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Land Planning and Development Mitigation for Protecting Water Quality in the Great Lakes System: An Evaluation of US Approaches

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**Land Planning and Development Mitigation
for Protecting Water Quality
in the Great Lakes System:
An Evaluation of US Approaches**

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1. Introduction to the Study

Evidence for the negative impacts of land alteration and urbanization on surface and subsurface water has been mounting since the early 1960's (Felton and Lull 1963; Antoine 1964; Espey, Morgan et al. 1966; Leopold 1968; Anderson 1970; Hammer 1972; Loehr 1974; Beard and Chang 1979). Concurrent with this early and growing interest in water quality impacts, the International Joint Commission (IJC) first looked at urbanization and its impact on the Great Lakes through the *Pollution from Land-Use Activities Reference Group* (PLUARG). Established in 1972, PLUARG focused on "land use water quality relationships" (International Reference Group on Great Lakes Pollution from Land Use Activities 1973). Their final report released in 1978 (International Joint Commission 1978) was consistent with the other leading scientific literature of the time and definitive in its finding that urbanization was a significant contributor to the water quality problems of the Great Lakes Basin (International Joint Commission 1978).

Subsequent studies by the IJC and others continued to identify urban land-use development as a major source of stress to the Great Lakes ecosystem. In 1996, the State of the Lakes Ecosystem Conference (SOLEC) documented extensive threats from non-point source pollution, particularly affecting lakes Michigan, Erie and Ontario (Thorp, Rivers et al. 1997). Since Annex 13 of the Great Lakes Water Quality Agreement (1989) was enacted to delineate programs and measures for the abatement and reduction of non-point sources of pollution from the alteration of land for human uses, it is particularly appropriate for the IJC to focus on these issues. However, studies continue to show increasing effects from non-point source pollution originating from urbanizing land uses. The key question for the IJC today, as an international commission with no direct enforcement power, is how the IJC can be effective in getting the parties and their jurisdictions to improve management of non-point source pollution issues when the land use trigger is primarily a local government issue.

To begin to answer this question, the primary objective of this current study is to assemble the latest data and analysis on the implementation of practical, efficient and effective land-based best management practices that minimize the impacts to Great Lakes water quality posed by urban and urbanizing development within the Great Lakes Basin. The focus of this report is two fold: first to analyze the current tools and techniques considered in the literature and practice to be stormwater best management practices that can act to mitigate the impact of urbanization on water quality. Secondly, given the status of the current understanding of watershed hydrology and the impacts of these best management practices, to answer two primary questions: 1) which tools and techniques, individually or in concert are the most effective in dealing with the water quality impacts of urban growth and development; and 2) what role can the IJC recommend for federal and state governments to play in the effort to support effective use of these tools in water quality planning and watershed development decisions.

2. Definitions

There is a considerable divergence in the literature regarding the common definitions of terms used in the field of watershed hydrology and stormwater best management practices.

This study uses the following terminology and definitions:

- Best Management Practice (BMP) – The literature tends to vacillate between defining a BMP as either any tool that can lead to improved watershed hydrology (Ellis and Marsalek 1996), or more commonly, limited to an engineered device that improves the quality or timing of stormwater flow (Center for Watershed Protection 1998; Strecker, Quigley et al. 2000). This report will use the comprehensive definition of the term: a device, practice, or method for removing, reducing, retarding, or preventing targeted stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters and/or a device, practice or method that maintains surface and subsurface flows as closely as possible to pre-development levels.
- Structural BMPs – engineered and bio-engineered solutions to managing stormwater; these are primarily used on a site-specific basis.
- Non-structural BMPs – primarily those BMPs that deal with tools to guide where to place development (Horner et al., 2002) or to modify actions on the part of people that may impact the watershed.
- Performance – a measure of how well a BMP meets its goals for protecting surface and subsurface water quality and quantity (Strecker, Quigley et al. 2000).
- Efficiency – a measure of how well a BMP achieves its goals of achieving pre-development levels (Strecker, Quigley et al. 2000).
- Impervious surface – any surface that will not allow rainwater to infiltrate into the soil. These are typically the roof and pavement surfaces of the built environment, however, they can also include soil which has been severely compacted.
- Pervious surface – any surface that entirely or partially absorbs rainwater into the soil and geological substrate.
- Infiltration: the process by which water, in the liquid form, enters the soil (Horton).
- Infiltration capacity: “the maximum rate at which rain can be absorbed by a given soil [or land cover] in a given condition” (Horton).

3. A Review of the Impacts of Urbanization on Surface Water Systems

Since the early 1960's numerous hydrologic studies have focused on the effects of urbanization on local hydrology (Carter 1961; Felton and Lull 1963; Antoine 1964; Espey, Morgan et al. 1966; Leopold 1968; Martens 1968; Brater and Sangal 1969; Anderson 1970; Stall, Terstriep et al. 1970; Hammer 1972; Yucel 1974; Hollis 1975; Beard and Chang 1979; Klein 1979). In the early years, most of these studies focused on the increase in intensity of runoff in urban areas, and its associated impairment of water quality (figure 1). To solve these problems, efforts at mitigation were focused on urban drainage, "with a single objective in mind - to provide hydraulically and economically effective transport of surface runoff from urban areas into local receiving waters and thereby to protect urban dwellers against flooding and provide for their convenience by controlling runoff ponding in urban areas" (Ellis and Marsalek 1996).

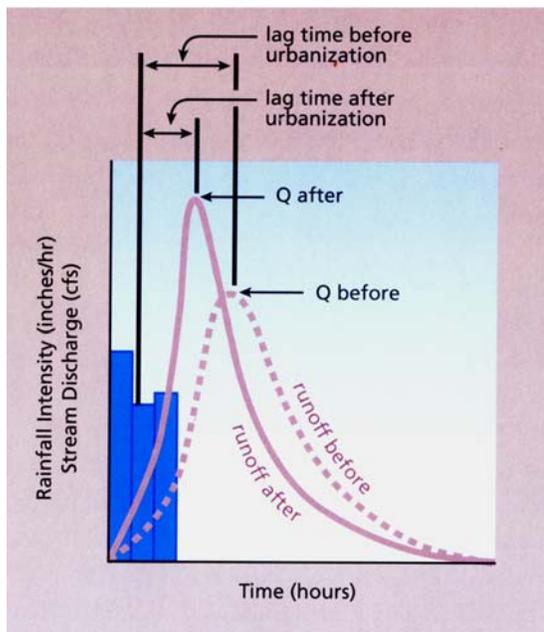


Figure 1: A comparison of hydrographs before and after urbanization. The discharge curve is higher and steeper for urban streams than for natural streams. (Federal Interagency Stream Restoration Working Group 1998)

This early concern for flooding and pollutants led to a focus on streams and other surface waters, particularly their water quality and morphological changes (table 1). The changes to

streams, wetlands, and ponds were found to be devastating to habitat, and freshwater ecosystems were found to decline in urban areas (Wydzga 1997). Various researchers found that runoff from sites of intensive human use was often heavily polluted with nutrients (Weibel 1969; Omernik 1977), oxygen-demanding organics (Weibel, Anderson et al. 1964; Keefer, Simons et al. 1979), suspended solids (Fusillo, Nieswand et al. 1977; Manning, Sullivan et al. 1977), petroleum products, or other toxicants (Bryan 1974; McConnell 1980)" (Scott, Steward et al. 1986). Others focused on the physical impacts on streams, particularly after high levels of urbanization (Yoder, Miltner et al.; MacRae 1997): "Incision represents a loss of geomorphic balance between the forces of downcutting (the moving water) and the resistance of the stream bed to erosion (determined by sediment size, channel roughness, and the action of anchoring debris). Urban development influences two of these factors: the magnitude of flows and the persistence of wood in the channel" (Booth 1991).

Table 1: Impacts and stresses on surface water caused by urbanization.

Category	Impact
Stream hydrology	Increased magnitude & frequency of floods Increased frequency of erosive bankfull floods More annual runoff volume as stormflow Less annual runoff volume as baseflow More rapid stream water velocities
Channel morphology	Channel widening & down cutting Greater streambank erosion Shifting bars of coarse-grained sediments Stream channelization & relocation Trash and debris jams
Water quality	Sediment pulse during construction Nutrient enrichment and algae growth Bacterial contamination Greater organic and hydrocarbon loads Higher trace metals levels Stream temperature
Ecology and habitat	Reduction in diversity of fish & aquatic insects Creation of linear barriers to fish migration Destruction of wetlands, riparian buffers, and springs

3.1 The Impervious Portion of the Watershed Equation

The focus on stream hydrology, morphology and water quality led to the identification of impervious surface in the urbanizing watershed as a key variable in, and indicator of, watershed

health (Espey, Morgan et al. 1966; Stankowski 1972). It was noted in the early research that there were two sides to the impervious surface equation: increasing urbanization resulted in increased amounts of impervious surfaces – roads, parking lots, roof tops, etc. – and a decrease in the amount of forested lands, wetlands and other forms of open space which absorb and clean stormwater in the natural system (Leopold 1968; Carter 1961). This change in the impervious-pervious surface balance was understood to cause significant changes to both the quality and quantity of the stormwater runoff, leading to degraded stream and watershed systems: an increased quantity of stormwater for stream systems to absorb, sedimentation, and an increased pollutant load carried by the stormwater (Morisawa and LaFlure 1979; Arnold, Boison et al. 1982; Bannerman, Owens et al. 1993). However, later research, particularly previously published summaries of the relationship between imperviousness and water quality, focused on the importance of impervious surface to the exclusion of pervious areas (Griffin, Grizzard et al. 1980; Harbor 1994; Arnold and Gibbons 1996).

Although many studies cited the link between imperviousness and water quality, the most widely cited report in the literature that linked the level of impervious surface to water quality was completed in 1995 (Schueler 1995). That report compiled the results of 11 previous studies (Klein 1979; Steward 1983; Jones and Clark 1987; Steedman 1988; Galli 1990; Limburg and Schmidt 1990; Booth 1991; Schueler and Galli 1992; Luchetti and Fuersteburg 1993; Taylor 1993; Shaver, Maxted et al. 1995) published before 1995, citing them as evidence that stream quality declined at 10 to 15% imperviousness. The primary drawback of both the compiling summary and the underlying studies is that they often equate urbanization with imperviousness. In doing so, they do not make a clear distinction between the area of urbanization as a whole and the actual amount of impervious surface that any particular type of urban land cover creates (Brabec, Schulte et al. 2002).

Therefore, although considerable study has been given to understanding the sources and fluxes of nutrients from individual watersheds (Schueler 1995), and the ratio of total imperviousness has been shown to be a key parameter in stormwater runoff models (Graham, Costello et al. 1974), comparatively little work has been undertaken to see how watersheds have changed in land cover over time and what effect these changes have had on the surface and subsurface watershed system (Osborne and Wiley 1988; Richards and Host 1994).

The scientific basis for the relationship between land use and the amount of impervious surface it creates was developed in the field of urban hydrology beginning in the 1970's. In the early research, imperviousness was evaluated four ways: 1) direct measurement: identifying impervious areas on aerial photography and then using a planimeter to measure their area (Graham, Costello et al. 1974; Stafford, Ligon et al. 1974); 2) sampling: overlaying a grid on an aerial photograph and counting the number of intersections that overlaid a variety of land uses or impervious features (Martens 1968; Hammer 1972; Gluck and McCuen 1975; Ragan and Jackson 1975); 3) land use classes: supervised classification of remotely sensed images (Ragan and Jackson 1975; Ragan and Jackson 1980); and 4) proxy or indicator uses: the percentage of

urbanization in a region as a proxy for percentage of imperviousness (Morisawa and LaFlure 1979). The majority of current impervious surface studies rely on the methods and findings of these original and subsequent studies. Currently, the majority of studies correlate impervious surface in a region to the area covered by a series of land use classes. The percent impervious surface of each land use is most often determined through a reliance on past studies that either employed direct measurement or used an estimate (see Table 2).

Table 2: Measurements of imperviousness ratios for land uses in various studies.

TIA/EIA	methodology	# of land use classes	Study
Direct Measurement			
TIA	aerial photos and field survey	17	(Hammer 1972)
		6	(Alley and Veenhuis 1983)
		10	(Rouge Program Office 1994)
EIA	measured from topographic maps	6	(Krug and Goddard 1986)
	from aerials but no clear methodology stated	10	(Natural Resources Conservation Service 1986)
	field survey	10	(Rouge Program Office 1994)
Estimates			
TIA	typical impervious area ratios	not indicated	(Booth and Jackson 1994)
		27	(Chin 1996)
		27	(Taylor 1993)
	County Land use maps and coefficients from SCS, 1975 and Graham et al., 1974	not indicated	(Klein 1979)
	Land use from digitized data and impervious estimates from USDA, 1986	not indicated	(Maxted and Shaver 1998)
	Not clear, suggested use of GIS land use classification and impervious coefficients	not indicated	(May, Horner et al. 1997)
	GIS derived land use intensity maps	9	(Hicks and Larson 1997)

	based on urbanization	not indicated	(Booth and Reinelt 1993)
	Urbanized areas from aerials and ratio of imperviousness of 30-50% from literature	not indicated	(Todd, Bedient et al. 1989)
TIA	Land use and ratio defined by Taylor, 1993	7	(Wydzga 1997)
	not indicated	8	(Galli 1990)
		not indicated	(Griffin, Grizzard et al.
		not indicated	(Horner, Booth et al. 1997)
not indicated	(Shaver, Maxted et al. 1995)		
EIA	Land use and ratio of estimated imperviousness from previous study	5	(Wang, Lyons et al.)
urbanization			
% urbanization	USGS land use classifications	not indicated	(Limburg and Schmidt 1990)
	land use /land cover	not indicated	(Wang, Lyons et al. 1997)
	satellite imagery	not indicated	(Miltner 1997)
		not indicated	(Yoder, Miltner et al.)
	unidentified	not indicated	(MacRae 1997)
Other measures			
housing density	census data	not indicated	(Miltner 1997)
population densities	census data	not indicated	(Jones and Clark 1987)

There are three major problems with this approach. First, the original data showed considerable variation of imperviousness within the same land cover class, indicating in many cases that the classes were too inclusive to provide accurate results when applying these ratios at the watershed level. For example, results from two studies show that values for a single commercial class (table 3) range between 66 and 98 and 52 and 90 percent imperviousness respectively. Second, imperviousness has been shown to vary considerably with lot size. For example, within a particular land use type, such as residential use, increasing lot size correlates with decreasing imperviousness on a site specific level. However, the percent imperviousness per capita at the watershed level increases due to the increased road length required to access each site. Thirdly, the base studies from which the impervious surface percentages were drawn for use in current studies were developed in east coast urban areas during the seventies and early

eighties: demographic and land use patterns have changed considerably since that time, with both
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homes and driveways of single family homes in new suburbs increasing significantly in size. Therefore it is critical to the accuracy of impervious data and watershed studies that local data is developed and field checked using a large number of land use classes, particularly in the residential category.

