**0.90**	**1.02**	**13.17**
87	**Berrien**	**2,800**	**139,355**	**159,197**	**14.24**	**1918**	**2020**	**5.32**	**4.62**	**5.51**	**19.34**
88	Cass	1,922	46,430	58,354	25.68	473	535	12.97	1.16	1.70	46.16
89	**St. Joseph MI**	**1,373**	**80,931**	**89,026**	**10.00**	**558**	**600**	**7.46**	**1.49**	**1.85**	**24.47**
90	Cass	2,361	86,069	101,386	17.80	1078	1157	7.31	2.31	3.00	29.78
91	St. Joseph MI	5,216	53,632	83,685	56.04	777	932	19.90	1.58	2.93	85.59
92	Hillsdale	2,306	68,470	80,847	18.08	740	804	8.60	1.61	2.17	34.63
93	St. Joseph MI	2,636	58,108	73,126	25.85	485	562	15.95	1.20	1.87	56.42
94	St. Joseph MI	3,679	53,101	74,490	40.28	585	695	18.83	1.38	2.34	69.72
95	St. Joseph MI	4,283	79,219	103,190	30.26	675	798	18.27	1.64	2.72	65.87
96	Hillsdale	879	49,308	54,035	9.59	515	539	4.72	1.14	1.36	18.61
97	Cass	2,636	59,151	77,273	30.64	715	808	13.04	1.63	2.45	49.88
98	Berrien	1,153	87,500	95,755	9.43	805	848	5.27	2.07	2.44	17.98
99	St. Joseph MI	2,526	59,835	74,103	23.85	429	503	17.10	1.12	1.76	57.52
100	Branch	8,182	143,978	189,009	31.28	1466	1697	15.81	3.29	5.32	61.57
101	Branch	4,173	67,547	90,396	33.83	564	681	20.86	1.39	2.42	73.89
102	Cass	714	39,950	44,522	11.44	386	410	6.09	0.92	1.13	22.27
103	Cass	4,503	126,505	153,989	21.73	1079	1220	13.11	2.62	3.86	47.20
104	Cass	1,208	48,776	55,879	14.56	523	559	6.99	1.15	1.47	27.77
105	Berrien	1,537	109,876	120,852	9.99	1391	1448	4.06	3.24	3.73	15.25
106	St. Joseph MI	6,370	66,952	102,511	53.11	878	1061	20.85	1.85	3.45	86.55
107	St. Joseph MI	6,315	65,417	101,613	55.33	808	994	23.06	1.69	3.32	96.19
108	St. Joseph MI	3,404	68,061	87,372	28.37	591	691	16.81	1.44	2.31	60.31
109	Branch	1,208	32,878	39,402	19.84	426	459	7.89	0.87	1.16	33.86
110	Berrien	494	28,405	31,915	12.36	300	318	6.02	0.96	1.12	16.43
111	Branch	3,185	76,331	93,690	22.74	412	501	21.68	1.24	2.02	62.96
112	St. Joseph MI	5,216	69,005	99,249	43.83	789	944	19.73	1.77	3.13	76.90

			Annual Runoff (acre-feet/year)			Annual TSS Loading (tons/year)			Annual TP Loading (tons/year)		
Number	County	Acres to be Developed	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase
113	Cass	2,142	62,321	75,166	20.61	577	643	11.45	1.37	1.95	42.13
114	Branch	6,425	63,545	98,962	55.74	792	974	23.01	1.64	3.23	97.34
115	Berrien	604	24,286	28,551	17.56	245	267	8.94	0.65	0.84	29.43
116	Branch	3,185	50,940	68,364	34.21	417	507	21.49	1.00	1.78	78.66
117	Branch	4,283	65,034	88,316	35.80	752	872	15.93	1.58	2.63	66.21
118	Branch	2,526	27,300	41,263	51.15	315	387	22.82	0.66	1.29	94.86
119	St. Joseph MI	1,428	39,588	47,559	20.13	424	465	9.68	0.92	1.28	38.87
120	Cass	714	17,014	21,163	24.39	163	184	13.13	0.37	0.56	50.27
121	St. Joseph MI	2,910	30,789	47,153	53.15	443	527	19.01	1.20	1.93	61.51
122	Cass	2,581	64,110	81,091	26.49	744	832	11.74	1.80	2.57	42.40
123	Berrien	384	72,673	75,400	3.75	773	787	1.82	1.87	1.99	6.56
124	**Cass**	**1,757**	**97,514**	**107,864**	**10.61**	**701**	**754**	**7.60**	**1.85**	**2.31**	**25.19**
125	Branch	1,537	42,809	51,187	19.57	268	311	16.07	0.77	1.15	48.79
126	Branch	1,318	35,500	42,714	20.32	364	401	10.20	0.83	1.15	39.28
127	St. Joseph MI	4,063	53,526	76,520	42.96	624	743	18.95	1.33	2.37	77.68
128	St. Joseph IN	1,702	99,017	110,539	11.64	610	669	9.72	2.17	2.69	23.89
129	LaGrange	3,185	67,360	84,943	26.10	607	697	14.91	1.43	2.22	55.41
130	St. Joseph MI	5,985	104,010	138,274	32.94	960	1137	18.36	2.34	3.88	65.89
131	LaGrange	4,448	59,024	83,832	42.03	703	830	18.17	1.51	2.63	73.77
132	LaGrange	1,977	34,599	45,722	32.15	279	336	20.54	0.68	1.18	73.68
133	Elkhart	1,318	56,797	64,382	13.35	420	459	9.29	1.09	1.43	31.37
134	Elkhart	4,338	53,276	78,737	47.79	494	625	26.51	1.34	2.49	85.40
135	Steuben	2,142	31,029	42,716	37.66	327	387	18.39	0.72	1.25	72.87
136	Elkhart	1,318	26,928	34,733	28.98	224	265	17.90	0.71	1.06	49.22
137	Steuben	2,306	108,235	120,807	11.62	640	705	10.11	1.96	2.52	28.89
138	St. Joseph IN	5,820	126,410	162,207	28.32	1261	1446	14.60	4.02	5.63	40.10
139	Elkhart	3,514	55,598	76,146	36.96	733	838	14.43	1.63	2.55	56.84
140	Elkhart	7,303	101,018	145,193	43.73	1087	1314	20.91	2.76	4.75	72.05
141	Elkhart	1,043	28,204	34,240	21.40	244	275	12.73	0.67	0.95	40.28
142	Steuben	1,812	30,539	40,474	32.53	322	373	15.90	0.72	1.17	61.95
143	Steuben	1,428	79,370	87,159	9.81	344	384	11.65	1.18	1.53	29.66
144	Elkhart	439	70,760	73,276	3.56	484	497	2.67	1.32	1.43	8.59
145	St. Joseph IN	5,985	69,220	105,260	52.07	675	861	27.46	2.16	3.79	74.94
146	St. Joseph IN	2,581	97,417	114,577	17.62	921	1009	9.59	3.26	4.03	23.70
147	LaGrange	2,471	52,830	66,773	26.39	559	630	12.84	1.27	1.90	49.23
148	Steuben	2,471	96,941	110,429	13.91	578	647	12.02	1.74	2.34	34.92
149	LaGrange	3,404	41,097	60,095	46.23	475	573	20.58	1.07	1.92	80.01
150	Elkhart	5,107	93,998	123,945	31.86	854	1008	18.04	3.08	4.42	43.81
151	Steuben	1,977	54,149	64,941	19.93	567	622	9.80	1.24	1.73	39.03
152	LaGrange	3,240	89,432	107,342	20.03	610	702	15.11	1.56	2.37	51.52
153	LaGrange	1,922	73,343	83,870	14.35	493	548	10.98	1.28	1.75	37.05
154	LaGrange	659	21,824	25,536	17.01	320	339	5.97	0.63	0.79	26.65
155	Elkhart	1,153	80,539	87,135	8.19	890	924	3.81	2.04	2.34	14.52
156	LaGrange	3,350	36,011	54,718	51.95	571	667	16.86	1.09	1.94	76.89
157	LaGrange	4,118	67,411	90,407	34.11	868	987	13.63	1.76	2.79	58.83
158	Steuben	549	45,604	48,597	6.56	417	433	3.69	0.95	1.08	14.18
159	LaGrange	1,483	51,147	59,290	15.92	440	482	9.52	1.02	1.39	35.82
160	Elkhart	2,471	53,191	67,475	26.85	490	563	15.01	1.60	2.25	40.10
161	LaGrange	2,581	72,532	86,782	19.65	624	698	11.74	1.46	2.10	43.95
162	St. Joseph IN	1,867	44,289	55,277	24.81	574	630	9.85	1.29	1.78	38.44
163	Steuben	1,153	54,207	60,506	11.62	505	538	6.42	1.26	1.54	22.54
164	Steuben	879	72,635	77,422	6.59	437	462	5.63	1.22	1.43	17.71
165	Elkhart	1,318	38,159	45,607	19.52	621	660	6.17	1.19	1.53	28.13
166	LaGrange	1,757	40,371	50,070	24.03	506	556	9.86	1.12	1.56	38.93
167	St. Joseph IN	3,240	138,334	158,590	14.64	1261	1365	8.27	4.45	5.36	20.48
168	St. Joseph IN	3,404	37,808	58,063	53.57	631	735	16.52	1.21	2.12	75.50

			Annual Runoff (acre-feet/year)			Annual TSS Loading (tons/year)			Annual TP Loading (tons/year)		
Number	County	Acres to be Developed	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase
169	LaGrange	2,361	25,166	38,280	52.11	415	483	16.24	0.78	1.37	75.43
170	LaGrange	1,592	46,538	55,324	18.88	356	401	12.71	0.87	1.27	45.25
171	Steuben	1,098	47,229	53,209	12.66	422	453	7.28	0.99	1.26	27.17
172	Elkhart	2,855	64,416	80,767	25.38	681	765	12.35	1.88	2.61	39.22
173	Steuben	769	22,303	26,492	18.78	305	327	7.06	0.65	0.84	28.81
174	Steuben	1,428	48,809	56,596	15.95	396	436	10.13	0.98	1.33	35.86
175	Elkhart	1,263	32,489	39,805	22.52	538	575	7.00	1.07	1.40	30.76
176	Elkhart	2,361	61,368	74,692	21.71	789	858	8.69	1.97	2.57	30.42
177	Elkhart	1,812	32,942	43,210	31.17	265	317	19.96	0.92	1.38	50.36
178	LaGrange	4,503	35,268	60,320	71.04	598	727	21.54	1.18	2.31	95.40
179	LaGrange	1,153	61,451	67,735	10.23	455	487	7.11	1.14	1.42	24.85
180	Elkhart	1,647	48,075	57,533	19.67	770	818	6.32	1.51	1.94	28.15
181	LaGrange	2,416	77,974	91,227	17.00	507	575	13.45	1.38	1.97	43.31
182	LaGrange	1,428	42,997	50,878	18.33	362	402	11.21	0.85	1.20	41.72
183	Dekalb	988	38,199	43,576	14.08	495	523	5.59	1.02	1.26	23.73
184	Elkhart	1,757	37,720	47,543	26.04	585	635	8.64	1.17	1.61	37.91
185	LaGrange	4,832	58,363	85,399	46.32	997	1136	13.95	1.88	3.09	64.79
186	Elkhart	659	14,320	18,006	25.74	168	187	11.30	0.35	0.52	46.79
187	Noble	769	52,239	56,426	8.02	468	490	4.60	1.08	1.27	17.41
188	Elkhart	3,514	43,409	63,699	46.74	764	869	13.66	1.54	2.45	59.28
189	Noble	1,428	57,503	65,297	13.55	401	441	10.00	1.05	1.40	33.35
190	Elkhart	1,153	40,048	46,574	16.30	551	584	6.10	1.16	1.45	25.30
191	Elkhart	933	21,071	26,361	25.11	393	420	6.93	0.73	0.97	32.43
192	Elkhart	3,789	52,082	73,322	40.78	624	733	17.52	1.35	2.30	70.82
193	Noble	220	15,358	16,572	7.90	172	178	3.63	0.37	0.42	14.83
194	Elkhart	3,514	25,941	45,518	75.47	412	513	24.42	0.79	1.67	111.05
195	Elkhart	2,087	37,460	49,323	31.67	601	662	10.16	1.33	1.86	40.17
196	Noble	1,867	73,166	83,357	13.93	667	719	7.86	1.54	2.00	29.83
197	Noble	3,899	67,025	88,458	31.98	847	957	13.02	1.73	2.70	55.65
198	Noble	1,098	66,395	72,364	8.99	560	591	5.48	1.66	1.93	16.21
199	Elkhart	659	35,550	39,251	10.41	536	555	3.55	1.11	1.28	15.00
200	Noble	2,581	55,154	69,468	25.95	747	821	9.86	1.62	2.27	39.65
201	Kosciusko	604	49,860	53,229	6.76	608	625	2.85	1.35	1.50	11.21
202	Noble	220	25,565	26,765	4.69	166	172	3.73	0.44	0.50	12.20
203	Noble	1,153	61,659	67,935	10.18	652	685	4.95	1.47	1.76	19.15
204	Noble	2,032	83,762	94,914	13.31	616	673	9.32	1.53	2.03	32.85
205	Kosciusko	5,052	130,408	158,426	21.49	688	832	20.96	2.24	3.50	56.29
206	Kosciusko	3,350	23,951	42,778	78.60	485	582	19.97	0.88	1.72	96.79
207	Kosciusko	1,098	42,826	48,939	14.27	372	403	8.46	0.90	1.17	30.59
208	Noble	4,118	46,115	68,829	49.26	727	844	16.07	1.40	2.42	72.86
209	Noble	769	38,973	43,215	10.88	397	419	5.49	0.88	1.07	21.79
210	Noble	1,098	58,116	64,083	10.27	371	402	8.27	0.97	1.24	27.58
211	Noble	604	50,964	54,259	6.46	397	414	4.27	0.97	1.11	15.36
212	Noble	1,428	50,922	58,728	15.33	448	488	8.97	1.05	1.41	33.31
213	Kosciusko	4,887	33,055	60,346	82.56	634	774	22.16	1.18	2.41	103.86
214	Elkhart	439	59,687	62,179	4.18	586	599	2.19	1.45	1.57	7.72
215	VanBuren	4,667	83,486	112,897	35.23	689	840	21.97	1.82	3.14	72.80
216	Elkhart	4,667	77,625	105,047	35.32	682	823	20.70	2.26	3.49	54.67
217	St. Joseph IN	5,711	96,170	130,098	35.28	897	1072	19.46	2.75	4.28	55.49

Bold subwatersheds were prioritized for preservation.
Shaded subwatersheds were parts of major subwatershed units prioritized for preservation.
Subwatershed numbers 89 and 124 fit both criteria.

Berrien, Branch, Calhoun, Cass, Hillsdale, Kalamazoo, St. Joseph (MI) and VanBuren Counties are in Michigan.
DeKalb, Elkhart, Kosciusko, LaGrange, Noble, St. Joseph (IN) and Stueben Counties are in Indiana.