Table 3: Percent imperviousness for various land cover classes as calculated directly from aerial photo and map analysis.

Land Cover Class	Notes	% Imperviousness		Reference
		Mean	Range	
Single-Family Residential	<0.25 acre lots	39	30-49	(Alley and Veenhuis 1983)
	0.25-0.5 acre lots	26	22-31	(Alley and Veenhuis 1983)
	0.5-1.0 acre lots	15	13-16	(Alley and Veenhuis 1983)
	Includes multi-family residential	30	22-44	(Sullivan, Hurst et al. 1978)
Multiple-Family Residential		66	53-64	(Alley and Veenhuis 1983)
Commercial		88	66-98	(Alley and Veenhuis 1983)
		81	52-90	(Sullivan, Hurst et al. 1978)
Industrial		60	-	(Alley and Veenhuis 1983)
		40	11-57	(Sullivan, Hurst et al. 1978)

3.2 Total Impervious Area (TIA) vs. Effective Impervious Area (EIA)

One attempt to refine imperviousness as a causal mechanism was proposed by Alley and Veenhuis (1983), who classified anthropogenic imperviousness features into two kinds of imperviousness, *directly-connected* and *unconnected*. *Directly-connected* imperviousness, also called effective imperviousness (EIA) is imperviousness that is hydrologically connected to anthropogenic features (storm sewers, gutters, ditches, etc.) which drain directly into streams. This type of imperviousness moves large quantities of runoff rapidly to the stream, reducing the opportunity for infiltration and evaporation. *Unconnected* impervious areas are patches of imperviousness that are adjacent pervious areas where runoff may infiltrate into the ground. Most watershed studies lump unconnected impervious areas together with connected areas under a term called total impervious area (TIA) (see table 2) (Brabec, Schulte et al. 2002).

Classification of imperviousness into the discrete categories of *directly-connected* and *unconnected* is difficult in practice, because even if an impervious feature has a direct hydrologic connection to the stream, the entire area of the feature is not always drained in every storm. Conversely, although unconnected impervious areas may have the opportunity to infiltrate, this infiltration may be imperfect. Due to the infiltration capacity of the soil and the runoff will overflow the catchment and enter the stream system. Runoff from impervious areas that are not directly connected to surface water bodies, has the opportunity to infiltrate into the soil profile to

saturation of the soil, compaction of the soil, and the rate of infiltration of that particular soil type.

Many studies of urban hydrology (Cherkaver 1975; Beard and Chang 1979; Alley, Dawdy et al. 1980; Driver and Troutman 1989) show that total impervious area (TIA), while correlating with changes in runoff, does not impact runoff as much as effective impervious area (EIA), the proportion of imperviousness that is directly connected to the stream network. Areas of effective impervious surface are extremely important to the hydrologic profile of a watershed since "Historically, urban drainage was designed with a single objective in mind - to provide hydraulically and economically effective transport of surface runoff from urban areas into local receiving waters and thereby to protect urban dwellers against flooding and provide for their convenience by controlling runoff ponding in urban areas" (Ellis and Marsalek 1996). These connections allow the direct flow of pollutants into surface water systems, and do not provide for cleansing of the runoff.

As discussed in the previous section, to determine total percent impervious area for the watershed, TIA is generally estimated based on land use type, and estimations for each land use are then calculated in proportion to the amount of that land use in the watershed. Effective impervious area (EIA), those surfaces that directly drain to surface water bodies can be measured directly through an overlay of the stormwater system on the watershed, however all of the studies reviewed except two (Krug and Goddard 1986; Rouge Program Office 1994), estimated the effective impervious area based on total impervious area percentages.

The majority of the studies reviewed do not distinguish between effective imperviousness and total impervious areas in their threshold analyses (see table 2). Although the methods of quantifying impervious area vary, the water quality results converge rather consistently. This may be attributed to the accuracy of the estimates; however it is more likely the result of the similarity and error in methods for estimating both EIA and TIA. While the methods for estimating both TIA and EIA have been difficult in the past (Booth and Jackson 1997), the problem of direct measurement has been largely resolved with the prevalence of Geographical Information Systems in planning use, and the increasing availability of digital mapping of both land use, ortho-photo aerials, and digitized storm sewer systems. Using TIA instead of EIA, or not distinguishing between the two in hydrologic models that assess impervious threshold cause a series of problems in the analysis of the results: 1) runoff volumes and peak flows may be largely overestimated; 2) the simulated changes in runoff due to increasing intensity of land use may be smaller if TIA is used; and 3) infiltration rates are likely to be overestimated (Alley and Veenhuis 1983).

This understanding of the systems focuses on the impact of directly-connected imperviousness. However, the effects of unconnected impervious areas may be equally severe. These impacts go beyond the additional storm flows, and include a variety of interconnected effects such as reduced evapo-transpiration from the loss of vegetative cover and the concentration of the majority of infiltration along narrow linear zones on the boundaries of the imperviousness features. For example, in the case of runoff from roof gutters and down spouts,

water delivery and therefore infiltration is focused into very small zones at the end of the down

spouts. As the proportion of imperviousness to perviousness increases in the watershed, the effective size of the precipitation event increases, and rainwater is forced to infiltrate over a smaller area. This could lead to an increase in recharge, if the flux of water into these areas exceeds the available water-holding capacity.

3.3 Infiltration and Evapotranspiration

As stated previously, most of the research efforts to date have focused on the morphological stream impacts of urbanization and land use change, using impervious surface as a key indicator (Hollis 1975; Klein 1979; Horner, Booth et al. 1997). While the changes to the riparian systems caused by the increasing flashiness due to impervious surfaces were devastating to the ecology and morphology of surface water bodies studies (Omernik 1976; May, Horner et al. 1997; Moscrip and Montgomery 1997), they did not acknowledge the full extent of the impacts, and therefore the full impacts of urbanization on the hydrological system (Krug and Goddard 1986). While urbanization increased stormwater runoff and decreased the lag time of stormwater discharge, there was a resulting lack of infiltration and reduction in evapotranspiration that is an essential part of any vegetative ecosystem (figures 2 and 3).

The alteration of these essential exchange processes (Brunke and Gonser 1997) in the hydrologic system can be severe. "After precipitation has been deflected from infiltration and recharge by impervious surfaces, and infiltrated water in the subsurface reduced by evapotranspiration, there is no possible amelioration of declining low flows; the water to support base flows is no longer available in the watershed (Ferguson and Suckling 1990)." Equally important is the presence of moisture in the upper two feet of soil that is available for plant uptake and evapotranspiration. If absent, and evapotranspiration is decreased, the result could be a troubling trend of increasing desertification.

A study in Nassau County found that base flow was reduced "to about 20 percent of total stream flow by (1) sanitary sewerage and the discharge of the resulting treated effluent to tidewater, (2) the routing of stormwater runoff directly to streams through storm sewers, and (3) the decrease in infiltration of precipitation as a result of the reduction in permeable area. In an adjacent urbanized but unsewered area, base flow has been reduced to about 84 percent of total stream flow by storm sewerage, reduced permeable area, and the effects of lowered ground-water levels in the adjacent sewerage area." (Simmons and Reynolds 1982)

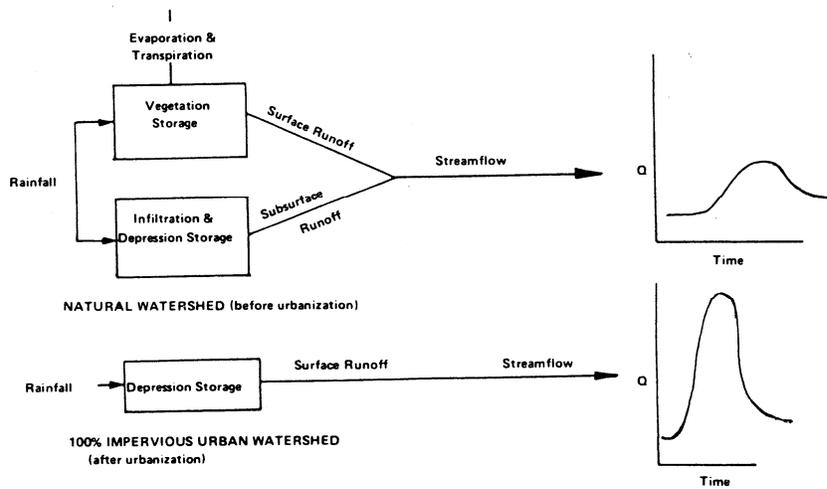


Figure 2: Comparison of natural and urban watersheds. (Lazaro 1990)

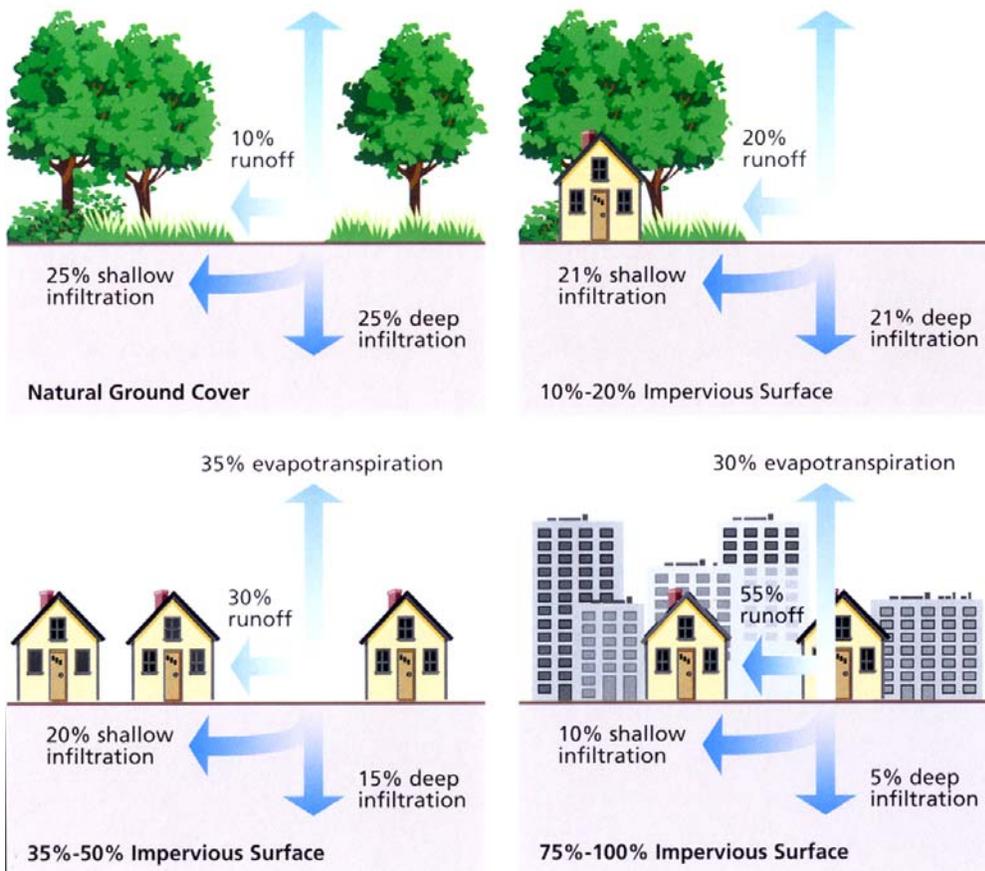


Figure 3: Relationship between impervious cover and surface runoff. Impervious cover in a

watershed results in increased surface runoff. As little as 10 percent impervious cover in a

watershed can result in stream degradation (Federal Interagency Stream Restoration Working Group 1998).

A recent study conducted in the Rouge River Basin of Michigan (Richards and Brabec 2004), focused on the link between connected and unconnected imperviousness. The results of this study indicated, first, that all roads, driveways and commercial and industrial imperviousness features were directly-connected to surface water bodies, even within internally drained portions of the watershed. This emphasizes the importance of focusing on the transportation network in designing environmentally friendly development. Watershed-wide, directly-connected imperviousness was found to have risen in the watershed from 1.8% to 14.2%, while unconnected imperviousness increased from 0.4% to 7.5%. Since the study region was a rural watershed in 1950 and became a highly urbanized watershed by 1999, the findings underscored the magnitude of the increase of directly-connected imperviousness in urbanized areas. The results also confirmed that storm sewers increased the effective size of the watershed under study, crossing sub-watershed boundaries.

Results from the hydrologic analysis of this study also indicated that the hydrologic efficiency of this watershed in both surface runoff and baseflow had increased over time. While the former is to be expected, the long term increase in baseflow is unexpected and does not support the common notion that urban development reduces recharge. Changes in actual evaporation caused by imperviousness may be partly responsible for this increase in baseflow. Another mechanism for increasing the efficiency of groundwater recharge as found in the study, is the change in infiltration flow-paths caused by the rerouting of water to the edge of unconnected impervious features, resulting in increased infiltration.



4. *The Importance of Planning*

To date a focus on the mitigation of degraded water quality and increased flashiness has led to an emphasis on the engineering solutions to achieve those results (Federal Interagency Stream Restoration Working Group 1998; US Environmental Protection Agency 1999(a)). Currently, federal, state, and NGO educational efforts and local government planning responses discuss primarily traditional engineering and site-specific BMPs, and avoid the large-scale planning BMPs. Even in those documents which do cross the planning “line,” efforts tend to focus on site level planning principles and avoid regional approaches to protecting water quality at the catchment or watershed level.

Discussions of catchment and watershed level planning are not new in the literature. For example, Marsh, in his textbook on Landscape Planning written in 1983, addresses the importance of planning the entire catchment (Marsh 1983). However even this framework for planning misses an important distinction: as the zones of the catchment are defined in Marsh’s work, only the riparian area and the immediate buffer zone surrounding the riparian area are targeted for protection from development. This approach ignores the importance of upland areas in the hydrologic system.

While the value of imperviousness as an indicator in water-quality planning has had significant support in the literature, the implications and thresholds for land use decision making are much more complex than reliance on a specific impervious surface threshold. An analysis of the existing literature and its application to planning negate an attempt to define the impacts and potential mitigation of the hydrologic system simplistically:

- a) while the determination of a threshold of watershed imperviousness is commonly applied to watershed planning, it is not the only or perhaps even the most important watershed variable;
- b) engineered and site-level mitigation efforts such as detention ponds and riparian buffers have limits to their effectiveness; arguing for a more comprehensive approach to watershed mitigation efforts;
- c) woodland cover and other pervious land uses are critical to the pervious/impervious equation and the balance of evapotranspiration, infiltration and base flow, and finally, perhaps the most comprehensive issue,
- d) the location of impervious surfaces in a watershed can have significant impacts on water quality and the hydrological system.

Research has identified many factors that contribute to the quality of a stream and how it is affected by impervious surfaces. At a basic level, stream hydrology and function are dependent on five variables: climate, geology, soils, land use, and vegetation (Morisawa and LaFlure 1979). These “first order” variables directly impact the “second order” factors of discharge, baseflow, and sediment load which in turn impact the hydrology and morphology of the stream. Of these variables, land use and vegetation are the only variables over which man has direct control, underscoring their primary significance in the land use planning process.

Indeed, (Booth and Jackson 1997) identify changes in upland land use as critical in determining
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overall stream function, degradation, and rehabilitation potential, finding that even with best efforts at mitigation some downstream aquatic system damage is probably inevitable without limiting the extent of watershed development itself.

It is this change in the hydrologic system that is critical in land use planning for watershed health. While the primary tools available for assessing land use related changes in watersheds are hydrological models such as the USDA TR55 (Natural Resources Conservation Service 1986) EPA SWMM (Bedient and Huber 1992); U.S Army Corps of Engineers STORM and HEC-1 (Harbor 1994), these models focus primarily on the changes to stream morphology caused by the “second order” factor of discharge, the increasing quantity of water the system must absorb. In addition to the limitations of their focus, the hydrologic models are rarely used in the land use planning process due to their complexity and high cost of accumulating data (Harbor 1994).

4.1 The Impacts of Impervious Surface Location Within a Watershed

Although there have been a variety of researchers that have acknowledged the importance of impervious surface location within a watershed (Weaver and Garman 1994; Allan, Erickson et al. 1997; Johnson and Gage 1997; Wang, Lyons et al. 2001), there has been surprisingly little quantitative research published on this issue. The placement of impervious surface within a watershed appears to be of some importance to stream quality (Carignan and Steedman 2000), although few quantitative relationships have been made in the literature between percent impervious surface, placement, and stream quality. The placement of impervious surface determines a number of changes in stream functioning including speed with which flow enters the stream and possible absorption by pervious surfaces.

The placement of impervious surface along the stream course may be the largest contributing factor in stream degradation or health. In general, upstream impacts will create disturbances over more stream miles while downstream disturbances will create more concentrated impacts (Maxted and Shaver 1998). Booth (Booth 1990) concluded that increased sediment from streambank erosion occurs especially when the upper watershed is paved.

The location of impervious surface within the watershed is of some importance to stream quality as well, though again its significance may well change if impervious areas are serviced with storm sewers. A study in Michigan (Roth, Allan et al. 1996) found that “local riparian vegetation was a weak secondary predictor of stream integrity” while regional land use was the primary determinant of stream conditions, even “able to overwhelm the ability of local site vegetation to support high-quality habitat and biotic communities.” When analyzing the effects of dispersed impervious surface compared to clustered development, higher sediment yields were measured in areas with dispersed impervious surface, however the spatial characteristics of the impervious area did not affect runoff volumes, only flow rates and associated sediment loads (Corbett, Wahl et al. 1997). Conversely, another study (Yoder and Rankin 1997) found that biological performance was good even with urbanization as high as 15% if the site was

developed with estate-type residences.

The distance between impervious cover and the stream channel appears to be one of the most important factors regarding placement, particularly for areas in which runoff is not piped directly to the stream. Impervious cover further away from the stream resulted in less channel enlargement in watersheds near Philadelphia (Hammer 1972). Another study found that nutrient concentrations changed significantly in relation to land use within 150 meters of streams in South Carolina, however beyond this point land use change did not significantly effect nutrient concentrations (Tufford, McKellar et al. 1998). In an assessment of Ontario area streams, found land uses in an area of 10 to 100km² above the site of interest were more important to biotic integrity than the land uses within the entire basin (Steedman 1988). These findings correlate well with the buffer findings discussed later in this report, since imperviousness placed further from the stream will have less impact on the hydrologic system simply by virtue of not destroying the buffer.

Although the research on watershed –wide locational impacts is relatively sparse, the findings have been supportive of increased reliance on planning to reduce the hydrologic impacts of development (Booth and Jackson 1997; Lammert and Allan 1999; Wang, Lyons et al. 2001). Both the type of land use as well as the intensity and location of the use have an impact on watershed hydrology (Booth and Jackson 1997; May, Horner et al. 1997; Wang, Lyons et al. 2001) For example, studies have found:

“Total phosphorus and total suspended solids were much better explained by land use within the stream ecotone in summer than in other seasons. However, total nitrogen, nitrate, orthophosphate and alkalinity were equally well explained by land use within the ecotone and throughout the whole catchment. Only total dissolved solids in summer and ammonium in autumn were explained better by the whole catchment than the ecotone.” (Johnson, Richards et al. 1997)

"Local riparian vegetation is a weak secondary predictor of stream integrity. In this watershed, regional land use is the primary determinant of stream conditions, able to overwhelm the ability of local site vegetation to support high-quality habitat and biotic communities (141)." (Roth, Allan et al. 1996)

"Habitat quality and index of biotic integrity (IBI) scores were significantly positively correlated with the amount of forested land and negatively correlated with the amount of agricultural land in the entire watershed and in a 100-m-wide buffer along the stream. Correlations were generally stronger for the entire watershed than for the buffer." (6) (Wang, Lyons et al. 1997)

"The 10-100 km² of drainage basin immediately above a station was most important in predicting stream quality, suggesting that "extraneous" information was included if whole-basin land use was included in the regressions. Hill (1978, 1981) found similar results....riparian forest within about 1km of a station was the most important in predicting maximum stream temperature and trout distribution in southern Ontario (Barton, Taylor et al. 1985)." "Details of the spatial nature of this "buffering" of

upstream effects under different land use conditions deserve further study and have direct

bearing on the maintenance of high quality "oases" within degraded river systems (Marsh and Luey 1982)." (Steedman 1988)

“It could be suggested that the influence of land use on stream integrity is scale-dependent. Instream habitat structure and organic matter inputs are determined primarily by local conditions such as vegetative cover at a site, whereas nutrient supply, sediment delivery, hydrology and channel characteristics are influenced by regional conditions, including landscape features and land use/cover at some distance upstream and lateral to stream sites.” (Allan, Erickson et al. 1997)



5. BMP's: The Tools and Techniques of Water Quality Protection

Although best management practices (BMPs) are used to mitigate the impact of development, in studies of stream quality these measures have been found to have varying degrees of effectiveness. In addition, there seems to be no conclusive answer to the question, "At what percent impervious surface can stream-quality impacts not be mitigated?" For example, after studying BMPs in Delaware, Maxted and Shaver (1998) found that BMPs could not mitigate the impacts of urbanization once the watershed reached 20% impervious cover. Galli (1990) found that none of the four BMPs he studied in Maryland prevented temperature standard violations in areas of impervious surface ranging from 12-30%.

5.1 The Selection of an Appropriate Suite of BMPs

When selecting BMPs to solve development-induced hydrologic problems in the watershed, there are a series of attributes that control the extent and impact of each BMP:

1. Stormwater management is location based, and is dependent on both site level and watershed-wide variables.
2. No single BMP offers a universal solution to stormwater pollution (Ellis and Marsalek 1996). It is necessary to develop a treatment plan using a variety of BMPs in concert, starting with catchment-wide planning, continuing in the collection area, and ending with in-stream measures.
3. The success and sustainability of BMPs has to be ensured through proper design, operation and maintenance to meet specific objectives (Ellis and Marsalek 1996); and finally;
4. Even though well-designed BMPs provide stormwater quantity and quality control, visual amenities, and wildlife habitat, "they must be recognized as wastewater treatment facilities that may impact on wildlife and cause contaminant entry into the food chain" (Ellis and Marsalek 1996).

The questions to determine the appropriate BMP for each water quality, quantity or delivery problem are:

1. What are the objectives based on critical resources to be protected, location, and overall watershed goals; and
2. How does each type of BMP affect the watershed impact of development e.g. stream hydrology, channel morphology, water quality, ecology, and habitat.

However, it is also important to remember that while appropriately designed and properly sited BMPs can provide some mitigation of stormwater impacts on stream communities, no BMPs single or in concert are able to fully restore a water body to a pre-development condition and

function (Jones, Via-Norton et al. 1996).

As stated above, when implementing site level BMPs, greater efficiency can be achieved by using a variety of traditional engineering techniques in concert with bioengineering solutions. For example, when attempting to maintain the pre-development runoff volume and time of concentration, the following BMPs can be effective (Department of Environmental Resources 2000):

- Maintain predevelopment flow path length by dispersing and redirecting flows, generally, through open swales and natural drainage patterns;
- Increasing surface roughness (e.g. reserving woodlands, using vegetated swales);
- Detaining flows (e.g. open swales, rain gardens);
- Minimize disturbance (minimizing compaction and changes to existing vegetation);
- Flattening grades in impacted areas;
- Disconnecting impervious areas (e.g., eliminating curb/gutter and redirecting downspouts); and
- Connecting pervious vegetated areas (e.g., reforestation, afforestation, tree planting).

For maintaining the predevelopment runoff volume: (Department of Environmental Resources 2000):

- Wider and flatter swales;
- Maintain sheet flow;
- Clusters of trees and shrubs in flow path;
- Tree conservation;
- Minimize storm drainage pipes;
- Disconnect impervious area; and
- On-lot bioretention (US Environmental Protection Agency 1999(h))

For improving infiltration rates and decreasing site level run-off:

- Infiltration drainfields (US Environmental Protection Agency 1999(f));
- Porous Pavement (US Environmental Protection Agency 1999(d)); and
- Infiltration Trench (US Environmental Protection Agency 1999(b)).

For cleaning stormwater before reentering the hydrologic regime:

- Flow diversion (US Environmental Protection Agency 1999(g));
- Hydrodynamic Separators (US Environmental Protection Agency 1999(e));
- Modular Treatment Systems (US Environmental Protection Agency 1999(c));
- Water Quality Inlets (US Environmental Protection Agency 1999(m));
- Lack of maintenance results in resuspension of settled pollutants (4) and the limited storage does not provide adequate storm water quality control; and
- Storm water wetlands (US Environmental Protection Agency 1999(i)).

For reducing erosion:

- Turf reinforcement mats (US Environmental Protection Agency 1999(j));
- Vegetative covers (US Environmental Protection Agency 1999(l)); and
- Vegetated Swales (US Environmental Protection Agency 1999(a)).

The following table (table 4) rationalizes the various BMPs into a table defining the extent of their use and efficacy in the watershed.

Table 4: Surface water degradation, watershed condition and land planning responses.

Degraded Condition	Watershed Condition Causing Degradation	Response	Implementation
1) Stream hydrology			
(a) Increased magnitude & frequency of floods, increasing bankfull floods, increased storm flow, more rapid water velocity	- impervious surface	- reduce imperviousness in the watershed - increase infiltration	- regional cluster development - urban infill / urban growth boundary - transfer of development rights
(b) Less annual runoff volume as baseflow	- impervious surface and soil compaction leading to reduced infiltration	- reduce impervious surfaces - increase pervious areas in the watershed - increase areas of infiltration - reduce areas of concentrated infiltration - maintain mature forests and maximum areas of native vegetation - reduce soil compaction and disturbance during construction	Regional - open space conservation and retention of mature forest stands through TDR, cluster development and parcel acquisition - increase density in existing urban areas by redirecting growth to urban growth areas, urban infill areas, infrastructure targeting Site level - preserve open space on site with cluster development options - detention ponds - use of pervious paving surfaces - reduce clearing and grading on construction sites - use of vegetated swales, vegetated infiltration beds and infiltration trenches
2) Channel morphology			
(a) Channel widening & down cutting	- increasing impervious surface	- slow the entry of stormwater flow into the system - increase infiltration	Regional - riparian buffers - clearing standards - mature forest conservation Site level - retention/detention ponds

(b) Greater streambank erosion	- increasing water velocity and bankfull floods caused by increasing impervious surface - lack of streamside forest/shrub and native grass stands	- maintain native cover along streamside, particularly bank stabilizing vegetation	Site level - riparian buffers - clearing standards - open space conservation
(c) Loss of large woody debris	- increasing water velocity and bankfull floods caused by increasing impervious surface - lack of streamside forest stands	- maintain streamside mature forest cover	Site level - forested riparian buffers
3) Water Quality			
(a) heat	- increasing temperature from water running over impervious cover - increased solar access to water body resulting from loss of shading forest cover	- decrease imperviousness close to riparian corridors - maintain distance of impervious areas from stream flow - maintain large riparian trees that shade the channel	Regional - use of TDR to move development away from water bodies - zoning to reduce intensity of development along the riparian corridor - targeted parcel acquisition to maintain open space along riparian corridors Site level - forested riparian buffers - cluster development targeting riparian areas as open space
(b) toxics	-turf and ornamental planting - agricultural land - heavy/light industry paved surfaces	reduction of use of toxics in the watershed - removal of toxics from stormwater runoff	Site level - containment BMP's - oil/grit separator - sand filters
(c) sediment	- clearing and grading in the watershed - disturbed land areas	- reduce the amount of bare soil in the watershed - remove sediments from stormwater runoff - reduce disturbance of erosive soils - reduce erosive slopes	Site level - grading standards - clearing standards - sediment removal BMP's - construction BMP's - multi-layered riparian buffers that will filter sediments before reaching surface water body
(d) nutrients	- turf and ornamental planting - agricultural land	- for phosphorous, remove sediment from stormwater flow - reduce nutrient application - reduce the entry of human and animal waste into surface and subsurface water flows	Site level - clearing standards - nutrient removal BMP's - grass and shrub buffers along water bodies

(e) bacterial levels	- septic tanks - livestock operations - domestic pet waste	-ensure safe depth to groundwater below septic systems - remove pet wastes	<i>Site level</i> - OSDS monitoring - tertiary treatment
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5.2 The Limits of BMP Efficiency

While there has been considerable research on the efficiency of some types of BMPs (retention/detention ponds, forest buffers, pervious cover) many of the BMP have not been adequately evaluated for their use and efficacy in the watershed. The following section presents an overview of current research findings, and typical pollutant removal efficiencies of some of the more common site-level BMPs are presented in table 5.

Table 5: Typical pollutant removal efficiencies of site-level BMPs.