ATTACHMENT D

Comparison of 1992 USGS Land Cover Data to 2000 NOAA Land Cover Data

Comparison of 1992 USGS Land Cover Data to NOAA Land Cover Data Sets

The 1992 USGS land cover data are available for the entire United States for download from the USGS website (http://edc.usgs.gov/products/landcover/nlcd.html). Those data were used in 2003 for the nonpoint source load model conducted for the St. Joseph River Watershed Planning Project (K&A, 2003). Since that time, 1995 and 2000 land cover data became available from the NOAA Coastal Change Analysis Program. These data cover the United State coastal areas, including land draining to the Great Lakes. The 2000 data were used to update the nonpoint source load model from 1992 data and as a baseline for the Landscape Analyst development model.

Although NOAA and USGS use the same type of satellite image data for land cover classification, and the classification process is also similar between the two agencies, they have different purposes for such data and hence, differing final classifications. NOAA's Coastal Change Analysis Program is interested in coastal habitat change, and its land cover classification reflects this by giving more detailed sub-classes for wetlands and coastal lands but less for human-influenced land uses (developed lands and agricultural lands) compared to 1992 USGS data.

For the nonpoint source modeling, the land cover types were grouped into classes, as show in Table D-1. It can be seen from the table that the NOAA data contain several divisions for wetland and shoreline land uses, while the USGS data contain more distinctions for human-influenced land uses. The USGS land cover data used for the 2003 nonpoint source loading were calibrated to loading data from a USGS study of major tributaries to Lake Michigan and Lake Superior (Robertson, 1997). Thus loading values generated from 1992 land cover data are considered representative of the watershed loading because USGS data define human-influenced land uses (which affect runoff) more distinctly than the NOAA data. The NOAA data were still considered adequate to use as a baseline for the Landscape Analyst development model which simply needed the general land cover divisions of: developed, forest, agriculture and wetlands. The nonpoint source loading model was updated with the 2000 land cover data to serve as a new loading baseline. It was then refined with the output of the build-out analysis to illustrate potential increases in runoff from future development. The validity of using the nonpoint source loading estimates calculated with the NOAA data stems from the desire to obtain a comparison of future loading from predicted development to baseline loading (i.e., the percentages reported in Tables 4 and 5 of the report text).

Table D-1. Grouping of land cover classes.

Major Land Cover Groups	NOAA Land Cover Classes (2000)	USGS Land Cover Classes (1992)
Water and Wetland	Open water, palustrine forest, palustrine scrub/shrub, palustrine emergent, unconsolidated shore, palustrine aquatic bed	Open water, woody wetlands, emergent herbaceous wetlands
Forest and Open Space	Deciduous forest, evergreen forest, mixed forest, scrub/shrub	Deciduous forest, evergreen forest, mixed forest, shrubland, grassland
Agriculture	Cultivated land, grassland	Pasture/hay, row crops, small grains
Residential	Low intensity development	Low intensity residential, high intensity residential, urban/ recreational grasses
Commercial, Industrial and Transportation	High intensity development	Commercial/industrial/ transportation

The land cover distribution and associated nonpoint source loading of sediments and phosphorus were compared among the 1992, 1995 and 2000 land cover data sets (see Table D-2). This comparison highlights significant discrepancies among the data sets for open water and wetland land cover types which seem to infer these are increasing in area over time. This is not considered realistic and thus, suggests incompatibility for comparing loading estimates between USGS and NOAA data. Therefore, forest lands and agricultural lands, though shown to be decreasing over time resulting in a decrease in sediment loading from 1992 to 2000, cannot be rationalized.

Other differences or discrepencies included the following:

- For the NOAA data, grassland and cultivated lands were summed as agricultural lands because the acreage of cultivated lands alone was much lower than the agricultural land in the USGS data set.
- With the USGS data, row crops, pasture/hay and small grains formed the agricultural land grouping. A separate grassland land cover type was grouped into the forest/open space grouping.
- Residential land increased sharply from 1992 to 1995 and then dropped in 2000. Only one land cover type in the NOAA data was available for the residential grouping, while three land cover types were delineated with the USGS data.
- The residential and agricultural land cover types signal that the USGS data are more refined for human-influenced land cover types which is more useful for nonpoint source load estimates.
- From the 1992 USGS data to the 2000 NOAA data, commercial land rose sharply over time. This may be because the NOAA grouping for high intensity development may include both commercial and residential land uses.

There are irreconcilable changes even within the 1995 and 2000 NOAA land cover data sets. For example, total acreage for the residential and commercial/industrial/transportation land cover groupings decreased from 172,667 acres in the 1995 NOAA data set to 170,147 acres with the 2000 NOAA data. This is not considered representative of the watershed, as it is known that development has increased over time. This may be partially explained by the limitations of the ArcView data processing capabilities. The NOAA data were made available as one large grid file encompassing all of the area of Michigan and Indiana draining to Lake Michigan in an Albers Conical Equal Area projection. These data needed to be reprojected to Universal Transverse Mercator Zone 16 to be compatible with the other GIS files used in this modeling exercise. However, the file was too large for ArcView to reproject in one step. It had to be cut into smaller pieces, which were reprojected individually. The pieces in the new coordinate system were then "mosaiced" back together. This data processing may have resulted in the loss or alteration of some "grids" from the original file. The USGS data did not have to manipulated in this way.

Regardless of these data discrepancies, the 2000 NOAA data set was considered valid to serve as a baseline for the development model to project future development and to calculate percent changes in stormwater runoff and nonpoint source loading associated with such development.

Reference

Robertson, Dale M. 1997. Regionalized Loads of Sediment and Phosphorus to Lakes Michigan and Superior: High Flow and Long-term Average. J. Great Lakes Res 23(4):416-439.

Table D-2. Comparison of 1992 USGS Land Cover to NOAA Land Cover Data Sets.

1992 USGS

	Water + Wetland	Forest/open	Agricultural	Residential	Com/ind/transp	Total
acres	248,191	495,175	2,109,499	87,699	29,450	2,970,014
% total	8.36	16.67	71.03	2.95	0.99	
TP (lbs/yr)	69,074	28,187	395,552	55,114	31,046	578,973
TSS (lbs/yr)	5,180,572	13,068,344	230,916,857	10,125,600	9,701,937	268,993,310

1995 NOAA

	Water + Wetland	Forest/open	Agricultural	Residential	Com/ind/transp	Total
acres	352,861	467,349	1,979,133	128,155	44,512	2,972,011
% total	11.87	15.73	66.59	4.31	1.50	
TP (lbs/yr)	98,780	26,210	371,965	79,167	46,961	623,083
TSS (lbs/yr)	7,408,521	12,152,086	217,147,003	14,544,668	14,675,202	265,927,480

2000 NOAA

	Water + Wetland	Forest/open	Agricultural	Residential	Com/ind/transp	Total
acres	438,765	394,619	1,968,416	121,634	48,513	2,971,946
% total	14.76	13.28	66.23	4.09	1.63	
TP (lbs/yr)	121,354	22,396	369,848	75,608	51,210	640,416
TSS (lbs/yr)	9,101,554	10,383,661	215,911,376	13,890,719	16,003,014	265,290,324

FIGURES

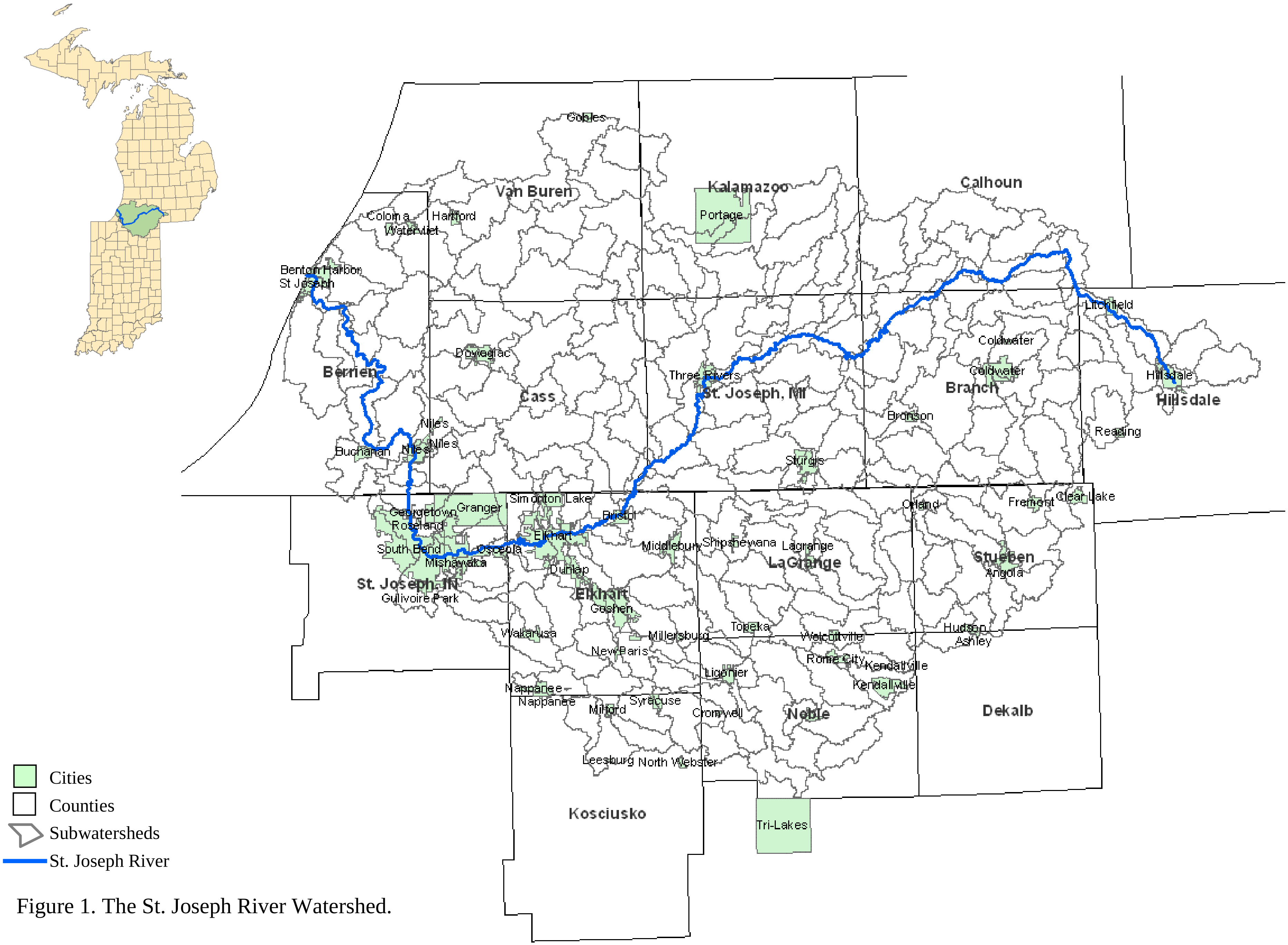

Figure 1. The St. Joseph River Watershed.

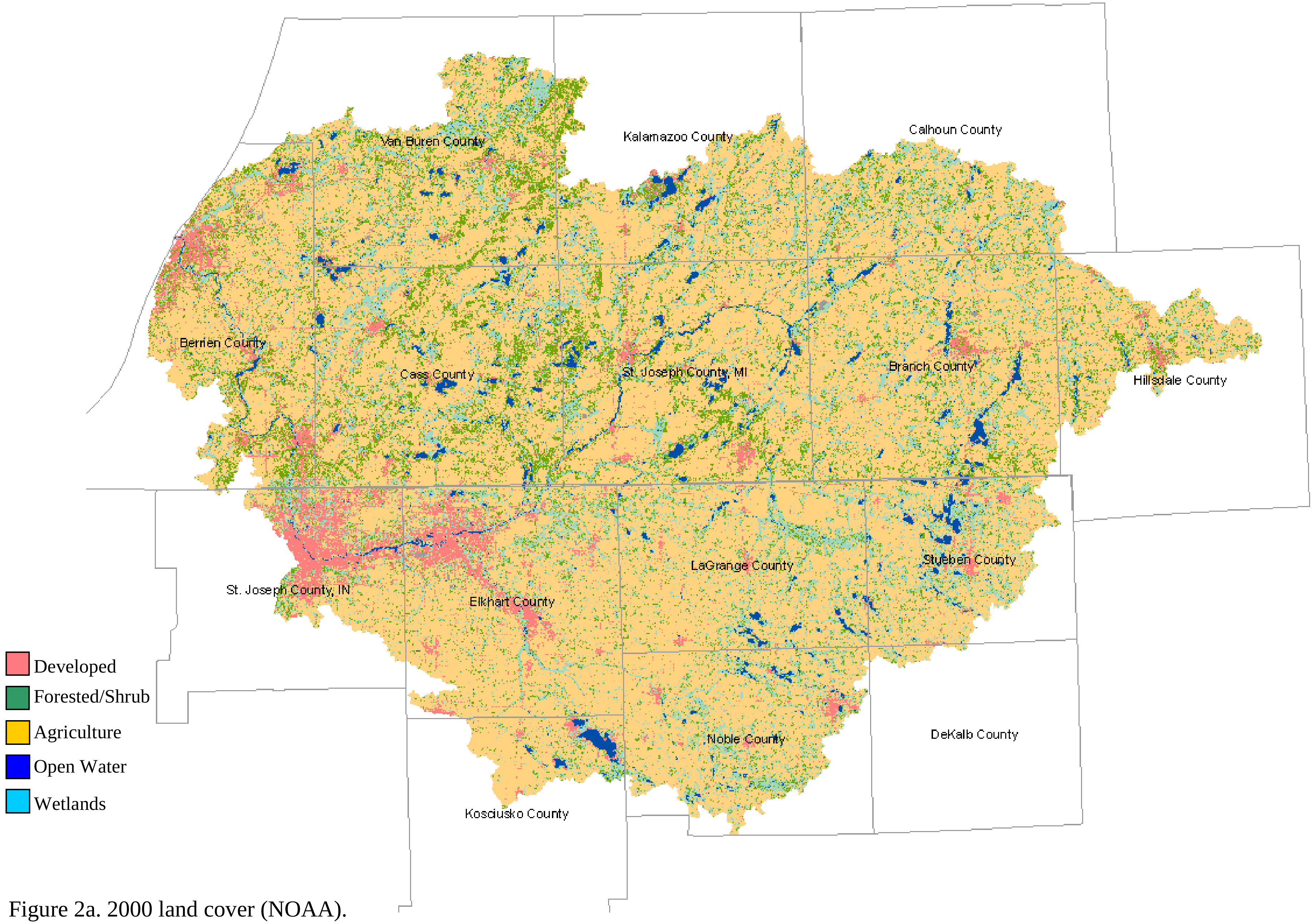

Figure 2a. 2000 land cover (NOAA).