Pollutant	Typical Percent Removal Rates of Site-level BMPs							
	Infiltration trench ¹	Modular Treatment Systems ²	Porous Pavement ³	Bio-retention ⁴	Storm Water Wetlands ⁵	Wet Detention Ponds ⁶⁷	Vegetated Swales ⁸	
Sediment	90	-	82-95	-	-	-	-	
Total Suspended Solids	-	99	-	90	67	50-90	7-11	81
Total Phosphorous	60	90	65	70-83	49	30-90	-	9
Total Nitrogen	60	77	80-85	68-80	28	-	-	38 (nitrate)
Soluable Nutrients	-	-	-	-	-	40-80	2-52	-
Metals	90	-	-	93-98	-	-	25-60	-
Lead	-	77	-	-	62	70-80	-	67
Chromium	-	98	-	-	-	-	-	-
Zinc	-	90	-	-	45	40-50	-	71
Cadmium	-	-	-	-	36	-	-	42
Copper	-	-	-	-	41	-	-	51
Bacteria	90	-	-	90	77	-	-	-
Fecal Coliform	-	97	-	-	-	-	-	-
Organics	90	-	-	90	-	-	-	-
Biochemical Oxygen demand	70-80	82	-	-	-	20-40	16-49	67

Petroleum Hydrocarbons	-	90	-	-	87	-	-	62
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- 1- Schueler 1992 in (US Environmental Protection Agency 1999(b))
- 2- StormTreat Systems, Inc., 1998 (US Environmental Protection Agency 1999(c))
- 3- (US Environmental Protection Agency 1999(d))
- 4- (US Environmental Protection Agency 1999(h))
- 5- (US Environmental Protection Agency 1999(i))
- 6- (US Environmental Protection Agency 1999(k))
- 7- (Kantrowitz and Woodham 1995)
- 8- (US Environmental Protection Agency 1999(a))

a. Pervious Cover

While 100% imperviousness is an absolute measure, are all developed sites equal in their polluting capacity? Although the data indicates that impervious surface is the dominant determinant of stream quality, various types of previous cover can also have considerable impacts. For example, one study found that "Highway construction increased sediment yield 10 times over that expected from cultivated land, 200 times that expected from grassland, and 2000 times that expected from forest land" (Vice, Guy et al. 1969). The increase of impervious area in a watershed, or conversely the loss of wooded land area, reduces evaporation and infiltration, and is directly related to a loss of vegetative storage and decreased transpiration (Lazaro 1979).

Ross and Dillaha (1993) compared runoff, nutrient and sediment concentrations from six different pervious surfaces in a simulated rainfall event (Table 6). The results showed a great difference in the runoff characteristics among different types of pervious surfaces. While a mulched landscape produced no runoff, a gravel driveway and bare soil acted very much like an impervious surface, although they would not normally be included in the calculations.

Table 6: Comparison of runoff characteristics for a variety of pervious surfaces (Ross and Dillaha 1993).

Surface	Runoff m3/ha	Nitrate NO3 mg/l	Soluable P PO4 mg/l	TSS mg/l
2 Gravel Driveway	303.4	0.03	0.06	692.8
4 Bare Soil	478.5	0.32	0.79	1935.8
6 Cold-Season Grass, sodded	41.1	0.44	1.12	29.2
5 Warm Season Turf	24.3	0.21	0.33	53.5
1 Mulched Landscape	0.00	None	None	None
3 Meadow	0.00	None	None	None

This difference in the runoff characteristics for various pervious surfaces is critical to
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land use planning, since land uses vary widely in their ability to absorb or shed rainfall. Even those areas that are typically considered completely pervious such as grassed lawn, meadows, and fields do not absorb the amount of rainfall absorbed by a mature forest stand given similar soils, soil composition, and topography. Since construction activity yields soil compaction and changes in soil profiles, more intense development equals more impacted land area that is at best only partially pervious (Booth and Jackson 1997).

The issue of forested vegetation is complicated by evapotranspiration. Forested areas simultaneously allow for a high level of infiltration and varying levels of evapotranspiration. Urban imperviousness causes two simultaneous impacts to low flows in streams: precipitation is deflected from infiltration by the impervious surface, and advective enhancement of evapotranspiration exacerbates the loss of groundwater, due to the increase in heat from surrounding surfaces (Ferguson and Suckling 1990).

Based on the importance of forest stands in the hydrologic system, it is critical to use mature forest stands as a baseline for planning adequate infiltration in the watershed. Several studies have found that forest stands in a watershed are vital for mediating other land use impacts on stream habitats (Osborne and Wiley 1988; Steedman 1988; Osborne and Kovacic 1993; Richards, Johnson et al. 1996). Whereas some water-quality parameters can be modified by local riparian conditions (Osborne and Kovacic 1993), dominant water-quality trends of streams among catchments are more strongly related to catchment-wide land use and geology (Richards, Johnson et al. 1996). While the threshold of forest cover needed has not been firmly established, at least one study (Taylor 1993) found that at least 15% forested cover should be protected to reduce event water-level fluctuations.

Studies of the effects of forested areas in a watershed have illustrated their potential mitigating effects for other land uses. For example, the domain of degradation for Toronto area streams ranged from 75% removal of riparian forest at 0% urbanization to 0% removal of riparian forest at 55% urbanization (Steedman 1988). However, whole catchments may be as important as buffers around streams for determining several components of stream habitat. Variables related to hydraulic regime, such as channel dimensions, are influenced more by catchment area and composition than factors specific to stream ecotones (Hynes 1975, cited in Richards, Johnson, and Host 1996). Steedman (1988) found a higher correlation between the proportion of basin in forest and water quality, than the proportion of the channel with riparian forest. Hicks and Larson (1997) concurred in their analysis of forests, finding no discernible human impact on water quality at 4% impervious watershed surface, more than 50% forested land area, and more than 80% of the stream with a 200 foot riparian buffer; a low level of impact at 9% impervious surface, 30 to 50% forest stand and 50-80% riparian buffer; a moderate level impact with 10 to 15% impervious surface and 10 to 29% forest stand and 20 to 49% riparian buffer; and a high level of impact with 15% impervious surface, 10% forest stand and less than 20% riparian buffer.

Forest stands, particularly riparian forests, directly affect the abiotic factors of stream quality, particularly woody debris and channel enlargement. The amount of forested land cover

is often positively related to the quantity and types of detrital and woody debris in streams

(Bisson, Bilby et al. 1987; Richards and Host 1994), and mitigates channel enlargement due to a higher level of stormwater absorption (Table 7).

Table 7: Channel enlargement effects of land uses in a 1-square mile basin (Hammer 1972).

<i>Land Use</i>	<i>Magnitude of Effect</i>
Wooded Land	0.75
Open land	0.90
Non-impervious developed land plus impervious area < 4 years old and unsewered streets and houses	1.08
Land in cultivation	1.29
Land in golf courses	2.54
Area of houses > 4 years old fronting on sewer streets	2.19
Area of sewer streets > 4 years old	5.95
Other impervious area > 4 years old	6.79

The location of wetlands also influenced several habitat features such as woody debris and some aspects of channel dimensions. When positioned in stream networks, wetlands also mitigate hydraulically driven variables including sediment, nutrients, temperature, and disturbance (Richards, Johnson, and Host 1996). Other studies have indicated that the spatial position of wetlands within the watershed influences their ability to modify inputs to streams (Johnston, Dettenbeck, and Niemi 1990, cited in Richards, Johnson, and Host 1996).

While agricultural land typically produces lower levels of run-off than impervious land cover, land under conventional agricultural management practices typically contributes more nutrients than other pervious or impervious land uses. However, nutrient levels are less critical to IBI scores than runoff volume. In a study of 103 streams in Wisconsin, only 10-20% urban land use was needed to put IBI scores in the poor range. Yet, over 50% agricultural land was required to reduce IBI scores, and IBI scores increased steadily with increasing forest cover (Wang, Lyons et al. 1997). A study comparing three watersheds dominated by forest, agricultural land, and urban land found that streams in an agricultural watershed had the most nutrients, but the urban streams had the highest temperature and concentration of metals (Crawford and Lenat 1989).

b. Riparian Buffers

Riparian buffers are a commonly accepted form of watershed BMP. However, since implementation is fairly straightforward and generally requires maintenance of existing site features rather than the conscious engineering of a constructed BMP, they are often imbued with powers far beyond their ability to impact the hydrologic system (Booth 1991). For example, one study found that “stream buffers (100m) were more important than whole catchment data for predicting sediment-related habitat variables; however, channel morphology was more strongly related to whole catchments. Results suggest that catchment-wide geology and land-use characteristics may be more important than stream buffers for maintaining or restoring stream

systems” (Richards, Johnson et al. 1996). One hundred foot buffers are generally accepted in

planning practice since benefits of wood recruitment, aquatic food supply and shading appear to decline much beyond 100 feet (Murphy, Heifetz et al. 1986; Budd, Cohen et al. 1987; Booth 1991).

There are several factors that can act to reduce the effectiveness of buffers (Booth 1991):

1. the effects of existing land use in the watershed;
2. stream crossings by roads and utilities;
3. human intrusion;
4. buffer alteration over time by individual property owners; and
5. channelized flow through the buffer into the stream carrying pollutants and sediments, along with flow increases from impervious surfaces.

While riparian forests have limits to their effectiveness, riparian buffers are key mitigants of the loss of large woody debris and leaf litter that enters the aquatic food chain (Booth and Jackson 1997), and temperature increases (Galli 1990). When streamside vegetation is cleared, less wood enters the channel which functions to protect the streambed and banks from erosion (Booth, Montgomery et al. 1996; Booth and Jackson 1997). For example,

“If corridor clearing is proportional to basinwide urban land uses, stream conditions can be no better than “fair” once the basin achieves about 30% urban land use. At typical suburban densities, this corresponds to about 7 to 10% impervious area. Even with virtually complete retention of streamside buffers (i.e., ‘percentage riparian forest’ equals 100%), impervious area coverage much beyond this range will lead to nearly certain, measurable degradation” (Booth and Reinelt 1993).

After watershed imperviousness reached 45% in Seattle area watersheds, riparian buffers ceased to effectively protect biological integrity (Horner, Booth et al. 1997). Steedman (1988) also found that the amount of riparian cover that can be removed while sustaining biological integrity is inversely proportional to the amount of impervious surface: with 0% urbanization, 75% of the riparian forest could be removed, and with 55% urbanization, 0% could be removed. Even complete retention of streamside buffers could not prevent “measurable degradation” after approximately 7-10% impervious area (Booth and Reinelt 1993). In addition, significant changes in instream nutrient concentrations were identified if land cover changes occurred within 150 meters of the stream channel, while insignificant changes in nutrient concentrations resulted if the land use change occurred at more than 150 meters from the channels (Tufford, McKellar et al. 1998). This finding suggests that basin land use planning aimed at reducing nonpoint sources of nutrient loading should be especially concerned with near-channel land uses. In particular, nutrient levels were found to be alleviated only temporarily by forested buffer strips (Omernik, Abernathy et al. 1981).

c. Retention and Detention Ponds

Retention and detention ponds come in a variety of forms. Some of the most common are defined below:

Detention devices - Devices to control and hold back temporarily the flow of runoff into surface waters. Detention basins are characterized by un-gated outlets.

Dry pond - Retention or detention ponds which drain completely between storms.

Extended dry ponds - Retention or detention ponds which discharge stormwater over a prolonged time period (several days) but do not maintain a permanent water pool.

Wet ponds – maintain a permanent water pool that also typically supports aquatic plants.

Retention devices - Devices operating to capture or intercept runoff water, preventing its release to surface waters for a relatively long period of time. Release is typically controlled by outlet structures. (Kulzer 1989)

Since allowing for runoff to sit before reentering the hydrologic system is the key to accomplishing removal (Horner, Booth et al. 1997), detention ponds are integral to the cleansing process and are statutorily required in many jurisdictions. In fact, two jurisdictions with very different hydrologic regimes, Beaufort County, South Carolina, and Bellevue, Washington (Comings, Booth et al. 2000), statutorily require removal of 50% of the pollutant loads. However, as noted in Comings, Booth, and Horner (2000), studies for both total phosphorous and soluble reactive phosphorous removal by detention ponds are highly variable, but generally fall below 50%. Utilizing one to two percent of the watershed area for the development of wet detention ponds at strategic locations could reduce pollutant loadings to meet targeted requirements of water quality improvements (Wu, Holman et al. 1996).

Although dry detention ponds are in use throughout the United States, pollutant removal efficiencies have been measured in only a handful of the ponds (Stanley 1996). The findings of various studies concur that detention ponds can provide a certain mitigation of stormwater impacts, however they are limited in their effectiveness (table 8 and 9), and more widespread use of stormwater infiltration ponds is impeded by such problems as concerns about groundwater contamination, lack of design guidance, and concerns about maintenance and longevity of infiltration systems (Ellis and Marsalek 1996).

Table 8: Comparison of findings of phosphorous removal capability by detention ponds (adapted from

Comings et al. 2000)

Study	Location	Total phosphorous	Soluble Reactive Phosphorous
Comings et al., 2000	Bellevue, Washington	19-46%	3-62%
Kantrowitz and Woodham, 1995	Pinellas County, Florida	13-66% Median 40%	
Gain, 1996	Florida	21-30%	
Wu et al., 1996	North Carolina	36-45%	
Stanley, 1996			-12%-26%
Maristany, 1993		64	-50%

Table 9: Comparison of the ability of detention ponds to clean various contaminants from stormwater.

Contaminant	Maristany 1993	Stanley 1996	NURP 1983	Kantrowtiz 1995
Total suspended solids	95.4	71	93	7
Turbidity	86.6	--	--	--
Total Chromium	77.5	--	--	25
Total Copper	72	26	64	52
Total Lead	91.3	55	84	>60
Total Nickel	68	--	--	--
Total Zinc	84.9	26	51	48
Total Organic Carbon	24.3	10	--	--
Chemical Oxygen Demand	14	--	44	16
Biochemical Oxygen Demand	20.3	--	51	49
Total Nitrogen	31.3	26	--	--
Ammonia	54.5	9	--	40
Total Kjeldahl Nitrogen	28.8	--	38	--
Nitrate	60	-2	44	--
Total Phosphorus	64	14	64	40
Orthophosphate	-50	26	--	52

The results suggest that modifications to stormwater retention basin designs (e.g.,

expanded capacity, constructed wetlands are in order to increase pollutant removal efficiency

(Maxted and Shaver 1998). The major limiting factors of detention ponds, compromising their ability to clean stormwater and mitigate impacts are:

" First, such ponds have an explicit design limit; flows that exceed this limit will overtop or bypass the storage area and experience little to no detention. Thus the largest storms are least reduced. Second, the design criterion for most ponds specifies a match of peak discharge but not of flow durations. Thus a given flow will occur for a longer period; if that flow is erosive, it will do work on the downstream channel for many times longer than in the predevelopment case. The final reason...is a result of the hydrologic modeling that is used in the pond design...these models specify an excessive rate of release from the pond, and they under predict the amount of storage that is needed to control sequential storms properly"(Booth 1991).