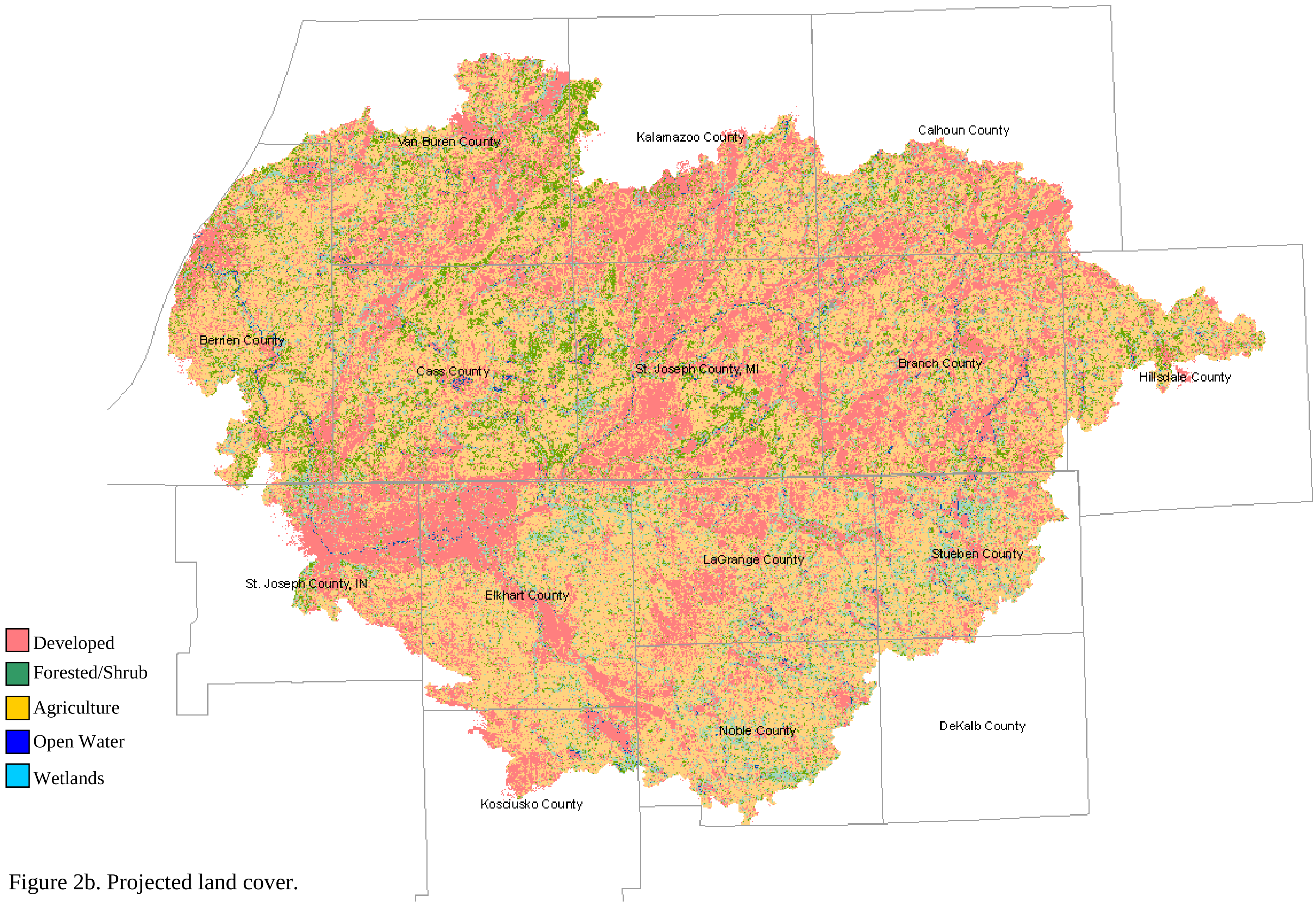

Figure 2b. Projected land cover.

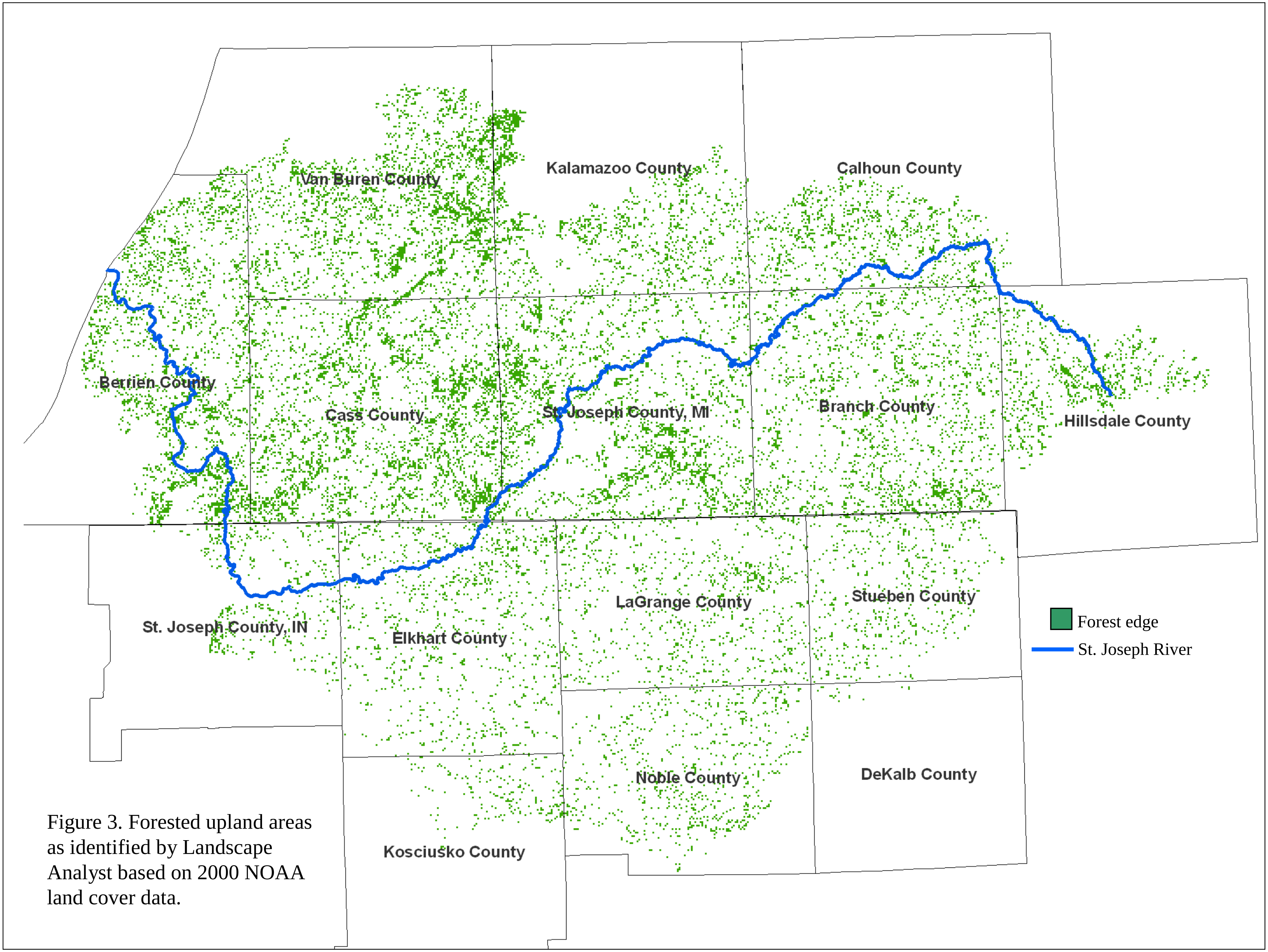

Figure 3. Forested upland areas as identified by Landscape Analyst based on 2000 NOAA land cover data.

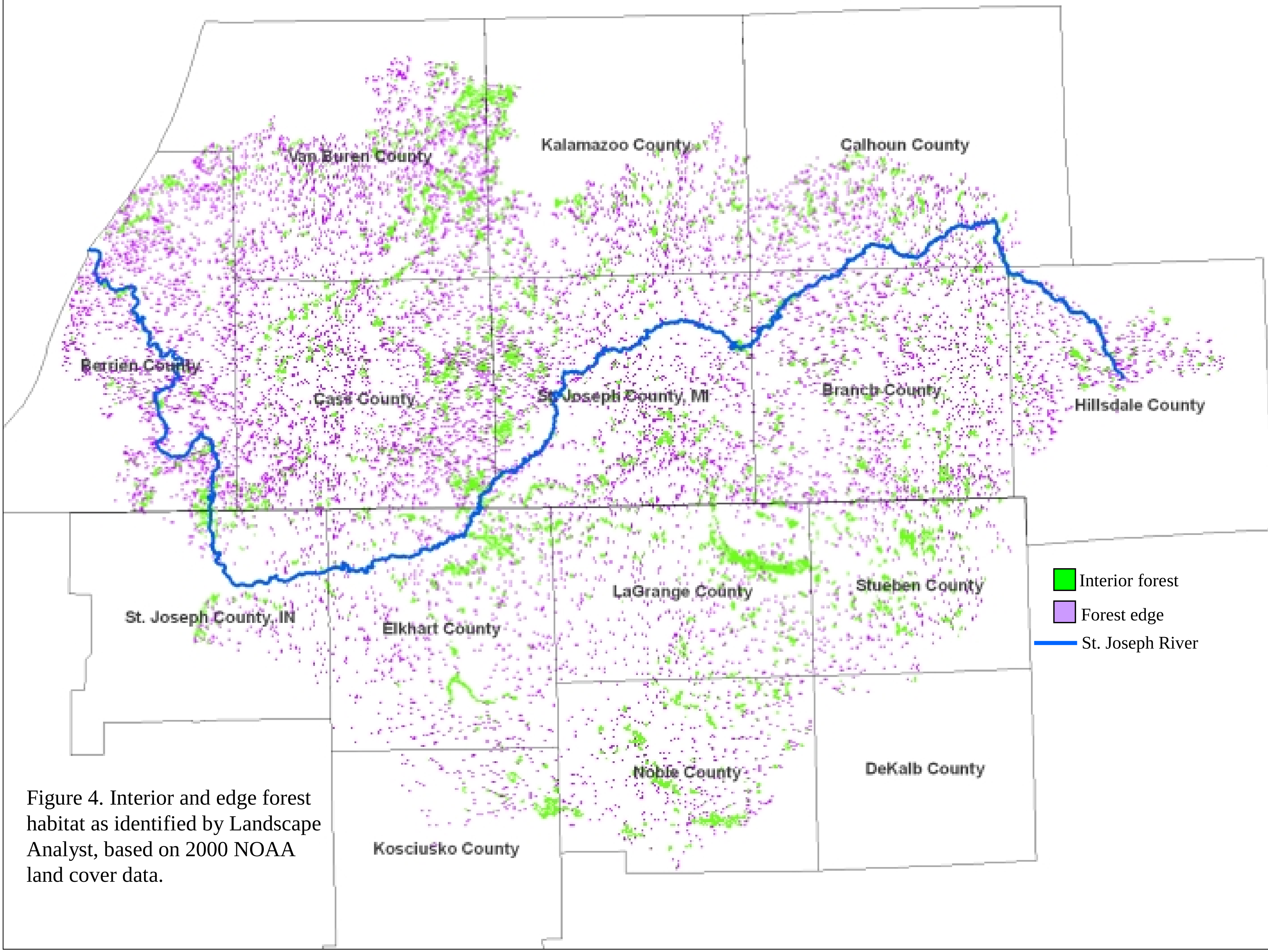

Figure 4. Interior and edge forest habitat as identified by Landscape Analyst, based on 2000 NOAA land cover data.

appendix e

analysis of urban stormwater best management practice options for the st. joseph river watershed

Analysis of Urban Stormwater Best Management Practice Options for the St. Joseph River Watershed

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Introduction

Although predominantly agricultural, the St. Joseph River Watershed has 19 of 217 subwatersheds with over 10% of the land area in urban uses (commercial, residential, industrial, or transportation) according to the 1992 land cover data from the U.S. Geological Survey (USGS) (http://www.stjoeriver.net/wmp/tasks/urban_lc.htm)). Major urban centers include South Bend-Mishawaka (IN), Benton Harbor-St. Joseph (MI), Elkhart (IN), and Goshen (IN). Nonpoint source (NPS) modeling work conducted by KIESER & ASSOCITES (K&A) revealed that in the 19 subwatersheds with over 10% urban areas, urban land uses contributed more than one-third of the total phosphorus (TP) loading from these subwatersheds (K&A, 2003). Therefore, while controling pollutant loadings from agricultural lands in the watershed is central in managing the overall water quality of the watershed, it is critical to reduce stormwater pollutant loadings from urban areas in order to protect and restore water quality in the streams draining urban subwatersheds.

From a regulatory perspective, USEPA's NPDES Phase II Stormwater Program (http://www.stjoeriver.net/wmp/tasks/npdesp2.htm) has put numerous urban communities in the watershed under regulatory obligation to develop stormwater pollution control and monitoring programs. As a result of this regulation and the predicted high pollutant loadings from urban lands, it is essential for watershed management planning efforts to examine stormwater pollutant loadings from urban subwatersheds. Planning must address solutions and associated costs of abating pollution from these urban sources. This report describes the work conducted by K&A to accomplish this.

This study is based on the empirical model used for estimating NPS pollutant loadings from various land cover types, including urban areas, that has been described by K&A in a report prepared for this 319 grant (K&A, 2003). In addition to updating the modeling work with newly available land cover data (2000), this study focused on the major urban centers in the St. Joseph River Watershed to explore: 1) the pollutant removal potential of select urban stormwater best management practices (BMPs); and 2) the costs associated with these BMPs. These efforts are meant to help the Watershed Management Plan being developed for the St. Joseph River to meet the required USEPA Nine Elements.

These analyses do not include pollutant loads from any combined sewer overflows (CSOs). Computations also assume there no current BMPs are in place and that predicted loads are solely associated with urban stormwater runoff. No additional mapping characterizations have been made which might also determine that select urban areas are isolated from surface waters either topographically or via stormsewer infrastructure. Budget and scope constraints precluded detailed deterministic modeling that would have been required for these consideration. Nevertheless, the findings of this report are still highly applicable as urban stormwater treatment and/or reduction will be necessary in these urban areas to realize water quality improvements.

Methods

The overall analysis procedure is represented in the flow chart shown in Figure 1. The 2000 land cover data for the St. Joseph River Watershed was downloaded from the National Oceanic and

Atmospheric Administration (NOAA)'s Coastal Change Analysis Program (http://www.csc.noaa.gov/crs/lca/greatlakes.html).

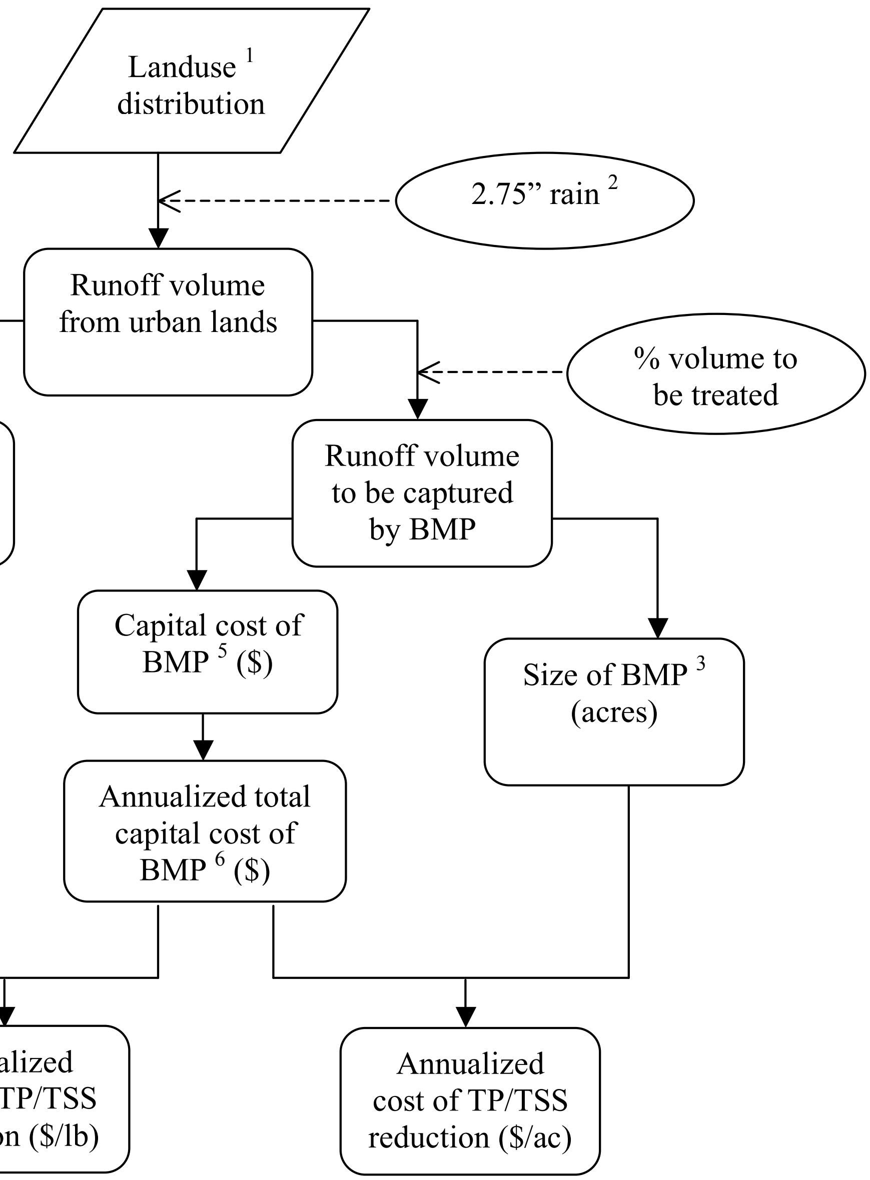

Figure 1. Flow Chart of Urban Stormwater BMP Cost Calculations.

[1] 2000 NOAA data.
[2] Equivalent to a one-hour 100-year or a 24-hour 2-year rain event for the St. Joseph River Watershed.
[3] General assumptions made for the physical dimensions of BMPs.
[4] Load reduction efficiencies of BMPs based on the Michigan Trading Rules and/or literature values.
[5] Cost based on Rouge River Watershed management plans and/or literature values.
[6] 30-year annualization with a 5% discount rate.

In the previous modeling effort (K&A, 2003), 1992 land cover data produced by USGS was used. Although NOAA and USGS use the same type of satellite image data for land cover/landuse classification and the classification process is also similar between the two agencies, they have different purposes for the data and hence different final classifications. NOAA's Coastal Change Analysis Program is interested in coastal habitat change and its land cover classification reflects this by giving more detailed sub-classes for wetlands and coastal lands but less for developed lands and agricultural lands, compared to the 1992 USGS land cover data. For this modeling purpose, however, these differences had minimal influence on data processing as the NPS model groups various land cover classes into five major categories: water and wetland, forest and open space, agricultural land, residential area (low intensity development), and commercial/industrial/transportation uses (high intensity development). Pollutant loading estimations were based on these five categories, and the combination of the latter two categories was considered urban in this study.

After processed and integrated into the St. Joseph River GIS database at K&A, land cover distribution for each of the 217 subwatersheds was tabulated and grouped into the five major categories. The grouping of land cover classes is shown in Table 1.

Table 1. Grouping of land cover classes.

Major Land Cover Groups	NOAA Land Cover Classes (2000)	USGS Land Cover Classes (1992)
Water and wetland	Open water, palustrine forest, palustrine scrub/shrub, palustrine emergent, unconsolidated shore, palustrine aquatic bed	Open water, woody wetlands, emergent herbaceous wetlands
Forest and open space	Deciduous forest, evergreen forest, mixed forest, scrub/shrub	Deciduous forest, evergreen forest, mixed forest, shrubland, grassland/ herbaceous
Agricultural land	Cultivated land, grassland, bare land	Pasture/hay, row crops, small grains
Residential area	Low density development	Low intensity residential, high intensity residential, urban/ recreational grasses
Commerical/industrial/ transportation uses	High density development	Commercial/industrial/transportation

To analyze urban pollutant loadings from the four major urban centers in the watershed, the land cover map was overlaid with the subwatershed delineation map (Figure 2). Subwatersheds containing these urban centers were then chosen for further analysis (Table 2). Because the purpose of this study is to analyze urban stormwater BMP options, it is assumed that only stormwater generated by the low density development and high density development land cover classes in the NOAA 2000 map are treated with the BMPs examined here.

Five widely used urban stormwater BMPs (wet retention ponds, dry detention ponds, vegetated swales, rain gardens, and constructed wetlands) were chosen in this study to evaluate pollution reduction opportunties and their cost-effectiveness in removing TP and TSS from urban stormwater runoff. These BMPs were selected because of their general applicability and the readily available information on their pollutant load reduction efficiencies (MI-ORR, 2002) and construction costs (Rouge River National Wet Weather Demonstration Project, 2001).

The holding capacity or the design volume of a stormwater retention or detention pond is a function of the rainfall depth of the storm event that the pond is designed to treat. As a generally accepted rule, pond volume is designed to fully capture minimally the first inch of the rainfall in a storm event, because runoff from this first inch is believed to carry most of the pollutants from the watershed. To achieve a higher and more consistent pollutant removal, however, ponds with larger holding capacities are necessary. In this study, a 2.75-inch rain depth representing a 24-hour, 2-year or 1-hour, 100-year storm event in the St. Joseph River Watershed (Huff, 1992), was chosen to ensure the TP and TSS removal efficiencies quoted in the Michigan Water Quality Trading Rule (MI-ORR, 2002) and used in this study can be achieved (listed in Table 4). The runoff and pond volume associated with the 2.75-inch rainfall was calculated using the NPS loading model (K&A, 2003) based on the percent of the urban area to be treated by the stormwater facilities. Costs of constructing the ponds were then derived based on pond volume and area (assuming a depth of 5 feet).

For vegetated swales, generally agreed design criteria on the size in relation to treated area could not be found. According to a fact sheet produced by the Center for Watershed Protection (http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Open%20Channel%20Practice/Grassed%20Channel.htm), vegetated swales should generally be used to treat drainage areas less than 5 acres. Optimum size of a swale may be 8 feet (width) by 200 feet (length), based on information available from the Low Impact Development Center (http://www.lowimpactdevelopment.org/epa03/LIDtrans/Ex_Swale.pdf). Using these design benchmarks (i.e., for every 5 acres of drainage, it will require a swale of 8ft ×200ft to reach expected treatment efficiencies), the total size of required swales to treat a certain percentage (e.g., 50%) of the targeted urban area was calculated.

A guidance manual produced by the University of Wisconsin-Extension Services (Bannerman and Considine, 2003) provides some detailed instructions on constructing a rain garden for average home owners. The manual suggests a range of size factors (fraction of the drainage area) for design of rain gardens based on soil types and distance from the downspout. Here, an average value of 0.19 from all the reported values across the entire range was used. In addition, it is assumed here that only runoff from the impervious portion of the urban landuses in a subwatershed is treated with rain gardens. This is a reasonable assumption because rain gardens are mostly used to treat runoff from parking lots, roadways, and rooftops in urban areas. Because of the restrictions on where rain gardens can be built in an urban watershed where private properties dominate, rain gardens can only achieve about 5-15% runoff flow reduction (K&A field data [http://www.kalamazooriver.net/pa319new/docs/handouts/downspout_survey.pdf] and Wade-Trim Detroit Study [http://www.wadetrim.com/resources/pub_conf_downspout.pdf]). Therefore, a maximum treatment coverage of 15% of the impervious area in a watershed was assumed in this study.

Figure 2. Major Urban Subwatersheds in the St. Joseph River Watershed

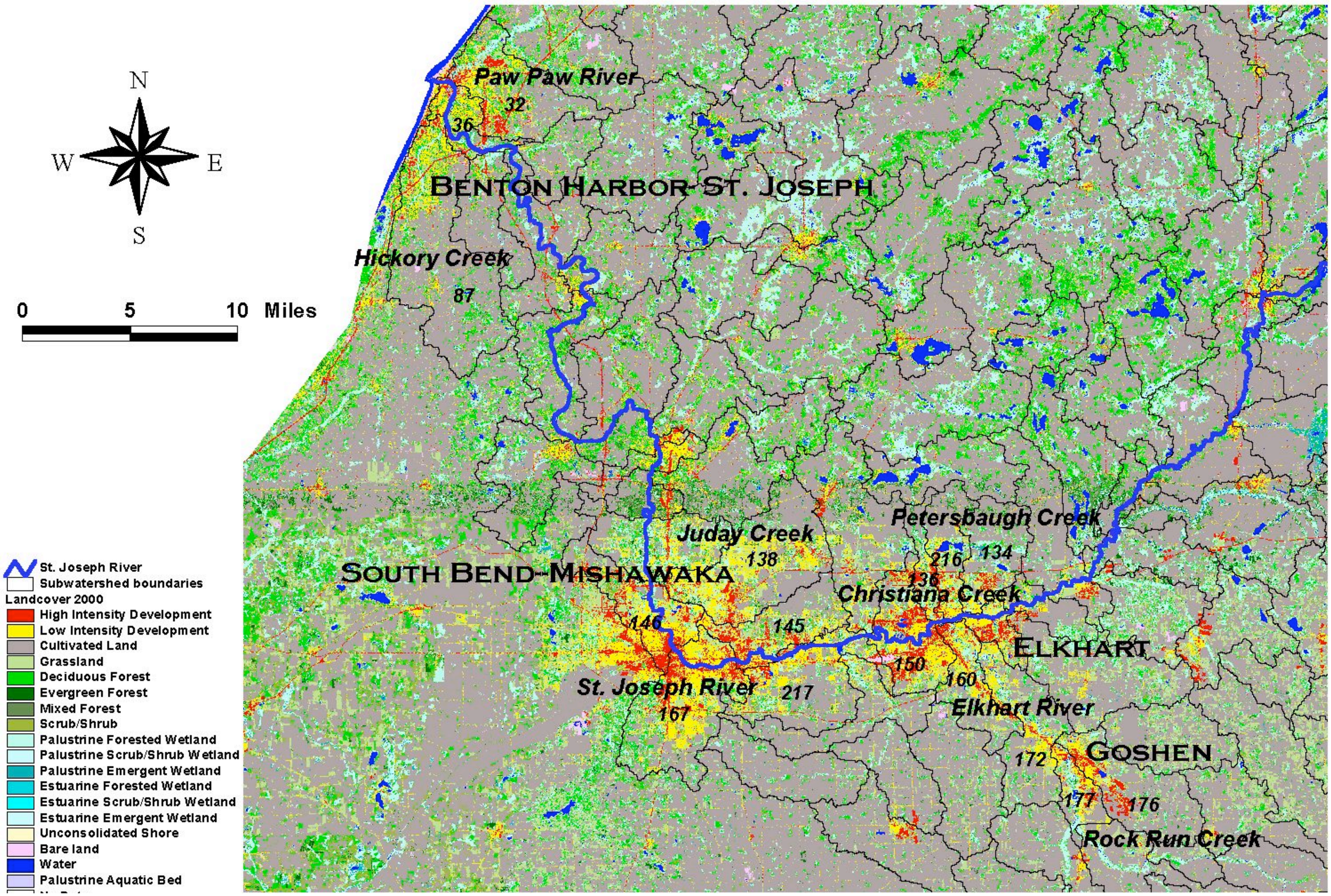

Table 2: Land cover distribution of urban subwatersheds.

Subwatershed			Water/Wetland		Forest/ Open Land		Agricultural		Residential		Commercial/Industrial /Transportation		Total
Urban center	Watershed number	Watershed name	acres	%[1]	acres	%	acres	%	acres	%	acres	%	acres
Benton Harbor – St. Joseph	32	Paw Paw River	1,215	7.5	2,677	16.6	7,868	48.8	2,684	16.6	1,681	10.4	16,125
	36	St. Joseph River at Lake Michigan	1,071	17.9	1,018	17.1	1,277	21.4	2,049	34.3	555	9.3	5,970
	87	Hickory Creek	1,550	4.8	4,700	14.6	21,762	67.6	3,405	10.6	798	2.5	32,215
South Bend – Mishawaka	138	Juday Creek	2,391	10.5	2,121	9.3	11,385	49.8	5,578	24.4	1,372	6.0	22,847
	145	St. Joseph River - Willow Creek	1,231	10.9	1,301	11.5	4,962	43.9	2,401	21.2	1,404	12.4	11,299
	146	St. Joseph River - Airport	1,256	10.5	898	7.5	3,706	31.0	3,715	31.1	2,385	19.9	11,961
	167	St. Joseph River - Auten Ditch	2,209	10.5	3,138	15.0	6,892	32.9	6,188	29.5	2,517	12.0	20,944
	217	St. Joseph River - Eller Ditch	2,401	13.6	1,776	10.0	9,258	52.4	3,320	18.8	918	5.2	17,674
Elkhart	134	Peterbaugh Creek	1,592	15.1	1,392	13.2	6,166	58.6	931	8.9	433	4.1	10,516
	136	Christiana Creek	725	17.6	502	12.2	1,823	44.2	606	14.7	469	11.4	4,126
	150	St. Joseph River - Elkhart West	1,491	12.3	792	6.5	3,324	27.4	3,792	31.2	2,749	22.6	12,148
	160	Elkhart River	1,194	13.4	733	8.2	4,046	45.5	2,040	22.9	882	9.9	8,894
	216	St. Joseph River - Osola Township Ditch	1,819	14.9	1,193	9.8	5,188	42.6	2,623	21.5	1,363	11.2	12,185
Goshen	172	Elkhart River - Leedy Ditch	1,605	11.1	1,502	10.3	8,912	61.4	2,171	15.0	328	2.3	14,518
	176	Rock Run Creek	1,042	7.2	978	6.8	10,102	69.9	1,237	8.6	1,089	7.5	14,448
	177	Elkhart River - Goshen	926	18.8	277	5.6	2,021	41.0	1,167	23.7	537	10.9	4,929

[1] Percent of the subwatershed total area.