Underscoring these findings is the fact that it has been suggested that a strong first flush is present when the first 20% of the storm runoff contains 80% or more of the total pollutant load (Stahre and Urbonas, 1990). However, recent studies have contradicted this finding, with the first 20% of the initial storm runoff carrying only 24-27% of the total particulate pollutant loads and 23-37% of the total dissolved pollutant loads (Stanley 1996).

Wet detention ponds have been cited as one method to improve water quality efficiencies. The establishment of aquatic vegetation has the effect of increasing the efficiency of detention ponds in reducing loads of urban-runoff contaminants in stormwater (Kantrowitz and Woodham 1995), but experience declining removal of organic matter (oxygen demand) if not properly maintained (Maristany 1993).

d. Using a regional planning approach to watershed protection

Using a regional planning approach to watershed protection requires the incorporation of development and open space planning into a regional growth management strategy. This goes far beyond simply recommending cluster developments, buffers, and conservation oriented subdivision design standards, to the siting of new development in the least sensitive areas of the watershed, and maintaining adequate mature forest stands and areas of open space that have not been impacted by human disturbance. The greatest impediment to the regional planning approach is that land use planning is a local initiative and decision makers are not oriented towards thinking about planning and growth management regionally, beyond the limits of their jurisdiction. Regional coordination requires strong leadership, beginning on a local level.

The regional approach:

- a) Identifies critical resources to preserve
- b) Directs growth within a watershed to areas best suited to assimilate the associated impacts
- c) Uses a menu of currently available growth management tools in concert with site specific BMPs and applies them on a regional basis.

Table 10 identifies one such strategy with trout streams, spawning habitat and shellfish

beds as the critical resources.

Table 10: An illustration of an integrated strategy of regional and site-level BMPs that work in concert to protect critical resources.

Resource	Critical Water Quality Measure	Condition to Address	Regional BMP	Site Level BMP
Trout stream	Temperature	Stream shading	Maintain mature forest stands along streams by <ul style="list-style-type: none"> • Stream buffers • Clearing standards 	Retention basin
	Base Flow	Cooling runoff before entering system Infiltration areas	Maintain forested areas with: <ul style="list-style-type: none"> • TDR • Clustering • Low density zoning 	<ul style="list-style-type: none"> • Detention basin • Porous pavement • Vegetated infiltration beds
Spawning habitat	Large woody debris	Debris falls	Maintain vegetation along streams by: <ul style="list-style-type: none"> • Stream buffers • Clearing restrictions 	
Shellfish beds	Sediment	Sediment transport Erosion	Clearing and grading standards	Detention basin On-site erosion mitigation
	Fecal coliform		Target sewage treatment upgrades	

e. Tradable permits and other market-based non-structural BMPs

Although water pollution trading programs have limited exposure in the United States, they are seen by some planners as a promising method to reduce non-point source pollution. In these programs, credits are created when one area reduces pollutants or stormwater flashiness below a control target. The difficulty facing these efforts is that the target level can not be below pre-development levels, therefore it assumes that a level of degradation will be acceptable in the watershed, sub-watershed or catchment.

Successful market-based trading programs have the following attributes (Fulton et al., 2004):

1. clear, enforceable goals;
2. a large number of potential buyers and sellers; and
3. a number of different abatement options to reduce pollutants.

An additional attribute of a watershed protection program should be a clear and comprehensive watershed plan that identifies the critical resources of the watershed, and prioritizes the relative water quality within individual catchments, as well as the overall water quality goal for the entire watershed or sub-watershed.

Perhaps a more promising approach to watershed protection efforts lies in mitigation banking. Assuming that different catchments within a watershed should achieve varying levels of water quality and hydrologic impairment, watersheds with high level goals can be targeted for mitigation efforts such as the purchase of open space easements in exchange for an acceptable level of degradation in another catchment.



6. The Role of Federal and State Governments in Protecting the Great Lakes Watershed

Sections 2 through 5 of this paper reviewed the research and implementation efforts that have characterized watershed planning efforts for the past 30 years. In addition to the many structural, site-level BMPs that have been developed and widely used, more recently the literature has begun to reflect the broadening of efforts to include non-structural or planning BMPs. Site-level BMPs are not 100% effective in protecting water quality or hydrology, and many research efforts have defined the limits of structural BMPs to achieve pre-development water quality and watershed hydrology. As such, in an effort to slow or even halt the continued degradation of the Great Lakes system, focus has turned to include the patterns of land use and growth management. Based on the preceding analysis of the state of the art in watershed protection, it is clear that the greatest strides can be made in the area of land use and watershed planning to reduce impacts of development on watershed hydrology (Booth and Jackson 1997; Lammert and Allan 1999; Wang, Lyons et al. 2001).

6.1 The Structure of Land Use Decision-making in the Great Lakes States

In the federal system of the United States, the Constitution sets the framework for the delegation of powers between the three levels of government: federal, state and local. The delegation is embodied in the Tenth Amendment: “the powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively or to the people.” By virtue of the Constitution, the power to control land and its various related issues is the prerogative of the States, which delegate their power to local governments.

The states exercise direct control over local governments, although many alter the state-local government relationship (Richardson, Gough and Puentes 2003). Local governments derive their power to control land and its use in three ways: from the state constitution, local charter, or state legislation. The eight Great Lakes states, Minnesota, Wisconsin, Illinois, Indiana, Ohio, Michigan, New York and Pennsylvania all have granted varying levels of home rule to their cities, townships and counties. All eight states operate at the township level of municipal government, with varying powers held by cities, towns, and counties. In Pennsylvania, townships comprise all areas of the state.

All of the Great Lakes states function at some level as home rule states. Illinois reserves some grants of power (Dillon’s rule) to certain municipalities, leaving only about 10 percent of municipalities and one county with complete home rule (Richardson et al., 2003). Indiana reserves Dillon’s rule only for townships; local governments in Minnesota retain all powers held by the state, except those powers expressly withheld by the state (Richardson et al., 2003). Table 6.1 below provides an outline of the extent of

home rule delegation in each of the states. Broad functional home rule means that “local governments have been given a great deal of autonomy in carrying out local government functions” (US Advisory Commission on Intergovernmental Relations 1993). Limited function home rule indicated the “local governments have been given little autonomy in carrying out local functions, that local powers are greatly circumscribed, and that limited local discretion is permitted” (US Advisory Commission on Intergovernmental Relations 1993). Model state enabling legislation for both planning and zoning was first enacted in the 1920s. To date, all of the Great Lakes states have enacted both planning and zoning enabling legislation, which authorizes localities to engage in a comprehensive planning process, adopt comprehensive plans, and to adopt land use controls.

Table 6.1: A review of home rule status in the Great Lakes states (adapted from US Advisory Commission on Intergovernmental Relations 1993).

<i>State</i>	<i>Cities/towns/ townships</i>		<i>Counties</i>	
	<i>Broad functional home rule</i>	<i>Limited functional home rule</i>	<i>Broad functional home rule</i>	<i>Limited functional home rule</i>
Minnesota	X			X
Wisconsin	X		X	
Illinois		X		X
Indiana		X		X
Ohio	X			X
Michigan	X			X
New York	X		X	
Pennsylvania		X		X

Local municipalities and townships typically affect water quality protection through their comprehensive plans, zoning and subdivision regulations. There has not currently been a comprehensive study of watershed protection measures and their adoption and implementation by local governments in the region, and this creates an important area for future research. In the absence of a broad, regional study, anecdotal evidence indicates that the weaknesses in implementation of watershed planning, and a focus on structural, engineered BMPs characterizes local government efforts in this area.

A particular obstacle to coordinating regional watershed management strategies lies in the home rule powers of local governments. Since home rule is typically seen as a right to regulate purely local matters without interference from the state legislature, local governments tend to be resistant to efforts by the states to encourage regional cooperation, or to the creation of state-wide land use planning initiatives.

6.2 Current Federal and State Legislative Initiatives and Strategies

There is a role for the federal government relative to land use planning decisions and mandates of state government for local municipalities (Hanchett 1994). However, defining the federal role with regards to coordinating local initiatives and enforcement / compliance requires a long-term commitment on the part of all participants, both in funding mandates and broad-based coordinated planning efforts.

Since the early 1980s, a number of programs have been created to care for the Great Lakes at nearly every category of government; some have a demonstrated track record of successes while others can point to long-term investment of federal dollars. As of 2003, the Government Accountability Office (GAO – formerly known as the General Accounting Office) identified 148 federal and 51 state programs receiving funding for environmental restoration activities in the Great Lakes Basin (Government Accountability Office 2003). Whereas many of these efforts are characterized as either nationwide or statewide programs that may or may not specifically focus on the Great Lakes, GAO identified 33 federal Great Lakes-specific programs, and an additional 17 Great Lakes-specific programs funded by states.

Although funding for Great Lakes water quality restoration is not routinely tracked for many of these programs, GAO did identify a total of nearly \$3.6 billion in basin-specific projects for fiscal years 1992 through 2001 (Government Accountability Office 2003). The report found a key problem in these efforts: the number of incongruent Great Lakes environmental strategies used at the bi-national, federal, and state levels. Currently, these strategies are not coordinated in a way that ensures effective use of limited fiscal resources (Government Accountability Office 2004). Because of the physical scale of the Great Lakes basin and the numerous units of government – local, state, federal and international – who play key roles in guiding how restoration takes place, a consistent overarching strategy should be crafted and used to guide management and restoration efforts. In their testimony before the Subcommittee on Water Resources and Environment, the Committee on Transportation and Infrastructure, and the U.S. House of Representatives, the GAO identified the need for a coordinated approach by the states to ensure measurable improvements (Government Accountability Office 2004).

a. Federal Interagency Task Force: EPA coordination

Nearly 200 federal and state programs are already in place to fund restoration activities in the Great Lakes Basin, 148 of which are federal and 51 are in place in state government (Government Accountability Office 2004). In an effort to coordinate restoration and management of the Great Lakes, and in response to a number of GAO Reports to Congressional Requestors (Government Accountability Office 2004) (Government Accountability Office 2003), President George W. Bush on May 18, 2004 signed an Executive Order creating a federal interagency Task Force on Great Lakes protection and management. It assigned the Administrator of the Environmental

Protection Agency (EPA) to head the group. The Executive Order responded to the findings in a GAO report (Government Accountability Office 2003) citing the lack of coordination among more than 140 federal and state programs dealing with the Lakes (Michigan Environmental Council 2004).

The Executive Order establishing the Task Force was a response, in part, to the 2003 Government Accountability Office report, *Great Lakes: An Overall Strategy And Indicators For Measuring Progress Are Needed To Better Achieve Restoration Goals* (Government Accountability Office 2003). The study found that 33 federal and 17 state programs had spent approximately \$1.7 billion on Great Lakes protection efforts, without a quantifiable confirmation that the investment had improved water quality (Great Lakes Environmental Directory 2004).

The Task Force purpose was [taken from the language of the Executive Order]:

“To further the policy described in section 1 of this Order, there is established, within the Environmental Protection Agency for administrative purposes, the "Great Lakes Interagency Task Force" (Task Force) to:

(i) Help convene and establish a process for collaboration among the members of the Task Force and the members of the Working Group with the Great Lakes States, local communities, tribes, regional bodies, and other interests in the Great Lakes region regarding policies, strategies, plans, programs, projects, activities, and priorities for the Great Lakes system.

(ii) Collaborate with Canada and its provinces and with bi- national bodies involved in the Great Lakes region regarding policies, strategies, projects, and priorities for the Great Lakes system.

(iii) Coordinate the development of consistent federal policies, strategies, projects, and priorities for addressing the restoration and protection of the Great Lakes system and assisting in the appropriate management of the Great Lakes system.

(iv) Develop outcome based goals for the Great Lakes system relying upon, among other things, existing data and science-based indicators of water quality and related environmental factors. These goals shall focus on outcomes such as cleaner water, sustainable fisheries, and biodiversity of the Great Lakes system and ensure that federal policies, strategies, projects, and priorities support measurable results.

(v) *Exchange information regarding policies, strategies, projects, and activities of the agencies represented on the Task Force related to the Great Lakes system.*

(vi) *Work to coordinate government action associated with the Great Lakes system.*

(vii) *Ensure coordinated federal scientific and other research associated with the Great Lakes system.*

(viii) *Ensure coordinated government development and implementation of the Great Lakes portion of the Global Earth Observation System of Systems.*

(ix) *Provide assistance and support to agencies represented on the Task Force in their activities related to the Great Lakes system.*

(x) *Submit a report to the President by May 31, 2005, and thereafter as appropriate, that summarizes the activities of the Task Force and provides any recommendations that would, in the judgment of the Task Force, advance the policy set forth in section 1 of this order.” (EPA 2004)*

The Order contained a key element that may be used to support a regional planning effort. First, it created a means to synchronize federal activities on the Great Lakes by creating the federal task force (Table 6.2) and appointing the Administrator of the EPA to lead it. Second, the order initiated the creation of regional collaboration to bring hundreds of regional, state, local, tribal and other interests together for the purpose of developing an overall strategy for protecting the Great Lakes (EPA 2004). The Executive Order called for the development of outcome-based goals such as cleaner water, sustainable fisheries, and system biodiversity and calls on the Task Force to ensure federal efforts target measurable results (Great Lakes Environmental Directory 2004); (Government Accountability Office 2003). However, what the Executive Order did not address were unified and/or regional based land use planning initiatives as a means for achieving the measurable results called for in the President’s Order.

Table 6.2: Great Lakes Interagency Task Force Members (EPA 2004) .

<u>Agency</u>	<u>Representative</u>
Environmental Protection Agency	Administrator Mike Leavitt (Chair)
Department of State	Secretary Condoleezza Rice
Department of Interior	Secretary Gale Norton
Department of Agriculture	Secretary Michael Johanns
Department of Commerce	Secretary Carlos Gutierrez
Department of Housing and Urban Development	Secretary Alphonso Jackson
Department of Transportation	Secretary Norman Mineta

Department of the Army
Council on Environmental Quality
Department of Homeland Security

Acting Secretary Les Brownlee
Chairman James Connaughton
Secretary Michael Chertoff

Although the White House as part of the Executive Order requested an additional \$45 million for water-quality projects for the Great Lakes basin, the President has simultaneously proposed cuts in EPA funding that would mean approximately \$178 million less in grants to local communities in the Great Lakes region (Great Lakes Environmental Directory 2004).