According to Rouge River National Wet Weather Demonstration Project (2001), constructed wetlands typically require a size of 0.1 acres per impervious acre of the drainage area. This design criterion was used in this study to calculated required surface area of constructed wetlands. Though not specified in the Rouge River documentation, effective treatment wetlands generally require pre-treatment (sediment removal) in the form of forebays. In this analysis, costs and effectiveness implicitly assume these additional design elements would be constructed.

Baseline loadings of TP and TSS were calculated using the NPS loading model (K&A, 2003) for the runoff and pollutant loads associated with the 2.75-inch rainfall. Load reduction efficiencies achieved by the treatment ponds and swales were obtained from the Michigan Water Quality Trading Rule (MI-ORR, 2002) and are shown in Table 3. The total load reductions for a treated urban area were then calculated by multiplying the total annual loads from the treated area by the load reduction efficiencies in Table 3.

Table 3: Treatment efficiencies of stormwater BMPs.

	TP	TSS
Wet retention pond	90%	90%
Dry detention pond	30%	50%
Vegetated swale	40%	80%
Rain garden [1]	100%	100%
Constructed wetland [2]	90%	90%

[1] Assuming rain gardens absorb all pollutants contained in the runoff captured.
[2] Assuming to be the same as wet retention ponds (Rouge River National Wet Weather Demonstration Project, 2001).

Costs of construction and maintenance were derived from literature values, most of which can be found in the Rouge River National Wet Weather Demonstration Project (2001). These cost values were based either on the volume and surface area of stormwater ponds or the surface area of swales or rain gardens (Table 4).

Table 4. Costs of stormwater ponds.

	Construction [1]	Design & permits [1]	Maintenance
Wet retention pond	\$0.50 – 1.00/cubic ft	30% construction	\$4,152/ac/yr [2]
Dry detention pond	\$0.40 – 0.80/cubic ft	30% construction	\$4,152/ac/yr [3]
Vegetated swale	\$0.30/sq. ft	--	\$0.02/sq. ft/yr
Rain garden	\$11/sq. ft [4]	--	--
Constructed wetland [1]	\$40,500/acre	\$10,500/acre	\$850/acre.yr

[1] Source: Rouge River National Wet Weather Demonstration Project, 2001; Median values were used in calculations in this study.
[2] Source: Pitt, 2002; average pond depth of 5 feet assumed; adjusted to 2000 dollar value based on \$1,500/acre/year in 1978 dollars with Consumer Price Index from Bureau of Labor Statistics of the U.S. Department of Labor (http://data.bls.gov/cgi-bin/surveymost?bls).
[3] Assumed to be the same as wet retention ponds.
[4] Bannerman and Considine (2003)

Results

Tables 5 and 6 show the annual TP and TSS loadings, respectively, from each of the five major land cover categories for the urban subwatersheds examined in this study. Loading distributions (percent of the total) of land cover categories are also shown in the tables. In addition, Figures 3 through 6 are pie charts of the land cover and TP and TSS loading distributions for the subwatersheds in each of the four major urban centers.

The general finding that can be drawn from these tables and figures is that urban lands (residential and commercial/industrial/transportation) contribute disproportionally high loads of TP and TSS compared to the area they occupy in the subwatersheds. This is especially true for TP loading. It is clear that to reduce TP and TSS loadings from these subwatersheds, it is crucial to treat stormwater from the urban areas of these subwatersheds.

Figure 7 illustrates pollutant loadings from urban lands and other land cover types of all the subwatersheds from each of the four urban centers. It shows that urban areas are the largest TP loading source in all the four urban centers. Not only does the South Bend-Mishawaka area have the largest urban TP and TSS loadings among the four urban centers, its urban lands account for 68.5% of the TP loading from all sources in the area, which is the highest among the four urban centers. This is a natural result of the highest portion (35.2%) of urban area in the South Bend-Mishawaka subwatersheds.

Table 7 shows the pond holding capacity (volume) that each subwatershed needs and the associated costs and load reductions if wet retention ponds are to be built to treat 50% of the runoff from urban areas in the subwatersheds of the urban centers. Table 8 shows the same set of results for dry detention ponds. Tables 9, 10, and 11 illustrate similar results (except pond volumes) for vegetated swales, rain gardens, and constructed wetlands, respectively. In terms of load reductions, wet retention ponds (Table 7) and constructed wetlands (Table 11) are the most effective, giving a total TP reduction of 21,454 lbs and TSS of over 5 million lbs for all the subwatersheds studied here.[1] Rain gardens, due to the limitations on treatment coverage typically being restricted to private lands in urban watersheds (10% areal coverage assumed in this study), yielded only 7,339 lbs of TP and less than 1.8 million lbs of TSS.

Due to the greater treatment efficiencies (Table 4) and comparable costs (Table 3), wet retention ponds are more cost-effective stormwater treatment structures than are dry detention ponds. On average for the 16 urban subwatersheds, it costs \$325 to reduce one pound of phosphorus over a 30-year period (the assumed life of these structures) for wet retention ponds, compared to \$804 for dry detention ponds. The cost-effectiveness for TSS is \$1.32/lb for wet retention ponds and \$2.02/lb for dry detention ponds.

[1] Due to the assumptions made on load reduction efficiencies (see the Method section and Table 3), constructed wetlands and wet retention ponds have the same load reductions.

Table 5: TP loading from urban subwatersheds.

Subwatershed			Water/Wetland		Forest/Open land		Agricultural		Residential		Commercial/Industrial /Transportation		Total
Urban center	Watershed number	Watershed Name	lbs/yr	%[1]	lbs/yr	%	lbs/yr	%	lbs/yr	%	lbs/yr	%	lbs/yr
Benton Harbor – St. Joseph	32	Paw Paw River	403	6.4	179	2.8	1,767	28.0	1,913	30.4	2,041	32.4	6,302
	36	St. Joseph River at Lake Michigan	357	12.5	68	2.4	288	10.1	1,467	51.3	677	23.7	2,858
	87	Hickory Creek	521	5.6	318	3.4	4,952	53.6	2,459	26.6	982	10.6	9,232
South Bend – Mishawaka	138	Juday Creek	698	8.7	125	1.6	2,249	28.0	3,496	43.5	1,465	18.2	8,032
	145	St. Joseph River - Willow Creek	352	8.1	75	1.7	960	22.2	1,473	34.0	1,468	33.9	4,328
	146	St. Joseph River - Airport	397	6.1	57	0.9	791	12.1	2,518	38.6	2,754	42.3	6,516
	167	St. Joseph River - Auten Ditch	656	7.4	187	2.1	1,384	15.5	3,943	44.3	2,732	30.7	8,902
	217	St. Joseph River - Eller Ditch	677	12.3	101	1.8	1,766	32.1	2,011	36.5	947	17.2	5,502
Elkhart	134	Peterbaugh Creek	444	16.5	78	2.9	1,162	43.3	557	20.8	442	16.5	2,683
	136	Christiana Creek	204	14.3	28	2.0	347	24.3	366	25.6	482	33.8	1,427
	150	St. Joseph River - Elkhart West	415	6.7	44	0.7	626	10.2	2,266	36.8	2,799	45.5	6,151
	160	Elkhart River	328	10.2	40	1.3	751	23.4	1,202	37.5	885	27.6	3,206
	216	St. Joseph River - Osola Township Ditch	507	11.2	67	1.5	979	21.7	1,570	34.8	1,390	30.8	4,513
Goshen	172	Elkhart River - Leedy Ditch	436	11.6	82	2.2	1,639	43.7	1,267	33.8	327	8.7	3,751
	176	Rock Run Creek	279	7.1	53	1.3	1,831	46.4	711	18.1	1,067	27.1	3,941
	177	Elkhart River - Goshen	260	13.6	16	0.8	384	20.0	703	36.7	551	28.8	1,913

[1] Percent of the subwatershed total TP load.

Table 6: TSS loading from urban subwatersheds.

Subwatershed			Water/Wetland		Forest/Open land		Agricultural		Residential		Commercial/Industrial/ Transportation		Total
Urban center	Watershed number	Watershed Name	lbs/yr	%[1]	lbs/yr	%	lbs/yr	%	lbs/yr	%	lbs/yr	%	lbs/yr
Benton Harbor – St. Joseph	32	Paw Paw River	30,248	1.4	82,852	3.9	1,031,340	48.3	351,419	16.5	637,782	29.9	2,133,641
	36	St. Joseph River at Lake Michigan	26,785	3.8	31,666	4.5	168,213	23.8	269,525	38.1	211,688	29.9	707,877
	87	Hickory Creek	39,112	1.0	147,413	3.8	2,890,674	75.4	451,720	11.8	306,811	8.0	3,835,729
South Bend – Mishawaka	138	Juday Creek	52,363	2.1	57,745	2.3	1,312,743	52.0	642,325	25.5	457,689	18.1	2,522,866
	145	St. Joseph River – Willow Creek	26,388	2.0	34,683	2.6	560,176	41.5	270,694	20.0	458,726	34.0	1,350,667
	146	St. Joseph River – Airport	29,744	1.6	26,424	1.4	462,020	25.1	462,570	25.1	860,498	46.7	1,841,256
	167	St. Joseph River – Auten Ditch	49,176	1.9	86,849	3.4	807,949	32.0	724,444	28.7	853,681	33.8	2,522,099
	217	St. Joseph River – Eller Ditch	50,800	2.8	46,706	2.6	1,031,235	57.5	369,376	20.6	295,976	16.5	1,794,094
Elkhart	134	Peterbaugh Creek	33,274	3.4	36,176	3.7	678,541	68.7	102,356	10.4	138,023	14.0	988,370
	136	Christiana Creek	15,298	3.4	13,170	2.9	202,429	45.1	67,177	15.0	150,632	33.6	448,708
	150	St. Joseph River – Elkhart West	31,127	1.8	20,557	1.2	365,496	21.4	416,360	24.4	874,664	51.2	1,708,204
	160	Elkhart River	24,577	2.5	18,757	1.9	438,460	44.8	220,757	22.5	276,481	28.2	979,032
	216	St. Joseph River – Osola Township Ditch	38,046	2.8	31,023	2.3	571,438	41.9	288,500	21.2	434,313	31.9	1,363,320
Goshen	172	Elkhart River – Leedy Ditch	32,721	2.4	38,062	2.8	956,738	70.2	232,819	17.1	102,048	7.5	1,362,387
	176	Rock Run Creek	20,939	1.3	24,431	1.5	1,068,710	67.7	130,714	8.3	333,477	21.1	1,578,272
	177	Elkhart River - Goshen	19,494	3.5	7,248	1.3	223,905	40.6	129,133	23.4	172,256	31.2	552,036

[1] Percent of the subwatershed total TSS load.

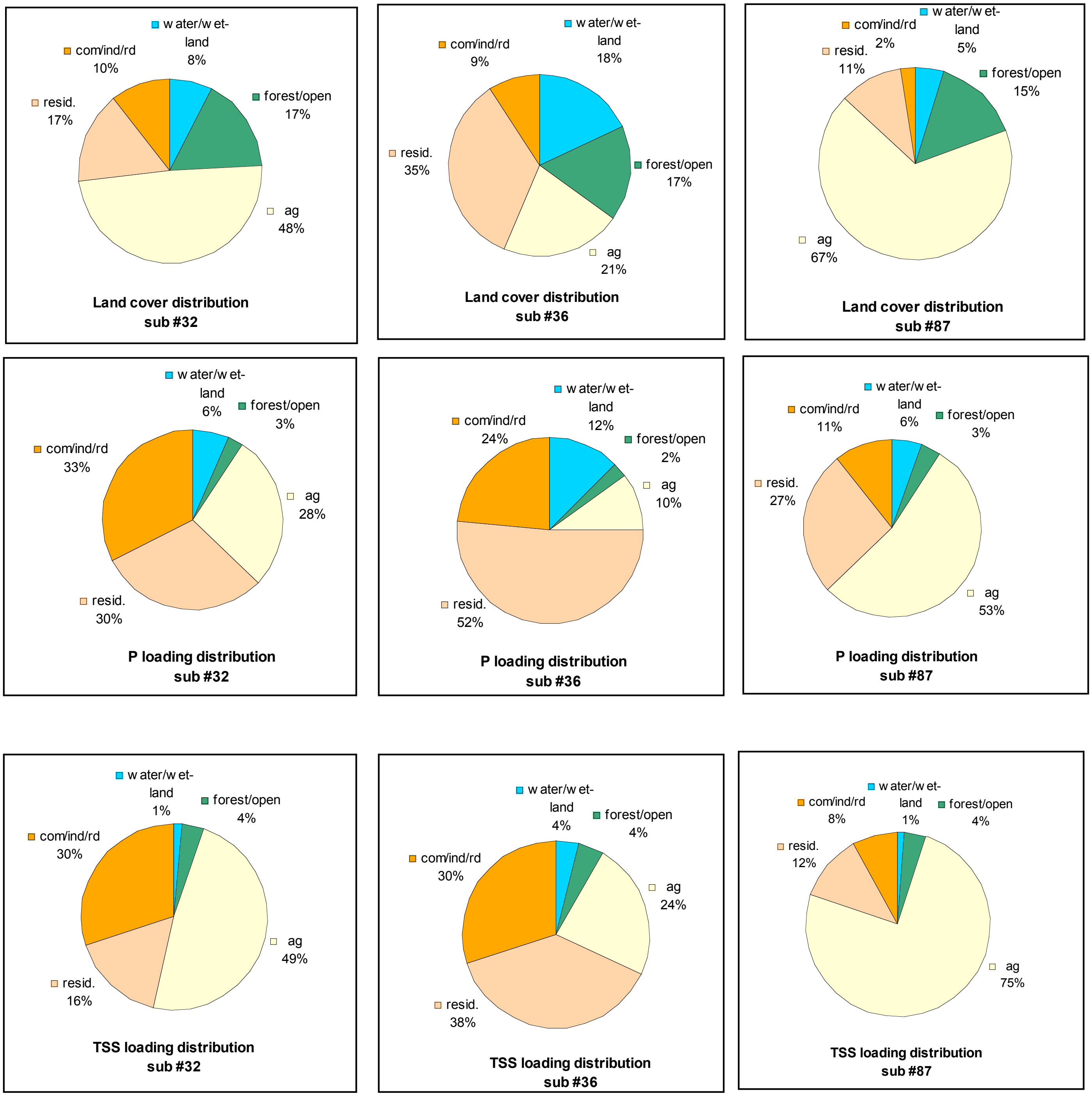

Figure 3. Land cover and TP and TSS loading distributions of subwatersheds in the Benton Harbor-St. Joseph (Michigan) area. (Note: ag: agricultural; resid.: residential; com/ind/rd: commercial/industrial/roads.)