Along with the Administration's lack of support for a regional coordinated land use planning strategy (Great Lakes Environmental Directory 2004), funding for this effort is unclear. There is no clear support providing federal funding for regional land use planning for states, nor is there a clear policy retaining this as a local issue of the states'. This distinction is important for crafting regional land use planning policies and education initiatives for land use decision makers which may depend on federal funding, particularly given recent cut-backs on a variety of state and local programs.

b. State Actions Relative to Land Use and Water Quality Protection

Efforts to protect and restore Great Lakes' water quality and habitat began more than 40 years ago, starting with local citizen pressure for the federal government to pass national laws in support of protecting water and air quality. In response to federal laws such as the Clean Air Act and Clean Water Act, establishment of the Environmental Protection Agency, and dedication of Earth Day, many states created new environmental departments charged with enacting federal policies at the local level. In spite of these actions, many states have seen programs, agencies, and departments reverse some very important policies as a result of political and special interest pressures, and competing initiatives for limited state dollars.

It is beyond the scope of this report to provide an in-depth assessment of existing state land use and water quality protection efforts of all eight of the Great Lakes states. However, the following review of Michigan initiatives provide an example of current approaches used through out the basin.

In a report published by the Michigan Environmental Council titled "*Dereliction of Duty: The Failure Of Michigan's Legislators To Stand Up For Michigan's Water, Air And Land,*" the authors criticize both houses of the legislature for their efforts to roll back protections for Michigan's water resources. Since 2001, general fund support for the Michigan's Department of Environmental Quality dropped from \$101 million to \$28 million in the budget recently passed for fiscal year 2004-5 (Michigan Environmental Council 2004).

However, there have been steps on the part of state government, to return to resource protection policies. For example, the current governor has prepared a plan including a number of state-wide administrative and legislative actions (Michigan Environmental Council 2004). Some of the recommendations relevant to regional planning include:

- ✓ Enacting a water use permitting statute for users of over 2 million gallons a day or 100 million gallons a year.
- ✓ Amending incongruent land use planning practices.
- ✓ An administrative rule to protect critical isolated wetlands.
- ✓ Fully funding the water discharge permit fee program currently pending before the Legislature.
- ✓ Developing a statewide sanitary code.

The root of the problem at the federal and state level of government is the absence of a comprehensive strategy and critical gaps in organizational leadership. Without effective coordination, it is difficult to determine the overall progress of restoration efforts. GAO recommended in its April 2003 report that the Administrator, of the Environmental Protection Agency ensures that the Great Lakes National Program Office fulfill its coordination responsibilities and develop an overarching Great Lakes strategy.

The GAO also recommended that either EPA or the states develop environmental indicators and a monitoring system for the Great Lakes Basin that can be used to measure overall restoration progress.

6.3 Recommended Actions

EPA Administrator Mike Leavitt, Chair of the Federal Interagency Task Force stated that the key component of President Bush's Interagency Task Force would be to provide central coordination while giving control of programs to local agencies (2000; EPA 2004). Specifically, he stated that priorities, policies, and plans should be centrally coordinated and programs, projects and people must be locally controlled. This recommendation provides a rational approach to managing the water quality / habitat protection and land use planning in support of those for the Great Lakes basin.

The Great Lakes Regional Working Group, called for in the President's Executive Order, is a potential forum for the development of program details such as leadership guidance for program goals, coordination of funding, and assistance in refining measurable outcomes. Many details such as funding levels and duration; how much money is needed; for how long can and should it be provided; at what point do the states and regional planning councils take over; and the point at which local governments take over financial responsibility for staffing and administration need to be determined.

Michigan Governor Granholm, and the GAO called for unified measurable indicators of water quality – each of the other states in the Great Lakes Basin need to begin to adopt uniform measurement indices.

In order to maximize its effectiveness in Great Lakes watershed protection efforts, the federal government must also coordinate the actions of its various agencies that impact land use with the goals of watershed-wide protection and growth management. For example, federal highway funding and HUD funding can be coordinated with a watershed-wide plan to ensure that development efforts are in congruence with watershed protection. Funding and acquisition programs such as federal funds for land acquisition (such as the Land and Water Conservation Fund) can also be coordinated with watershed planning to ensure that funding goes to critical parcels of open space that will have the effect of protecting water quality.

Given the President's Executive Order establishing the Federal Task Force, the Regional Working Group, and the annual Great Lakes Regional Collaboration (GLRC) meeting held in Chicago, Illinois, a public administrative framework exists by which to bring key leaders together, clarify priorities, chart an administrative process, and assign measurable benchmarks for success. Millions of dollars will need to be devoted to a top-down incentive process for requiring regional land use planning for water quality protection. However, a great amount of base information already exists along with case study examples for what works and what does not work as effectively. Some communities may already be effectively working in a collaborative manner and as such, can be used as a model for others to follow. Providing funding and assistance for local and state leaders should help to ensure coordinated success. And finally seeking out and actively soliciting the opinions and desires and most importantly, the involvement of the public in land use, watershed, and natural resource planning is a key element that can not be overlooked.

a. The Need for Uniform Standards for Measuring Water Quality

- coordinated indicators for water quality between each state
- a comprehensive assessment of current restoration progress

In a report entitled, *Greening the Governments* released in April 2002 (Michigan Environmental Council 2002), Great Lakes states were criticized for not using a consistent method for reporting the quality of Great Lakes water and related land use indicators. The report proposed the creation of a "Right to Know Compact," assuring that such information be reported consistently (Michigan Environmental Council 2002).

Michigan Governor Jennifer Granholm asked Governors of Great Lakes' states to establish uniform standards for determining Great Lakes water quality. The Governor's request responded to a call by Michigan Environmental Council (MEC) in 2002 that the

state should lead the way in creating a consistent "Great Lakes report card," enabling citizens and policy makers to know whether the condition of the Lakes is improving or deteriorating (Michigan Environmental Council 2002; Government Accountability Office 2003; Government Accountability Office 2004; Michigan Environmental Council 2004). A consistent method for monitoring and reporting would assist the IJC and others in their efforts to recommend land use planning practices relative to protecting water quality and achieve the President's Order calling for measurable results of clean up efforts.

The key issue is that each state measures and monitors different standards and then reports those in a different way around the basin, making determining the health of the Great Lakes more difficult. The findings of two GAO reports, *Great Lakes: A Coordinated Strategic Plan And Monitoring System Are Needed To Achieve Restoration Goals* (General Accounting Office 2003) and, *Great Lakes: A Comprehensive Strategy And Monitoring System Are Needed To Achieve Restoration Goals* (Government Accountability Office 2004) support the need for consistent monitoring practices.

The Great Lakes Water Quality Agreement of 1987 (Government Accountability Office 2004) charged EPA's Great Lakes National Program Office with the responsibility for coordinating federal actions for improving water quality of the Great Lakes. In fact, the amended 1987 Great Lakes Water Quality Agreement called for the establishment of a comprehensive monitoring system to measure restoration progress and to assess the degree that the United States and Canada both complied with the goals and objectives laid out in the agreement. However, the available data on current environmental indicators do not allow a comprehensive assessment of restoration progress in the Great Lakes (Government Accountability Office 2004). The issue is that the indices of water quality rely on limited, or incomplete, quantifiable data and can only render subjective conclusions determining whether conditions are improving (Government Accountability Office 2003);(Michigan Environmental Council 2004).

The ultimate success in developing water quality indices for the Great Lakes is not clear since the measures of Great Lake's water quality rely on resources voluntarily provided by several organizations. This dependence on volunteer efforts to monitor water quality is not unique to the region of the Great Lakes. When watershed restoration budgets become limited, one of the first areas of spending to be cutback is water quality monitoring. Although the lapses can be mediated by citizen or other volunteer efforts (Metropolitan Washington Council of Governments 1990), relying on volunteer efforts can leave gaps or uncertainties in collected data and indicators for determining the overall health of riparian systems. As of May, 2004, GAO determined that no date for completing a final list of indicators had been established. The challenge in establishing clear indicators for measuring the health and vitality of Great Lakes' water quality has to do with the need for effective coordination of efforts.

b. Improve Regional Watershed Planning Efforts

- The need for coordinated regional state and county wide planning

A variety of options, or models, exist for how each of the Great Lakes states can go about initiating coordinated regional land use planning to protecting water quality and coastal resources (Gale 1992; Deyle and Smith 1998; Carruthers 2002; Hamin 2003; State of Wisconsin 2000). Similarly, there are also directed ways in which the federal government can influence the process (EPA 2004). Two examples are the incentive-based approach of Maryland and Florida (Deyle and Smith 1998). According to these successful approaches, each state government directs local units of government – county, township, city or village – to develop land use and growth management plans with an emphasis on protection and conservation of critical resources. Growth management planning has larger benefits since there are direct linkages between resource protection and economic sustainability of the Great Lakes and communities (Great Lakes Commission 2004). States such as Florida and Maryland – as cited in the two case study examples – recognized that strong coordinated land use planning translated into sustainable local economies.

However, suggesting that state governments enact coordinated land use planning mandates without funding is not effective policy. Many Great Lakes states are in the middle of an economic downturn and are only slowly beginning to see budgets stabilize as a result of aggressive cost-cutting. Many Great Lakes states did not fully experience the economic boom of the late 1980s and decade of the 1990s. As such, sales tax revenue has for many years been less than adequate to fund even basic and essential state services.

Similarly, many local governments are also fiscally constrained. Local communities have found that preparing annual capital improvement plans often requires eliminating many programs that do not have a revenue source; the same is true for state budgets. With the goal of promoting effective regional growth management, states will need to provide incentive and funding for local units of government to develop coordinated land use and growth management plans; many local and county governments do not have the staff or resources currently to do it alone. In a similar fashion, states that enact statutes for such programs will require federal assistance to support the effort.

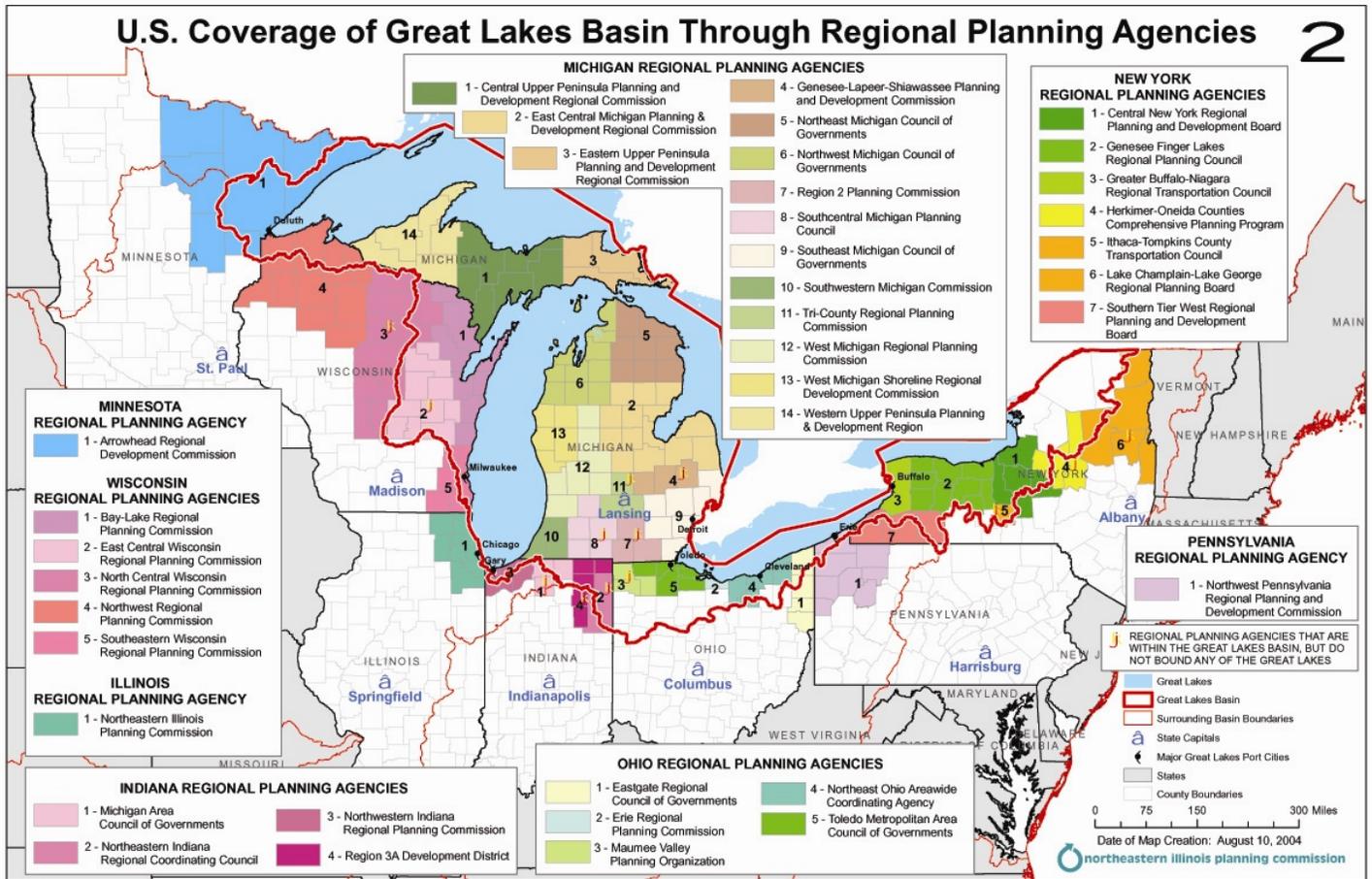
c. Improve Effectiveness of Regional Planning Organizations

- Improve the effectiveness of the existing regional planning agencies
- create Regional Stormwater Authorities

Within the eight states in the Great Lakes Basin, there are 38 regional planning agencies. Although this paper does not examine of each of these regional entities in

detail, these regional councils of governments (COGs) and their member governments cover an extensive region boarding each of the Great Lakes states (see figure 6), and provide a basis for improved regional planning efforts.

Figure 6: Regional Planning Agencies in the Great Lakes Basin.



In the United States and the Great Lakes basin, regional COGs typically provide long-range planning forecasts of population, transportation employment, housing and other socio-economic indicators. For example:

- The Northeastern Illinois Planning Commission (NICP) is the official comprehensive planning agency for six counties – Cook, DuPage, Kane, Lake, McHenry, and Will – that form the greater Chicago metropolitan area. Whereas the NICP works with local governments and others to promote sensible growth,

they like other COGs have no jurisdictional authority and serve primarily in an advisory role to member governments.