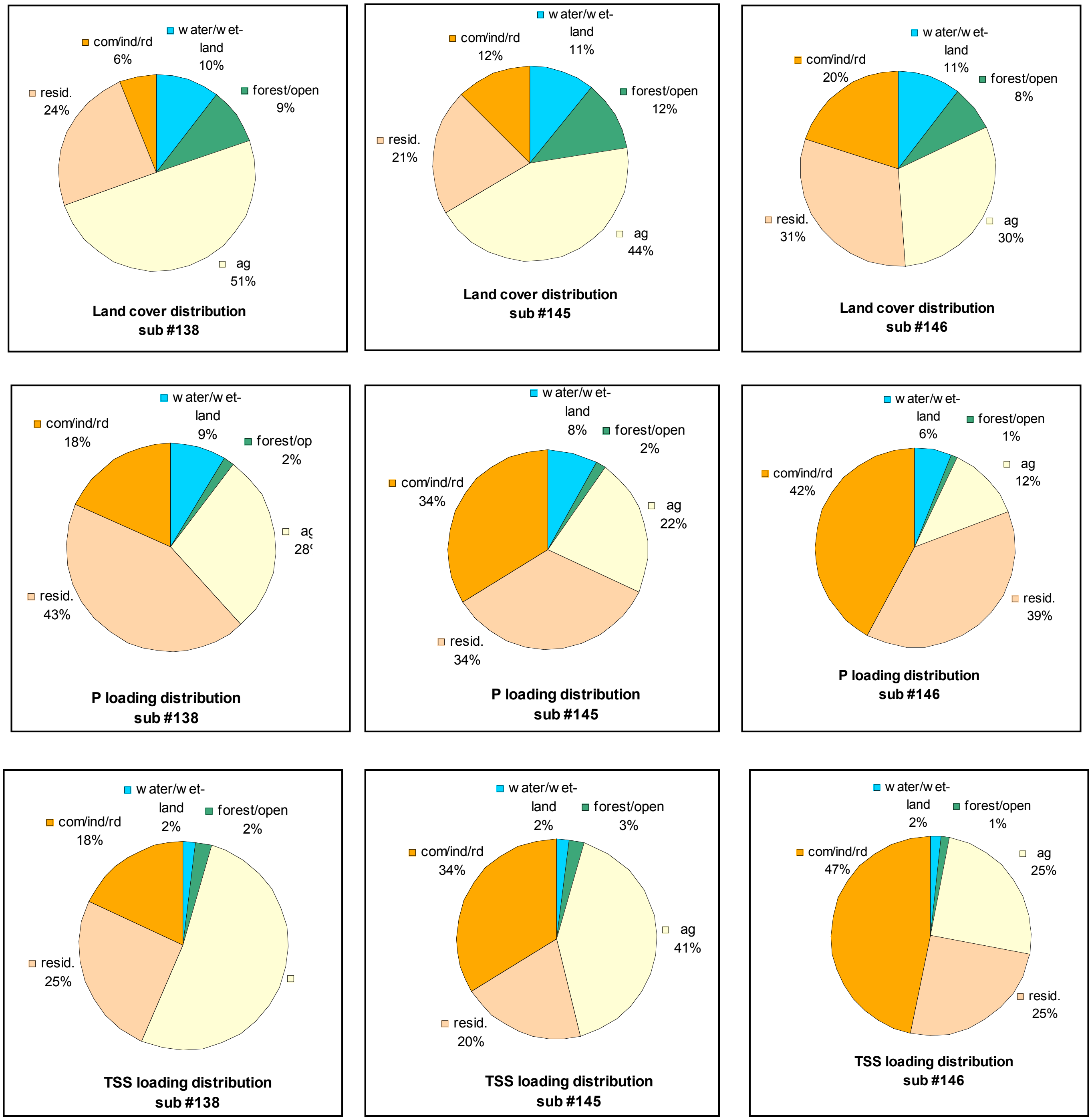

Figure 4: Land cover and TP and TSS loading distributions of subwatersheds in the South Bend-Mishawaka (Indiana) area.

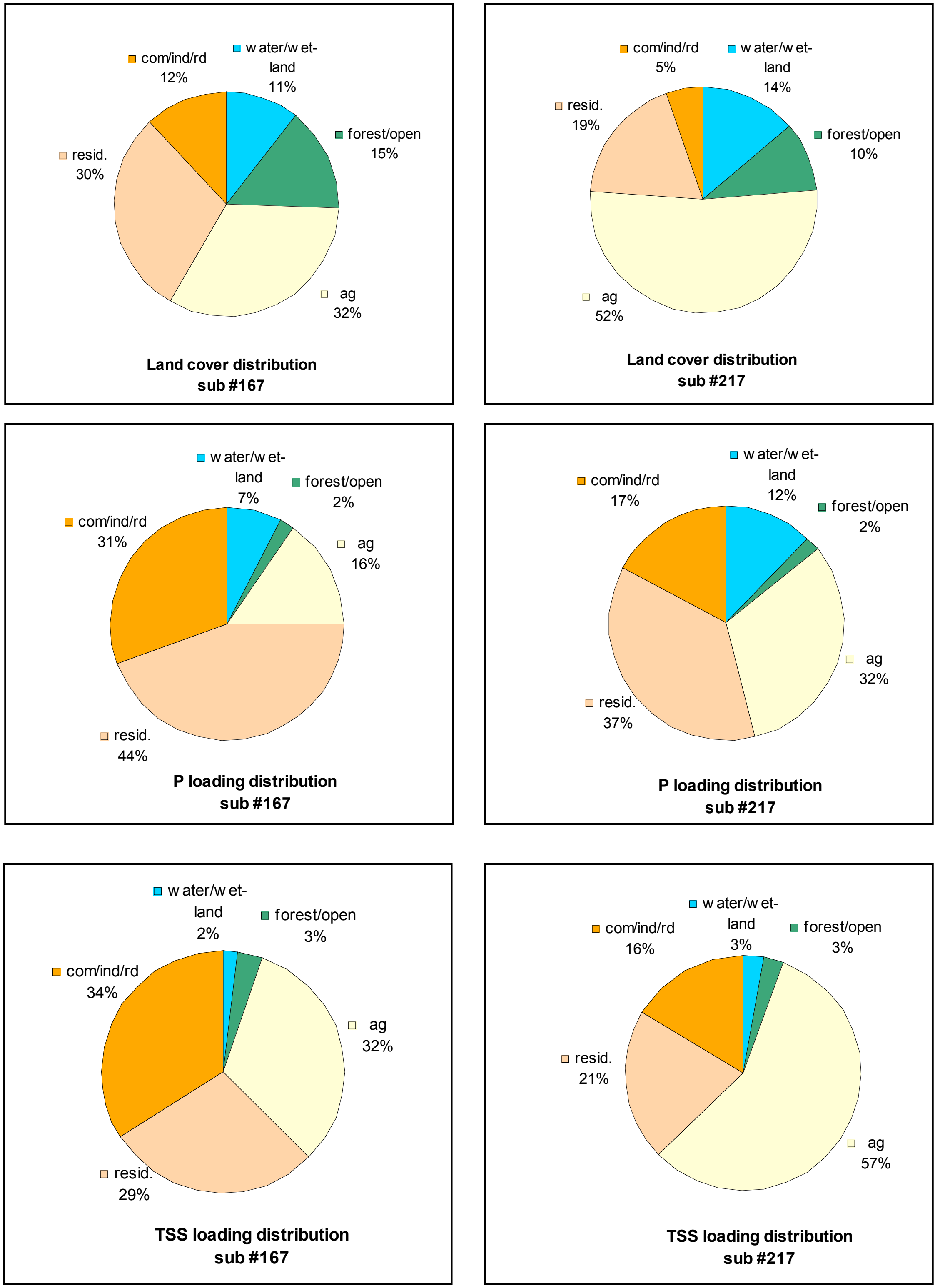

Figure 4 (cont'd): Land cover and TP and TSS loading distributions of subwatersheds in the South Bend-Mishawaka (Indiana) area.

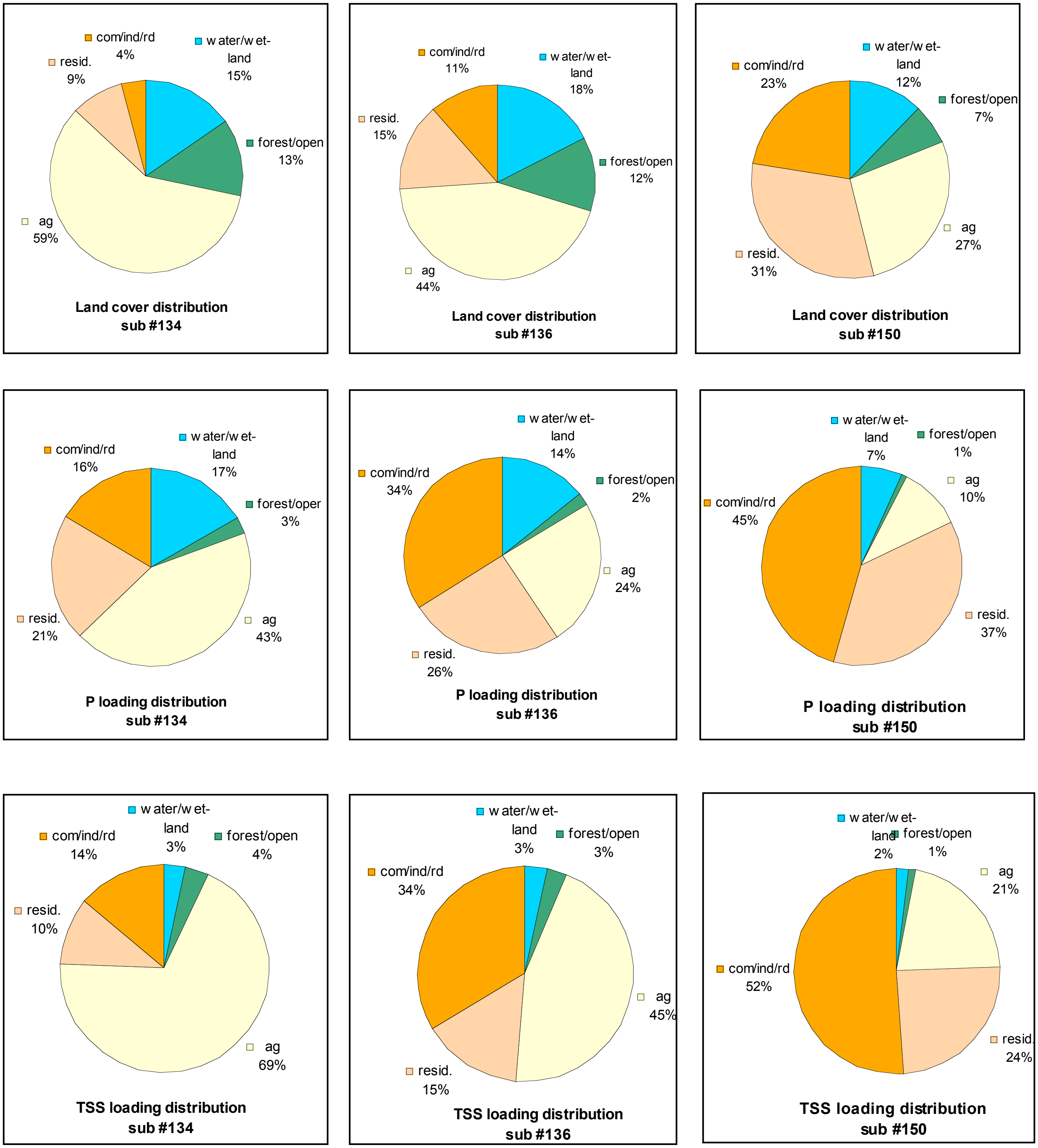

Figure 5: Land cover and TP and TSS loading distributions of subwatersheds in the Elkhart (Indiana) area.

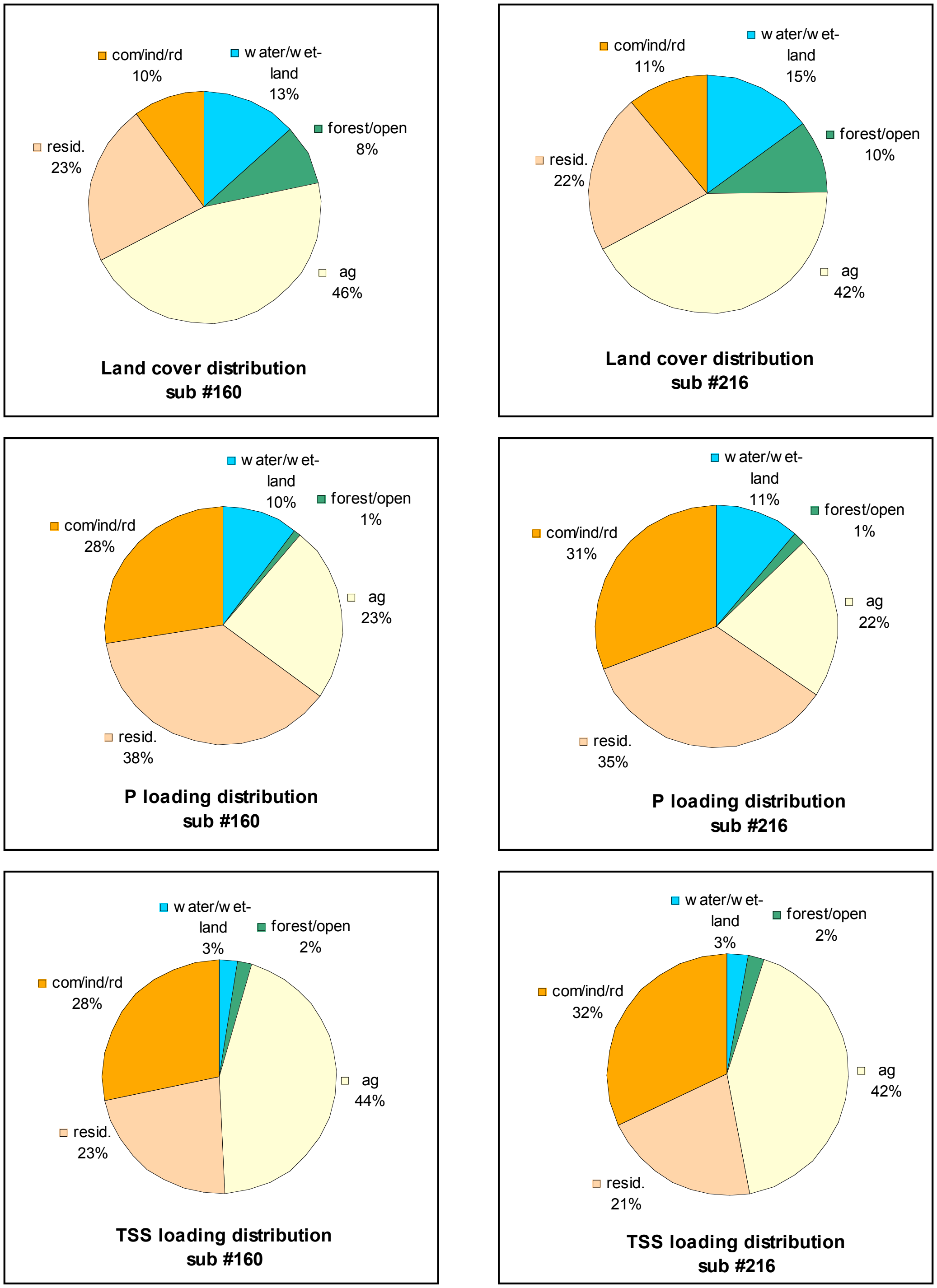

Figure 5 (cont'd): Land cover and TP and TSS loading distributions of subwatersheds in the Elkhart (Indiana) area.

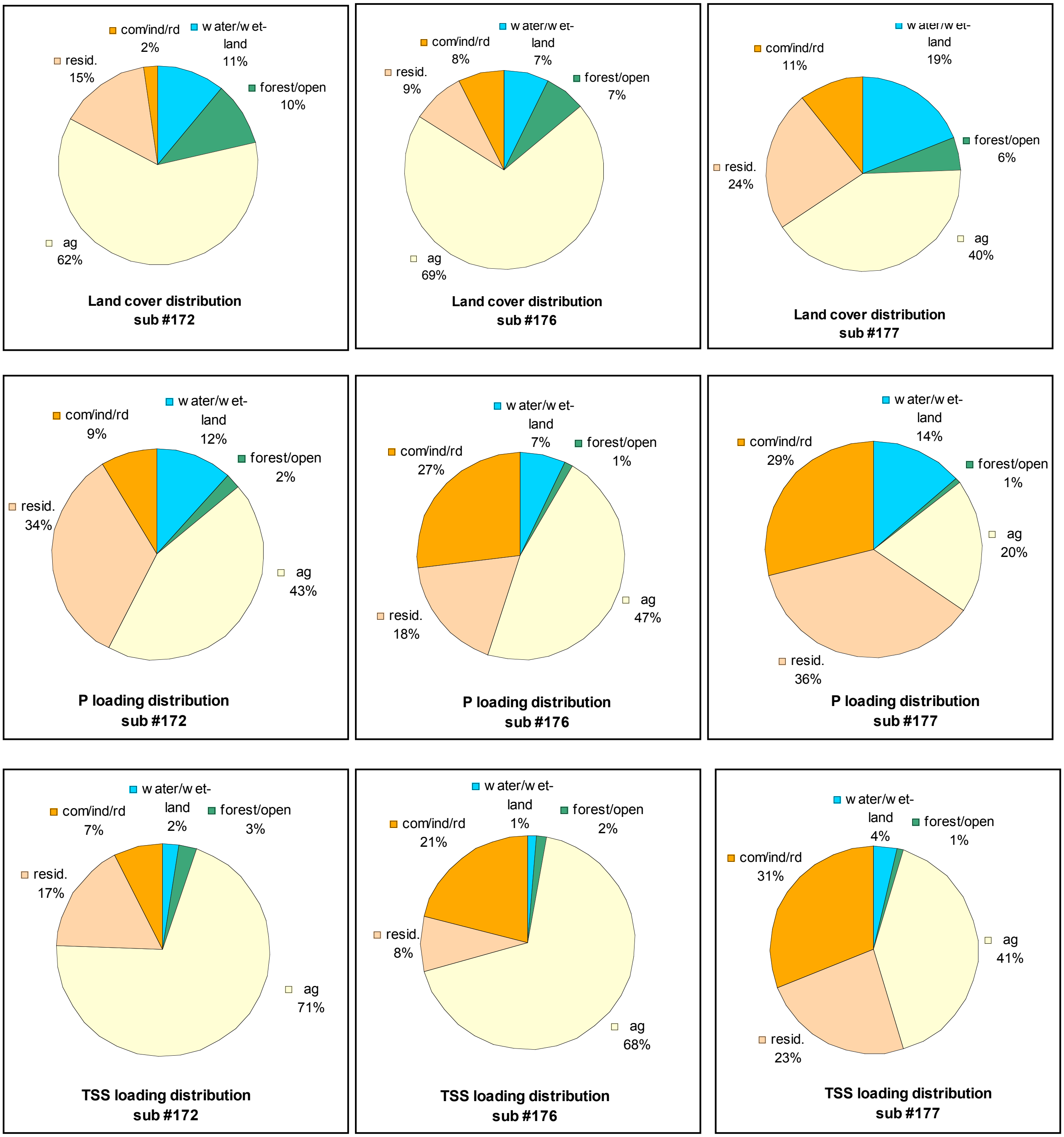

Figure 6: Land cover and TP and TSS loading distributions of subwatersheds in the Goshen (Indiana) area.

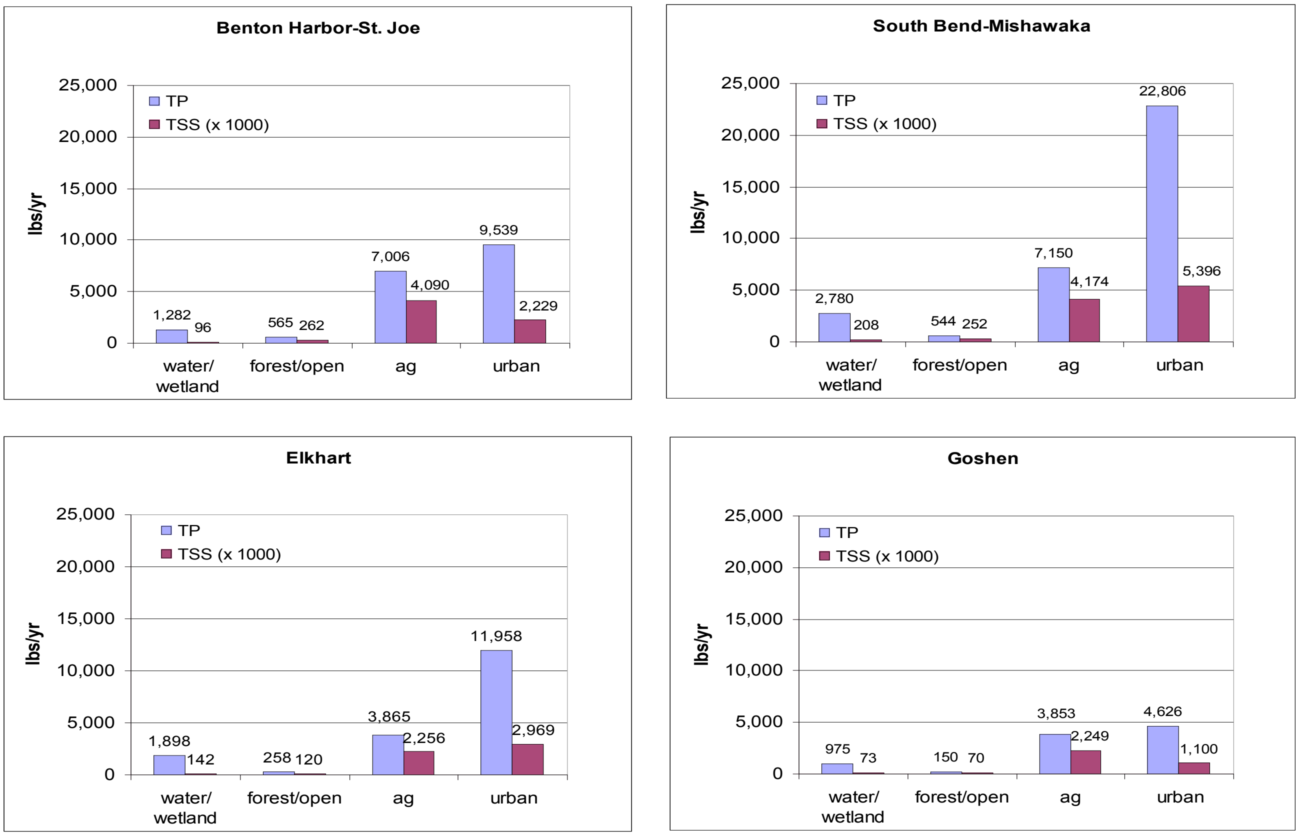

Figure 7: Total TP and TSS loadings from subwatersheds of the urban centers. (Note: TSS values shown in the graphs are in 1000 lbs.)

Compared to detention ponds, vegetated swales, at averages of $41/lb TP and $0.09/lb TSS, show a distinctly higher cost-effectiveness (Table 9) over stormwater ponds (Tables 7 and 8). Clearly, the lower per unit cost of constructing swales ($0.30/sq. ft. construction plus $0.02/sq. ft. maintenance) and comparable TP and TSS load reduction efficiencies (40% and 80% respectively) make this BMP an attractive option for high investment returns.

Cautions should be taken in using these per pound reduction cost values in the context of watershed pollutant load reduction planning, and particularly in comparison with other BMPs such as stormwater ponds. This is because of: 1) the uncertainties on the required size of vegetated swales (see the Methods section on Page 6 of this report); 2) the non-specific nature of the load reduction efficiency values used in this study (MI-ORR, 2002) [2]; and 3) the fact that vegetated swales are often used as a pretreatment or conveyance device for stormwater ponds in stormwater management designs, indicating the intermediate nature of vegetated swales as a stormwater BMP. Moreover, swales require additional right of way and therefore are not always practical in and of themselves as a primary stormwater treatment strategy. They also have limited capabilities for recharge. The ability to construct ponds in select areas as regionalized treatment devices, a smaller overall footprint and groundwater recharge capabilities, make ponds attractive in many instances especially considering their effectiveness for pollutant and hydraulic mitigation. A treatment train combining these options can also be considered.

[2] Load reductions by swales very much on the conditions and properties of underlying soils. The efficiency values quoted in the Michigan's Water Quality Trading Rule (MI-ORR, 2002) do not specify the applicability of these efficiency values with respect to soil types.

Table 7: Wet retention pond pollutant treatment costs with a 50% treatment coverage of urban lands.

Subwatershed			Pond volume	Area [1]	TP load reduction	TSS load reduction	Capital cost [2]	30-year annualized cost [3]	TP load reduction cost	TSS load reduction cost
Urban center	Watershed number	Watershed name	ft^3	acre	lbs/yr	lbs/yr	$	$/yr	$/lbs/yr	$/lbs/yr
Benton Harbor – St. Joseph	32	Paw Paw River	6,237,599	28.6	1,779	445,141	6,081,659	514,526	289	1.16
	36	St. Joseph River at Lake Michigan	3,169,786	14.6	965	216,546	3,090,542	261,469	271	1.21
	87	Hickory Creek	4,995,635	22.9	1,548	341,339	4,870,744	412,079	266	1.21
South Bend – Mishawaka	138	Juday Creek	8,323,977	38.2	2,232	495,006	8,115,878	686,627	308	1.39
	145	St. Joseph River – Willow Creek	5,361,441	24.6	1,324	328,239	5,227,405	442,254	334	1.35
	146	St. Joseph River – Airport	8,761,103	40.2	2,372	595,380	8,542,075	722,685	305	1.21
	167	St. Joseph River – Auten Ditch	11,408,686	52.4	3,004	710,156	11,123,469	941,078	313	1.33
	217	St. Joseph River – Eller Ditch	5,177,420	23.8	1,331	299,408	5,047,985	427,074	321	1.43
Elkhart	134	Peterbaugh Creek	1,836,623	8.4	449	108,171	1,790,707	151,499	337	1.40
	136	Christiana Creek	1,603,040	7.4	381	98,014	1,562,964	132,231	347	1.35
	150	St. Joseph River – Elkhart West	9,629,349	44.2	2,279	580,961	9,388,615	794,305	348	1.37
	160	Elkhart River	3,874,136	17.8	939	223,757	3,777,283	319,569	340	1.43
	216	St. Joseph River – Osola Township Ditch	5,482,251	25.2	1,332	325,266	5,345,195	452,219	339	1.39
Goshen	172	Elkhart River – Leedy Ditch	2,791,213	12.8	717	150,690	2,721,433	230,241	321	1.53
	176	Rock Run Creek	3,561,994	16.4	800	208,886	3,472,945	293,821	367	1.41
	177	Elkhart River – Goshen	2,288,696	10.5	564	135,625	2,231,478	188,790	335	1.39
Total/Average	--	--	*84,502,950*	*388.0*	*22,018*	*5,262,586*	*82,390,377*	*6,970,470*	*325*	*1.32*

[1] Ponds are assumed to have an average depth of 5 feet.
[2] Construction cost + design and permits.
[3] Assuming a 5% interest rate and including a $4,152/acre/year maintenance cost.

Table 8: Dry detention pond pollutant treatment costs with a 50% treatment coverage of urban lands.

Subwatershed			Pond volume	Area [1]	TP load reduction	TSS load reduction	Capital cost [2]	30-year annualized cost [3]	TP load reduction cost	TSS load reduction cost
Urban center	Watershed number	Watershed name	ft^3	acre	lbs/yr	lbs/yr	$	$/yr	$/lbs/yr	$/lbs/yr
Benton Harbor – St. Joseph	32	Paw Paw River	6,237,599	28.6	593	247,300	4,865,327	316,496	734	1.76
	36	St. Joseph River at Lake Michigan	3,169,786	14.6	322	120,303	2,472,433	160,835	688	1.84
	87	Hickory Creek	4,995,635	22.9	516	189,633	3,896,596	253,478	676	1.84
South Bend – Mishawaka	138	Juday Creek	8,323,977	38.2	744	275,004	6,492,702	422,358	781	2.11
	145	St. Joseph River – Willow Creek	5,361,441	24.6	441	182,355	4,181,924	272,039	848	2.05
	146	St. Joseph River – Airport	8,761,103	40.2	791	330,767	6,833,660	444,538	773	1.85
	167	St. Joseph River – Auten Ditch	11,408,686	52.4	1,001	394,531	8,898,775	578,876	795	2.02
	217	St. Joseph River – Eller Ditch	5,177,420	23.8	444	166,338	4,038,388	262,702	815	2.17
Elkhart	134	Peterbaugh Creek	1,836,623	8.4	150	60,095	1,432,566	93,190	856	2.13
	136	Christiana Creek	1,603,040	7.4	127	54,452	1,250,371	81,338	880	2.05
	150	St. Joseph River – Elkhart West	9,629,349	44.2	760	322,756	7,510,892	488,593	885	2.08
	160	Elkhart River	3,874,136	17.8	313	124,310	3,021,826	196,574	864	2.18
	216	St. Joseph River – Osola Township Ditch	5,482,251	25.2	444	180,703	4,276,156	278,169	862	2.12
Goshen	172	Elkhart River – Leedy Ditch	2,791,213	12.8	239	83,717	2,177,146	141,626	815	2.33
	176	Rock Run Creek	3,561,994	16.4	267	116,048	2,778,356	180,735	932	2.14
	177	Elkhart River – Goshen	2,288,696	10.5	188	75,347	1,785,183	116,128	849	2.12
Total/Average	--	--	*84,502,950*	*388.0*	*7,339*	*2,923,659*	*65,912,301*	*4,287,676*	*804*	*2.02*

[1] Ponds are assumed to have an average depth of 5 feet.
[2] Construction cost + design and permits.
[3] Assuming a 5% interest rate and including a $4,152/acre/year maintenance cost.