- Similar to the NICP, the Bay-Lake Regional Planning Commission (BLRPC) was created in 1972 by then Governor Lucey at the request of seven county boards in the region under Wisconsin Statutes s. 66.945 as the official area-wide planning agency for northeastern Wisconsin. The Commission serves a region consisting of the eight counties of Brown, Door, Florence, Kewaunee, Manitowoc, Marinette, Oconto and Sheboygan. The Bay-Lake Region is comprised of eight counties, 17 cities, 39 villages, 120 towns, and the Oneida Nation of Wisconsin, for a total of 185 local units of government. The total area of the region is 5,433 square miles, or 9.7 percent of the area of the State of Wisconsin. The region has over 400 miles of coastal shoreline along Lake Michigan and Green Bay, and contains 12 major watershed areas that drain into the waters of Green Bay and Lake Michigan.
- SEMCOG, the Southeast Michigan Council of Governments, serves as the regional planning authority in Southeast Michigan. SEMCOG influences the seven most populated counties in Southeast Michigan; Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne counties. At SEMCOG, local government representatives deliberate on regional issues such as improving transportation and water quality. Policy decisions are made by local elected officials of SEMCOG's member governments, ensuring that regional policies reflect the interests and concerns of the member communities.

A key recommendation of this paper is to engage these 38 established COGs in a coordinated fashion to promote growth management and water quality protection between various units of local government through out the Great Lakes region. To varying degrees, some of this coordination is already taking place. If funding dollars were available to future promote and implement regionally mandated policies, great strides could be made in the area of watershed planning to reduce impacts of development on watershed hydrology.

Rather than creating new governmental organizations charged with developing and administering coordinated regional growth management, using existing Regional Planning Agencies – in association with state offices of planning – could provided a needed outlet for implementing necessary actions and funded programs for protecting water quality within the Great Lakes basin.

Attempting to coordinate large-scale watershed restoration efforts is not new, particularly when numerous levels of government and non-governmental agencies are involved. In 1987, more than 50 local, state and federal units of government joined together to coordinate restoration efforts in the highly urbanized metropolitan

Washington, D.C. Anacostia River watershed as part of the Anacostia Restoration Agreement of 1987 (Metropolitan Washington Council of Governments 1990). In 1991, all signatories of the original agreement pledged their continuing support as part of a coordinated *Six-Point Action Plan* to improve water quality and riparian habitat (Metropolitan Washington Council of Governments 1991). Although this effort was far reaching in its efforts to protect and improve water quality of the Anacostia River watershed – a significant tributary to the Chesapeake Bay – it did not address land use and growth management. This weakness was at least addressed when Maryland began efforts to control sprawling land use as part of their Smart Growth Initiative (Haeuber 1999).

In addition to the existing regional planning agencies, Stormwater Authorities or Utilities, are relatively new organizations designed to address many of the secondary impacts of growth. However, if used in combination with regional growth management, there is tremendous potential to both deal with growth and sprawl regionally while managing impacts of development on watershed hydrology locally.

A stormwater authority is a useful funding mechanism for controlling regional water quality problems caused by non point source stormwater runoff (Center for Watershed Protection and Land Ethics 1996). Various local governments from across the United States, such as San Antonio, Texas, Cincinnati, Ohio, Bellevue, Washington, Asheville, North Carolina, and Brevard County, Florida, for example, have found stormwater utility authorities as a reliable means by which to finance regionally-based stormwater management programs (Maniatis 1990). Despite some initial acceptance problems, though, the number of stormwater utilities is increasing rapidly. The first few stormwater utilities were started in the early 1970s. A 1994 Environmental Protection Agency report estimated the number of regional stormwater authorities in the United States at just over 100. Today there are more than that in the state of Florida alone, and more than 400 nationwide, with high concentrations in Washington, Oregon, and California. It is estimated that the country will have 2,500 stormwater utilities within the next 10 years (Kaspersen 2001).

A regional stormwater authority requires users to pay service fees. In the same way that water and sanitary sewer utilities are self-supporting, a Stormwater Authority/Utility charges fees for the operation and maintenance of the stormwater infrastructure, engineering and design, and for capital improvements. These user fees are then used to finance stormwater projects; commercial and residential users pay a fee in proportion to the extent to which they contribute runoff. To establish an equitable system for how much to charge customers, many utilities base their rates on the amount of surface runoff contributed by an individual land use area. The area of surface runoff is calculated by either accounting for the size of the land or the amount of impervious surface area (Maniatis 1990).

Example of a Successful Regional Stormwater Authority: Brevard County, Florida

- Brevard County, Florida encompasses approximately 1,500 square miles with most of the urbanized sections of the County located along the coast and barrier islands. Unlike other areas of Florida, where most of the stormwater drains to a relatively small number of lakes or rivers through large collection systems, the stormwater outfalls in Brevard County drain to either the Indian River Lagoon (IRL) or the St. John's River. The IRL occupies the majority of central Brevard and includes the Indian River, Banana River and Mosquito Lagoon. Throughout Brevard, there are over 2,000 stormwater outfalls, which convey untreated stormwater into the Lagoon.

As part of the implementation of its growth management plan, local regulations were changed in 1978 to assure that all subdivisions and commercial sites developed within Brevard County were required to treat stormwater runoff and to store runoff volumes to decrease flooding of downstream properties. Much of Brevard was developed prior to this time and had little or no local or regional stormwater treatment facilities; untreated stormwater was conveyed into larger receiving bodies of water. To prevent flooding in these areas and address stormwater-related pollution problems, additional measures were required. In September 1990, Brevard County adopted an ordinance that created the Stormwater Utility, thereby providing a dedicated source of funding for the stormwater management program.

The stormwater utility is an assessment billed yearly in November. The billing is based on the equivalent residential unit or ERU (Maniatis 1990), which is equal to an average of 2,500 ft.² of impervious area for a single-family residential property, and not based on the value of the parcel. As of 2001, the fee was \$36/ERU per year. All funds collected from the utility are used for the implementation and construction of capital improvement projects that address both water-quality and -quantity (flood control) issues. Funds collected in specific districts are used for projects in that district, so in essence, this is a revolving fund.

The utility is administered by a staff of 13 people including engineers; environmental scientists; and public-outreach, finance, and field-inspection personnel. Together they are responsible for planning, designing, constructing, and maintaining the projects supported by stormwater funds. Additionally, Brevard has developed and implemented a Stormwater Utility Assessment credit program for owners of property serviced by approved and maintained stormwater treatment systems (BMPs). These systems reduce runoff pollutant loadings before they reach receiving water bodies. The policy provides a reduction in stormwater assessments for various levels of owner-implemented and -maintained

stormwater treatment. A compliance and inspection program for proper maintenance of the treatment system is an integral part of this program.

Kaspersen noted that a Natural Resources Defense Council survey of laws in all 50 states found that in almost all cases, municipalities can legally create stormwater utilities (Kaspersen 2001). Typically two ordinances are needed: the first to establish the utility itself and the second to set the rate structure. Depending on state and local law, a general referendum may be needed for the first ordinance, or the city council or county board of supervisors may vote on it.

The benefit of Regional Stormwater Authorities / Utilities is that they essentially function as a special assessment district set up to generate funding specifically for stormwater management. Unlike a stormwater program that draws on the general tax fund or uses property taxes for revenue, the people who benefit are the only ones who pay, hence the phrase, “revolving fund.” When stormwater authority/utilities are combined with coordinated regional land use and growth management planning, there is great potential deal with growth and sprawl regionally while managing impacts of development on watershed hydrology locally.

d. The Root of the Problem at the Local Level of Government: Ineffective Land Use Planning

- Improve the inclusion of the public in the planning process

In spite of what appears to be many years of successful programs and initiatives enacted to protect water quality of the Great Lakes, legislators have been slow to address the important issues; sprawling development and the associated impacts which can be attributed to non point source pollution (Michigan Environmental Council 2002; Michigan Environmental Council 2004). Land use planning has not adequately addressed issues regionally and only on a spot by spot – or community by community basis. Whereas this issue was brought to light more than ten years ago (Michigan Environmental Council 2002), there are many actions which can establish land use policies that will in fact affect water quality in a measurable way.

In addition to the need for coordinated regional state and county-wide planning, many existing efforts have been criticized for not better including the public in the planning process through round table discussions and long-term visioning (Michigan Environmental Council 2004). Seeking out and actively soliciting the opinions, desires, and involvement of the public in watershed and natural resource planning is a key point which has a history of being either overlooked or underestimated by government.

Numerous researchers have identified the need for public and interagency coordination and dialogue among stakeholders (Duram and Brown 1999; Konisky and Beierle 2001; Burby 2003). Although this point is well established in the literature, comprehensive watershed approaches have not been consistently employed in resource management and the implementation of those management plans (National Research Council 1993). Within the past 10 years, there has been emphasis placed on including public participation in all phases of the community master planning process. Many of these communities are suburban in density and the key issues then to be associated with preservation of quality of life such as preservation of open space, sustainable neighborhoods, accommodating traffic congestion, or providing economic stability. What often results is dependence on the part of resource managers to rely on expert knowledge and government regulations with secondary concern for public involvement.

However, recent studies have shown that public participation is becoming recognized as a viable part of watershed management and their related land use plans, particularly when addressing complex problems such as non-point-source pollution (Goldfarb 1994) as cited in (Duram and Brown 1999). In their research into key factors that can have a positive influence on the public's perception of watershed planning, Duram and Brown determined that involving collaboration of government bureaucracy and the general public is essential to ensure the long-term success of a watershed plan. The public involvement process provided a forum for increased awareness of watershed issues.

Konisky and Beierle determined that of the some of the frequently used methods of public participation, such as hearings and comment forums elicit primarily reactive responses (Konisky and Beierle 2001). This is particularly true when the public hearing has not been preceded by visioning workshops and roundtable input sessions; the public feel that their input is of little consequence. Some of the innovative participatory processes include the use of study circles, round-table discussions, and a collaborate variety of watershed management efforts amongst different government agencies. Plans, be they for watershed management or general community comprehensive planning, have a positive impact and are effectively implemented if they involve a wide array of stakeholders in the process (Burby 2003).

An effective public participatory process begins with input sessions and concludes with a formal hearing to adopt a plan which should have included numerous forums for input by stakeholders, citizen action groups, neighborhood associations, non government organizations, neighboring municipalities, and elected officials. Problems can exacerbated by a lack of openness from the scientific community, which further reduces the public's trust in being involved in the decision-making process (Till 1995).

Of benefit in the past decade, state and federal legislation have mandated increased public involvement in resource planning. This type of government action

should be viewed as a positive step as it will help smooth the progress of implementing resource plans (EPA Office of Water 1993; EPA Office of Water 1995).

e. Smart Growth Initiatives

- implementing smart growth initiatives on a broader scale
- deal with sprawl as a means for limiting the impacts of development on watershed hydrology

Various states and municipalities have begun to experiment with alternative patterns of land use over the past twenty five years. However, some of the legislative and planning approaches such as Oregon’s Land Use Act which was passed in 1973 (Gale 1992) have experienced varying degrees of success. The issue lies in the regional policies of concern to state government which have little apparent or immediate relevance to local government (Deyle and Smith 1998).

In a 1992 report published in the Journal of the American Planning Association, eight different state-sponsored growth management programs were compared (Gale 1992), revealing wide diversity in how the programs were implemented along with differing program requirements. Table 6.3 details primary components of each of the eight different state sponsored growth management programs (adapted from Gale 1992). All of the eight state-sponsored growth management plans were provided for through state enabling legislation; mandating local comprehensive (master) plans – some states requiring county or regional comprehensive plans; mandating review and approval of the local plans by a state authority; mandating a system of incentive-based programs to encourage compliance; limiting the number of plan amendments; and mandating periodic master plan updates. As described by Gale, the greatest benefit for enacting state-sponsored growth management laws relates to bridging the void between state environmental – or federal environmental regulations, disjointed attempts at regional planning, and scattered inconsistent local growth management efforts. Thus, the applicability for enacting state-sponsored growth management laws is relevant in states, such as Michigan, where each city and township develop their own comprehensive plans with little or no regional oversight to ensure consistency in objectives and policies.

Table 6.3: Growth Management Programs by State (*adapted from Gale 1992*)

	Legislation	Date Enacted	State Agency Oversight	Eligible Or Mandated to Prepare Plan
Oregon	Senate Bill 100 Oregon Land Use Act	1973	Department of Land Conservation and Development: Land Conservation and Development Commission	241 communities, 36 counties and Portland Metro Service District
Florida	State Comprehensive Planning Act / Growth Management Act	1985 / 1986	Department of Community Affairs	467 Communities, 67 counties, 11 regional bodies and state
New Jersey	State Planning Act	1986	Department of Treasurer, Office	Five planning area plans

Maine	LD 2317 Comprehensive Planning and Land Use Act	1988	of State Planning and State Planning Commission Department of Economic and Community Development	prepared by the state 494 communities
Vermont	Act 220 Growth Management Act	1988	Department of Housing and Community Affairs	247 communities and 14 regional commissions
Rhode Island	PL 88-601 Comprehensive Planning and Land Use Regulation Act	1988	Department of Administration (Division of Planning)	39 communities, state agency plans, and state guide plan
Georgia	House Bill 215 Georgia Planning Act	1989	Department of Community Affairs	538 incorporated cities, 159 counties, 18 regional development councils, and state
Washington State	House Bill 2929 Growth Management Act House Bill 1025 (amendments)	1990 / 1991	Department of Community Development	39 counties and the cities within them

Research indicates that states that are most likely to enact growth management legislation are those with valuable and high quality natural resources, such as tidal estuaries, fisheries, lakeshore, and seacoasts (Gale 1992). The linkages between natural resource amenities and revenue from tourism would seem to be self evident. However, the need for political leadership who are willing to make tough decisions and enact regulatory measures which may not always receive broad support from constituents is a key component that requires both grass-route support and top-down leadership. Researchers advocate that if regional planning and growth management ideas are to be effectively implemented, social capital must be built, and social movements carefully cultivated (Wheeler 2002). Recognizing that the act of establishing trust between political leaders at every level of government, private sector interests, and environmental advocates is an ongoing process. Clearly illustrating the interdependent nature of business, economic prosperity, natural resource protection, and coordinated planning efforts is critical to success.

Some states, such as Maryland, have taken leadership roles early-on in response to sprawl and its impacts on the environment through implementation of their Smart Growth initiative. Enacted in 1997, Maryland's Smart Growth legislation has been successful in using incentives for local units of government who wish to join together initiatives such as urban revitalization and land conservation (International Joint Commission 1978; Haeuber 1999).

Two examples, one from Maryland and one from Florida provide insight into how broad state mandated growth management efforts can effectively impact watershed protection.

1. The Chesapeake Bay Critical Area Protection Act

In 1984, the State of Maryland enacted the Chesapeake Bay [Critical Area] Protection Act through an Act of the state General Assembly. The Critical Area Act recognizes that the land immediately surrounding the Bay and its tributaries has the greatest potential to affect water quality and wildlife habitat and thus designated all lands within 1,000 feet of tidal waters or adjacent tidal wetlands as the “Critical Area.” (State of Maryland General Assembly 1984). The Act required the 16 counties, Baltimore City, and 44 municipalities surrounding the Bay to implement a land use and resource management program designed to mitigate the damaging impact of water pollution and loss of natural habitat, while also accommodating the jurisdiction’s future growth. Although these twin initiatives may seem to be in conflict with each other, the Critical Area Act was successful in accommodating both agendas for more than 20 years. The Critical Area Act is a useful example of how a state-mandated planning act has been used to guide local (County) units of government in a coordinated manner for resource protection and land use planning.

One of the interesting components of the Maryland Critical Area Act has to do with how implementation was encouraged and promoted at the local level. Specifically, the Act provided the option for allowing each of the Critical Area municipalities to develop their own plan, using the new state law as a baseline and adding other specific provisions unique to their jurisdiction. Each plan had to be submitted to the state for review and approval. If one of the 44 plus-municipalities chose not to develop their own plan, the state would devise a generic one for them; most every jurisdiction developed their own plan within an allotted period of time. This flexibility gave the state the ability to delegate implementation to each of the local units of government rather than encumbering themselves with the responsibility of both developing plans and then enforcing them in each municipality. Specifically, State government provided financial assistance to each of the 16 counties, et al, to develop and implement their own land use and resource management plans. Funding was to be used to hire staff who would then draft a local plan, coordinate with the state Critical Area office, amend local master plans, and review proposed development plans for compliance. Each jurisdiction’s state house representative sat on the 27-member Chesapeake Bay Critical Area Commission, and worked to craft polices in the spirit of consensus. The Maryland Critical Area Act has been successful because it provided funding and incentives for local units of government to develop and enact a state regional planning initiative.

2. The Florida State Comprehensive Planning Act / Growth Management Act

Florida’s Comprehensive Planning Act, which derives from the 1985 Local Government Planning Act (Chapter 163 of the Florida Statutes), specifies that all cities and counties in the state prepare and adopt local comprehensive plans and have them approved by the state Department of Community Affairs. This planning mandate was considered to be both broad and detailed; early on Florida was generally thought to be one of the strongest states for mandating coordinated local planning via a regional (state) authority (Deyle and Smith 1998). Whereas many local governments prepare master

(comprehensive) plans in other states, they are not often required to submit them to a state authority for review and approval.

Only recently have states such as Michigan required an external review period where draft comprehensive plans are circulated to neighboring municipalities and the county for review and comment. In Florida, local comprehensive plans as part of the Local Government Planning Act are required to include eight key program elements or chapters. These include the following:

1. capital improvements
2. future land use
3. traffic and circulation
4. sanitary sewer and solid waste, drainage, potable water and aquifer recharge
5. conservation of natural resources
6. recreation and open space
7. housing
8. intergovernmental coordination

Municipalities with coastal waters were also required to prepare plans for dealing with coastal storm hazards as part of a coastal management chapter. These plans focused on existing land use inventories, hurricane evacuation plans, post disaster guidance for redevelopment, beach and dune system analysis, coastal inventory and analysis, and a series of goals and policies for management and restoration.

Once a municipality prepared their draft plan, it was submitted to the Department of Consumer Affairs (DCA) for review, comment, and identification of deficiencies. Plans were reviewed by teams of planners who made suggestions for how to amend the draft(s) and resubmit for approval. The teams who conducted the review of the draft plans were themselves reviewed by senior staff at DCA. The overall time frame for communities to prepare the draft plans and then amend them spanned a four year period between 1988 and 1991 (Deyle and Smith 1998). The DCA had state authority to find the plans in compliance with state law or to impose sanctions for noncompliance through the State Administrative Commission.

Deyle and Smith conducted a very careful and detailed evaluation and review of the coastal elements contained in the final state adopted comprehensive plans as prepared by nine counties and nine cities located across the state of Florida and found substantial variation in levels of compliance. They concluded – based upon literature review and experience – that when it came to coercing local governments via a state mandate, political pressure and governmental feasibility substantially affected how the DCA enforced the planning mandates. Their findings suggest that it was primarily the way in which state officials imposed sanctions (such as withholding state funds from local governments) more than the sanctions themselves which caused variability in the overall

success of the state mandated planning act. To ensure buy-in and conformity by various local officials, primarily using the power of the law for enforcement can create adverse working relationship and potentially short circuit well intention initiatives. Local officials must feel that they have the ability to work with state officials and not against them when it comes to developing the details of their local plans.

In retrospective, Florida’s Comprehensive Planning Act has been somewhat successful in coordinating many of the local units of government to prepare master plans which address a consistent set of issues and elements – based on state mandated statutes. Although some communities have not been successful in crafting a master plan which fully complies with the intent of state initiatives, there are an equally large number of those which have. Thus, it can be concluded that state mandated planning for local government has been effective in Florida, particularly when planning for natural hazards. The key to ensuring success with regards to state mandated statutes on local units of government is cooperation, negotiation, and inclusion through out the planning process. Where variability in compliance does exist, it may have to do with the details of the state’s requirements how they mirror and influence the local issues in certain communities.

f. Actions in Great Lakes States Relative to Smart Growth

Whereas statewide growth management laws have not been uniformly enacted in many Great Lakes states, there are a number of smart growth initiatives being considered as programmatic or policy changes on the state level. Some have been adopted through state planning and other legislation as part of their comprehensive planning laws such as Wisconsin; others are recommendations prepare through bi-partisan commissions or councils as in the Land Use and Leadership Council report in Michigan. Table 6.4 summarizes smart growth initiatives underway in six of the seven Great Lakes states. What is needed next is for each of the states to coordinate these smart growth initiatives and work to enact them uniformly, perhaps thorough the 38 regional planning organizations.

Table 6.4: Smart Growth Initiatives in Great Lakes States (Victoria Pebbles, Great Lakes Commission, unpublished work, 2004.)

Illinois	Illinois Tomorrow	Creation of a Balanced Growth Cabinet to evaluate and coordinate state programs to ensure they are being used effectively
Michigan	Michigan Land Use Leadership Council Report Recommendations	More than 160 recommendations; new legislation, modification of existing rules and regulations
Minnesota	Minnesota Smart Growth Initiative	Established a statewide smart growth framework with: bonding criteria; smart buildings partnership; state development strategy; guide for local planning; model ordinances

Ohio	Ohio Balanced Growth Initiative	Establish Watershed Planning Partnerships; designate Priority Conservation Areas and Priority Development Areas
Pennsylvania	Growing Smarter and Growing Greener (Volumes I and II)	<ul style="list-style-type: none"> • Interagency Land Use Team; established Center for Local Government Services; revamped state planning laws to encourage TDR, multi-municipal planning, etc; planning grants • \$800 million bond initiative for farmland & open space; environmental cleanup; community revitalization--paid for by fees on waste and pollution
Wisconsin	Comprehensive Planning and Smart Growth	Legislation defines "comprehensive plan," outlines procedures for adopting the plans, requires consistency between zoning and adopted plans; provides grants for planning.

Experiences in Michigan provide further insight into state growth management efforts. In spite of the inability of legislators to respond to studies and reports citing unmitigated sprawl as the culprit which damages water resources, in Michigan land use reform has begun to take shape. It evolved out of a grass roots, citizen and non government lead movement unlike Maryland where the impetus for a Smart Growth Initiative came from both local and state government, and then championed by former Governor Glendenning's administration. Led by the Public Interest Research Group in Michigan (PIRGIM), Michigan's environmental community reached out to more than 20,000 citizens to engage them in the Michigan Land Use and Leadership Council process (Michigan Environmental Council 2003). Created by executive order in February 2003, the group worked for six months to reconcile politics with the restructuring of local land use planning, all in an attempt to address both sprawl and urban decline. It was the desire to address both sprawl on farmland and associated decline of urban centers which made this effort unique. The effort did not assume that by reining in suburban sprawl, urban centers and higher density downtowns would quickly begin to revitalize through gentrification. The effort did make the argument that the state could no longer support the price associated with "flight" from established urban areas onto rural township landholdings.

The report suggested increasing coordination among the 1,800 local units of government involved in planning; Michigan relies on township government and local planning commissions to form land use policies. Historically, there has not been effective regional planning, but rather a myriad of piece-meal attempts to foster growth control. The report also recommended providing an increased role for state participation and better targeting of state funding. Other recommendations included directing re-development funds and expertise into existing urbanized areas that already have sufficient infrastructure needed to meet demands for growth. The approach was very similar to that of the Maryland Smart Growth Initiative's Priority Funding Areas (PFAs).

The recommendations contained in report of the Michigan Land Use Leadership Council (Michigan Land Use Institute 2004) can be used as a guide for what is possible in a state that has not historically engaged in coordinated regional approaches to solving locally based issues. What are needed next are steps towards implementing many of the recommended actions, one of which should be state-mandated local planning reforms that support growth strategies for protecting water quality of the Great Lakes. Should Michigan or any of the other Great Lakes states move forward with coordinated local planning, they will be effective if they take place in a strategic and cohesive manner. Similar approaches have been successfully implemented in states such as Florida (Deyle and Smith 1998) and Maryland (Haeuber 1999; State of Maryland General Assembly 1984). In these states, and others, planning mandates have been used to achieve state planning goals specific to protection of resources.

Additional efforts to encourage local municipal government to work regionally have begun to gain momentum in Michigan. Described as an aggressive effort to spur community-wide planning, the Partnerships for Change program was created by the Land Information Access Association (LIAA) in partnership with the Michigan Municipal League (MML) and the Michigan Townships Association (MTA) (Michigan Environmental Council 2004). Local governments across Michigan will be invited to apply for support under Partnerships for Change, but only as partnerships including at least one city or village and one or more townships. A project advisory committee has been named to help guide the project, comprised of a number of local officials and planning experts. The project is designed to help cities, villages and adjacent townships develop a common vision for the greater community. According to the project sponsors, cooperative planning can result in big savings on infrastructure investments, like water and sewer projects, as well as reducing the detrimental impacts of uncoordinated development. This is Michigan's first statewide grant program to provide direct professional support for joint municipal planning and resource management.

7. Key Recommendations of this Report

- **Central Coordination and Local Control: Incentive Based Approach**
 - State and or regional planning authorities should provide incentive funding for local government to develop coordinated land use growth management plans at the watershed level.

- **Actively Engage the Federal Interagency Task Force in Regional Watershed Planning Efforts**
 - The Interagency Task Force was charged with using regional collaboration to bring hundreds of regional, state, local, tribal and other interests together for the purpose of developing an overall strategy for protecting the Great Lakes.
 - The federal government should take advantage of this leadership role by making funding available to state and regional authorities who wish to develop joint or regional growth management plans.
 - GAO recommended in its April 2003 report that the Administrator, of the Environmental Protection Agency ensures that the Great Lakes National Program Office fulfill its coordination responsibilities and develop an overarching Great Lakes strategy. A cornerstone of this strategy should be regional coordinated land use planning.

- **Make Better Use of Regional Planning Groups (COGs)**
 - A key recommendation would be to actively engage the 38 established COGs in each of the eight states in a coordinated fashion to promote growth management and water quality protection between various units of local government through out the Great Lakes region. This might involve re-delegation of greater planning and implementation power to the COGs. Many local units of government are already members and have representation and should have a voice in regional decision making.

- **Institute Uniform Standards for Measuring Water Quality**
 - The GAO recommended that either EPA or the states develop environmental indicators and a monitoring system for the Great Lakes Basin that can be used to measure overall restoration progress.
 - States should establish uniform standards for determining Great Lakes water quality. A consistent method for monitoring and reporting will help the IJC and others in their efforts to recommend land use planning practices relative to protecting water quality and achieve the President's Order calling for measurable results of clean up efforts.

- **Promote Smart Growth Initiatives**
 - There are a number of smart growth initiatives being considered as programmatic or policy changes at the state level. Some have been adopted through state planning legislation as part of their comprehensive planning laws. What is needed next is for each of the states to coordinate these smart growth initiatives and work to enact them uniformly, perhaps thorough the 38 regional planning organizations.

- **Implement the Recommendations of the Michigan Land Use and Leadership Council Report**
 - Take action on the Michigan Land Use Leadership Council recommendations for coordinated planning among 1800 units of local government.
 - The report also recommended providing an increased role for state participation and better targeting of state funding.
 - Other recommendations included directing re-development funds and expertise into existing urbanized areas that already have sufficient infrastructure needed to meet demands for growth.

- **Create Regional Stormwater Authorities in the Great Lakes States**
 - A stormwater authority is a useful funding mechanism for controlling regional water quality problems caused by non point source stormwater runoff. If used in combination with regional growth management policies, there is tremendous potential to both deal with growth and sprawl regionally while managing impacts of development on watershed hydrology locally.

- **Increase Public Involvement in Watershed Planning Initiatives**
 - Seeking out and actively soliciting the opinions, desires, and involvement of the public in watershed and natural resource planning is a key point which has a history of being either overlooked or underestimated by government.
 - Actively involve both public and interagency coordination and dialogue among stakeholders.
 - Innovative participatory processes include the use of study circles, round-table discussions.

- **Education**
 - Expand watershed mitigation education efforts to include the importance of comprehensive watershed planning.

- Expand education efforts to include a scheme of integrated structural (engineering, bioengineering) and non-structural (site planning, regional planning) tools
 - Focus background educational efforts on the importance of the balance of runoff, infiltration and evapotranspiration in the hydrologic scheme.
 - Expand education on the limits of BMP efficiency and the strengths and weaknesses of each approach.
 - Provide additional education on coordinated use of BMPs and planning techniques as part of a comprehensive approach to water quality and watershed hydrology planning.
 - Improve design standards for structural BMPs.
 - Implement mitigation banking and tradable permits on a trial basis to assess their efficacy.
- **Research**
- Conduct ongoing research on the effects of planning techniques to determine which are the most successful and how to amend current practices.
 - Identify a comprehensive and detailed series of land use classes a typical of the Great Lakes region that identify specific TIA and EIA percentages for each land use type from actual measurements in the region.
 - Using these figures as a baseline, analyze the actual effects that regional and site planning techniques can make on TIA, EIA, infiltration, base flow and evapotranspiration.
 - Expand research on the effects of the location of impervious surface within a watershed.

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