Table 9: Vegetated swale pollutant treatment costs with a 50% treatment coverage of urban lands.

Subwatershed			Area [1]	TP load reduction	TSS load reduction	Capital cost [2]	30-year annualized cost [3]	TP load reduction cost	TSS load reduction cost
Urban center	Watershed number	Watershed name	acre	lbs/yr	lbs/yr	$	$/yr	$/lb/yr	$/lb/yr
Benton Harbor – St. Joseph	32	Paw Paw River	16.0	791	395,681	209,542	27,600	35	0.07
	36	St. Joseph River at Lake Michigan	9.6	429	192,485	124,989	16,463	38	0.09
	87	Hickory Creek	15.4	688	303,412	201,749	26,574	39	0.09
South Bend – Mishawaka	138	Juday Creek	25.5	992	440,006	333,580	43,939	44	0.10
	145	St. Joseph River – Willow Creek	14.0	588	291,768	182,642	24,057	41	0.08
	146	St. Joseph River – Airport	22.4	1,054	529,227	292,836	38,572	37	0.07
	167	St. Joseph River – Auten Ditch	32.0	1,335	631,250	417,813	55,034	41	0.09
	217	St. Joseph River – Eller Ditch	15.6	592	266,141	203,457	26,799	45	0.10
Elkhart	134	Peterbaugh Creek	5.0	200	96,152	65,510	8,629	43	0.09
	136	Christiana Creek	3.9	170	87,124	51,580	6,794	40	0.08
	150	St. Joseph River – Elkhart West	24.0	1,013	516,410	313,971	41,356	41	0.08
	160	Elkhart River	10.7	417	198,895	140,211	18,468	44	0.09
	216	St. Joseph River – Osola Township Ditch	14.6	592	289,125	191,288	25,196	43	0.09
Goshen	172	Elkhart River – Leedy Ditch	9.2	319	133,947	119,993	15,805	50	0.12
	176	Rock Run Creek	8.5	356	185,677	111,667	14,709	41	0.08
	177	Elkhart River – Goshen	6.3	251	120,556	81,810	10,776	43	0.09
Total/Average	--	--	*232.8*	*9,786*	*4,677,854*	*3,042,638*	*400,770*	*41*	*0.09*

[1] Total area of vegetated swales in the subwatershed. Assuming for every 5 acre of drainage area, an 8×200 sq ft swale is needed.
[2] Construction cost
[3] Assuming a 5% interest rate and including a $0.02/sq ft/yr maintenance cost.

Table 10: Rain garden pollutant treatment costs with a 10% treatment coverage of urban lands.

Subwatershed			Area [1]	TP load reduction	TSS load reduction	Capital cost [2]	30-year annualized cost [3]	TP load reduction cost	TSS load reduction cost
Urban center	Watershed number	Watershed name	acre	lbs/yr	lbs/yr	$	$/yr	$/lb/yr	$/lb/yr
Benton Harbor – St. Joseph	32	Paw Paw River	66.1	593	148,380	31,659,991	2,059,521	3,473	13.88
	36	St. Joseph River at Lake Michigan	31.8	322	72,182	15,217,750	989,933	3,078	13.71
	87	Hickory Creek	49.6	516	113,780	23,759,115	1,545,560	2,995	13.58
South Bend – Mishawaka	138	Juday Creek	82.9	744	165,002	39,710,284	2,583,203	3,471	15.66
	145	St. Joseph River – Willow Creek	56.5	441	109,413	27,093,664	1,762,476	3,995	16.11
	146	St. Joseph River – Airport	93.0	791	198,460	44,538,091	2,897,257	3,664	14.60
	167	St. Joseph River – Auten Ditch	117.5	1,001	236,719	56,280,075	3,661,088	3,657	15.47
	217	St. Joseph River – Eller Ditch	51.9	444	99,803	24,888,853	1,619,050	3,649	16.22
Elkhart	134	Peterbaugh Creek	19.1	150	36,057	9,142,676	594,742	3,970	16.49
	136	Christiana Creek	17.2	127	32,671	8,243,442	536,246	4,217	16.41
	150	St. Joseph River – Elkhart West	102.9	760	193,654	49,323,077	3,208,527	4,223	16.57
	160	Elkhart River	40.0	313	74,586	19,190,054	1,248,337	3,989	16.74
	216	St. Joseph River – Osola Township Ditch	57.4	444	108,422	27,490,894	1,788,316	4,028	16.49
Goshen	172	Elkhart River – Leedy Ditch	27.0	239	50,230	12,932,765	841,292	3,519	16.75
	176	Rock Run Creek	38.5	267	69,629	18,455,725	1,200,568	4,500	17.24
	177	Elkhart River – Goshen	23.8	188	45,208	11,384,842	740,598	3,937	16.38
Total/Average	--	--	*875.1*	*7,339*	*1,754,195*	*419,311,296*	*27,276,715*	*3,716*	*15.55*

[1] Total area of rain gardens in the subwatershed. Assuming rain garden area of 19% of the drainage area, which in turn is assumed to be 10% of impervious urban lands.
[2] Construction cost.
[3] Assuming a 5% interest rate.

Table 11: Constructed wetland treatment costs with a 50% treatment coverage of urban lands.

Subwatershed			Area [1]	TP load reduction	TSS load reduction	Capital cost [2]	30-year annualized cost [3]	TP load reduction cost	TSS load reduction cost
Urban center	Watershed number	Watershed name	acre	lbs/yr	lbs/yr	$	$/yr	$/lb/yr	$/lb/yr
Benton Harbor – St. Joseph	32	Paw Paw River	116	1,779	445,141	5,911,879	483,106	272	1.09
	36	St. Joseph River at Lake Michigan	56	965	216,546	2,841,615	232,211	241	1.07
	87	Hickory Creek	87	1,548	341,339	4,436,546	362,545	234	1.06
South Bend – Mishawaka	138	Juday Creek	145	2,232	495,006	7,415,113	605,947	271	1.22
	145	St. Joseph River – Willow Creek	99	1,324	328,239	5,059,208	413,428	312	1.26
	146	St. Joseph River – Airport	163	2,372	595,380	8,316,610	679,616	287	1.14
	167	St. Joseph River – Auten Ditch	206	3,004	710,156	10,509,195	858,789	286	1.21
	217	St. Joseph River – Eller Ditch	91	1,331	299,408	4,647,503	379,784	285	1.27
Elkhart	134	Peterbaugh Creek	33	449	108,171	1,707,215	139,510	310	1.29
	136	Christiana Creek	30	381	98,014	1,539,300	125,788	330	1.28
	150	St. Joseph River – Elkhart West	181	2,279	580,961	9,210,112	752,631	330	1.30
	160	Elkhart River	70	939	223,757	3,583,364	292,825	312	1.31
	216	St. Joseph River – Osola Township Ditch	101	1,332	325,266	5,133,383	419,489	315	1.29
Goshen	172	Elkhart River – Leedy Ditch	47	717	150,690	2,414,939	197,344	275	1.31
	176	Rock Run Creek	68	800	208,886	3,446,243	281,620	352	1.35
	177	Elkhart River – Goshen	42	564	135,625	2,125,895	173,724	308	1.28
Total/Average	--	--	*1,535*	*22,018*	*5,262,586*	*78,298,119*	*6,398,357*	*291*	*1.22*

[1] Total area of constructed wetlands in the subwatershed. Assuming constructed wetlands to have 10% of the impervious drainage area.
[2] Construction cost + design and permits.
[3] Assuming a 5% interest rate and including a $850 /acre/year maintenance cost.

Calculations for rain gardens suggest that this practice is very expensive (Table 10) compared with other BMPs (Tables 7-10). At an average per pound cost of $3,716 for TP and $15.55 for TSS, these values are several times higher than wet retention ponds and vegetated swales for TP, and hundreds of times higher for TSS. Only lowering the installation cost of rain gardens to $3/sq. ft.[3], can one bring down the per pound cost to $1,014 for TP and $4.24 for TSS. These costs still do not compare favorably with stormwater ponds and swales. This is a direct result of the high per square foot cost ($11) for rain gardens and the high surface area required (19% of the drainage area) for rain gardens to work properly. Moreover, it is assumed here that rain gardens will only be applied to 10% of the urban land cover. Typically, these are applied to individual properties making it difficult to achieve significant stormwater treatment benefits or broad scale adoption and implementation given the vast number of property owners required to construct such features.

Again, caution should be taken in interpreting these numbers, especially when comparing rain garden applications to other BMPs. The value of rain gardens goes well beyond treating stormwater runoff. Effective for source control, rain gardens also provide habitat to native plants and animals, enhance the aesthetics of urban lands, and raise the awareness of stormwater issues among the general public. Rain garden applications will be most effective with new construction. Retrofit requirements with existing infrastructure make it a difficult to sell this approach to an effective number of private landowners.

At $291/lb of TP and $1.22/lb of TSS, constructed wetlands (Table 11) show lower per pound cost values than wet retention ponds but much higher costs than vegetated swales. The differences between constructed wetlands and wet retention ponds mainly lie on the much lower maintenance cost for wetlands ($850/ac/yr compared to $4,152/ac/yr for wet retention ponds). On the other hand, wet retention ponds occupy a much smaller area (388 acres in total for all the subwatersheds) than constructed wetlands (1,535 acres) due to the greater depth of the ponds (up to 5 feet) vs. wetlands (<1 ft).

Because land purchase expenses were not considered in calculations for Tables 7 through 11, cost differences were not factored into the per pound costs. These two BMP applications show similar load reduction capabilities and comparable long-term (30 years) cost-effectiveness, however, additional land costs to accommodate the necessary footprint for wetlands must ultimately be a consideration for any stormwater treatment strategy.

General equations can be derived from the calculations that lead to the outputs in Tables 7 and 8 for the reduction capacity and cost of urban stormwater ponds for any area in the St. Joseph River Watershed. Due to the uncertainties involved in calculations for swales, rain gardens, and wetlands, equations for these BMPs are not presented in this report.

<u>Equation 1:</u> TP load reduction (lbs/yr):

$$(0.01864*A_L + 0.03175*A_H)*R*T\%*E_p\%$$

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[3] Assuming no professional assistance is needed for designing and constructing a rain garden. Only expenditure is for purchasing plants (http://natsci.edgewood.edu/wingra/management/raingardens/rain_build.htm).

where: A_L: Area of low intensity development (acre);
A_H: Area of high intensity development (acre);
R: Annual rainfall total (inch);
T%: Percent of urban area ($A_L + A_H$) treated; and
E_p%: TP load reduction efficiency of the stormwater pond (90% for wet retention ponds and 30% for dry detention ponds).

Equation 2: TSS load reduction (lbs/yr):

$$(3.4245*A_L + 9.9228*A_H)*R*T\%*E_s\%$$

where: E_s% is the TSS load reduction efficiency of the stormwater pond (90% for wet retention ponds and 50% for dry detention ponds).

Equation 3: Wet retention pond capital cost ($):[4]

$$9732.94*(0.1913*A_L + 0.4379*A_H)*T\%$$

Equation 4: Dry detention pond capital cost ($):[5]

$$7786.35*(0.1913*A_L + 0.4379*A_H)*T\%$$

Equation 5: Wet retention pond 30-year annualized unit TP reduction cost ($/lb/yr):[6]

$$\frac{823.44*(0.1913*A_L + 0.4379*A_H)}{(0.01864*A_L + 0.03175*A_H)*R*E_p\%}$$

Equation 6: Dry detention pond 30-year annualized unit TP reduction cost ($/lb/yr):[7]

$$\frac{696.81*(0.1913*A_L + 0.4379*A_H)}{(0.01864*A_L + 0.03175*A_H)*R*E_p\%}$$

Equation 7: Wet retention pond 30-year annualized unit TSS reduction cost ($/lb/yr):[8]

$$\frac{823.44*(0.1913*A_L + 0.4379*A_H)}{(3.4245*A_L + 9.9228*A_H)*R*E_s\%}$$

Equation 8: Dry detention pond 30-year annualized unit TSS reduction cost ($/lb/yr):[9]

[4] Construction cost + cost of design and permits.
[5] See Note 4.
[6] Assuming a 5% interest rate and an average pond depth of 5 feet, and including a $4,152/acre/year maintenance cost
[7] See Note 6.
[8] See Note 6.

$$\frac{696.81*(0.1913*A_L+0.4379*A_H)}{(3.4245*A_L+9.9228*A_H)*R*E_s\%}$$

These equations require five inputs that either are readily available (A_L, A_H, and R), can be assumed (T%) or are obtained from the literature (E_p or E_s). Therefore, these equations can be used to quickly determine the cost-effectiveness of stormwater ponds in removing urban TP and TSS loadings for any area in the St. Joseph River Watershed. It should be noted that these equations, their parameters and factors are based on the NPS model that was calibrated specifically for the St. Joseph River Watershed (K&A, 2003). Applying these equations to areas outside of the watershed may require calibration specific to the targeted geographic area.

Conclusions

This study shows that in the St. Joseph River watershed, urban storm runoff is a significant source of TP and TSS loads in subwatersheds with the substantial presence of urban landuses. It is important to control this source of loading when water quality in local waterways is to be improved. Among the five urban BMPs examined here (wet retention ponds, dry detention ponds, vegetated swales, rain gardens, and constructed wetlands), wet retention ponds and constructed wetlands provide the highest load reductions for TP and TSS while vegetative swales show the highest cost-effectiveness (lowest per pound cost of load reduction). Cautions should be taken, however, in interpreting these results due to the uncertainties in design parameters of vegetative swales and rain gardens.

This study has also provided some easy-to-use equations for calculating load reductions and cost-effectiveness of stormwater ponds. Overall, site-specific engineering will be required in all cases to effectively apply urban stormwater BMPs. Groundwater recharge and restored natural flow regimes should be the ultimate goal of any BMP strategy.

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[9] See Note 6.

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