How Much Development is Too Much?

A Guidebook on Using Impervious Surface and Gravel Road Capacity Analysis to Manage Growth in Rural and Suburban Communities.

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Introduction

HISTORY OF THE PROJECT

This project was funded by the Kellogg Foundation through their People and Land Program, which funds organizations working in land-use education, leadership development, planning model identification, and policy development. PAL seeks to raise awareness and inform the land-use debate in Michigan to help find common ground among diverse interests.

The project is a partnership between the Huron River Watershed Council (HRWC), Planning & Zoning Center, Inc. and staff of the Livingston and Washtenaw County Road Commissions.

WHAT IS THE HURON RIVER WATERSHED COUNCIL?

The Huron River is located in southeast Michigan and flows to Lake Erie. It is the only river in southeast Michigan designated a Country-Scenic Natural River. Along with the member governments (who have land in the watershed under their jurisdiction) and hundreds of individual and business members and volunteers, HRWC inspires attitudes, behaviors, and economies that protect, rehabilitate, and sustain the Huron River System. HRWC was established in 1965 under Michigan's Local River Management Act, and it is the first and oldest Watershed Council in the State. HRWC has worked closely with local governments since 1965 to enact local wetland protection ordinances, stormwater management plans, and groundwater protection ordinances in communities throughout the Huron River Basin. HRWC was also instrumental in the passage of Michigan's Goemaere-Anderson Wetland Protection, Inland Lakes and Streams, and Natural Rivers Acts and in passage of State Natural River designation for the Huron River. Today, over thirty five communities, representing more than 350,000 people, and numerous businesses and individuals, support HRWC's technical assistance, hands-on education, and advocacy programs through voluntary membership.

WHAT IS THE PLANNING AND ZONING CENTER?

Planning and Zoning Center is a multi-disciplinary team of professionals devoted to research, education and consultation in appropriate community planning and development control, founded in 1982.

Over the past 20 years, Planning and Zoning Center has been involved in conducting over 400 training programs on a wide range of topics for over 20,000 local officials including planning and zoning commissioners, zoning board of appeals members, zoning administrators and other local officials. Over 60 specialized research projects have been completed in a wide range of areas. These have resulted in publications which have substantially contributed to improving the quality of planning, zoning, and environmental projects in the State of Michigan. Planning and Zoning Center, Inc. also publishes *Planning & Zoning News*, a monthly magazine read by over 6,000 readers.

WHAT ARE COUNTY ROAD COMMISSIONS?

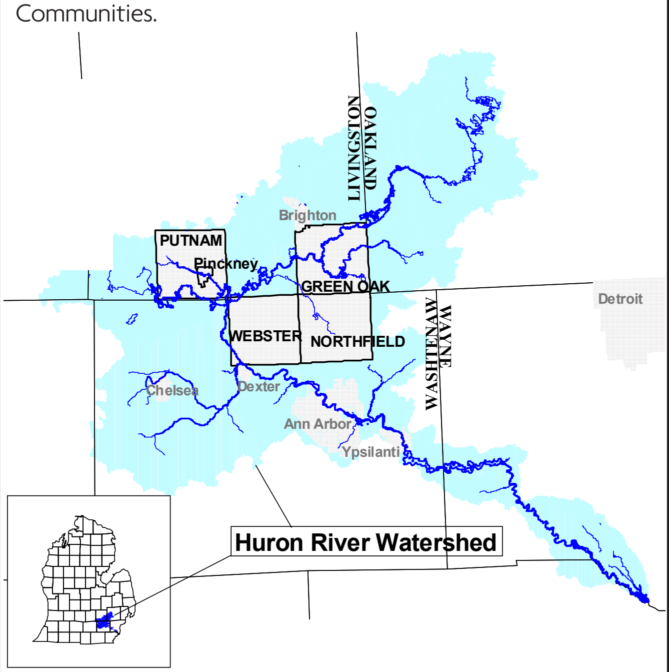
Every county in Michigan has a county road agency (with the exception of Wayne County, where the road commission merged with county general government in the 1980s). The road commission is a separate agency, removed from county general government and responsible for its own budget. Funding comes from state-collected road funds and federal road funds. Road commissions do not have taxing authority, but some local municipalities levy millages dedicated to roads and turn the money over to their county road commission for various projects.

The responsibilities of road commissions vary from county to county. In rural counties, for example, road commissions spend a great deal of time maintaining gravel roads. Commissions in the more urban counties of southern Lower Michigan split their time between maintaining gravel and paved roads. For most road commissions, winter maintenance (plowing and salting) is a major priority.

THE ADVISORY COMMITTEE

The project activities were guided by a 25 member Advisory Committee made up of representatives from county Drain and Road Commissions, County Planning Departments, the planning profession, the private sector, and 4 pilot communities chosen because they are rural but facing growth pressures. The pilot communities were Putnam Township and Green Oak Township in Livingston County and Northfield Township and Webster Township in Washtenaw County (see Figure I).

Figure I. Location of the Huron River Watershed and the Pilot Communities.



Source: HRWC.

SPRAWL AND GRAVEL ROADS

Much of the rural residential development cropping up in Michigan's rural areas is in areas served by gravel roads. As traffic volumes increase, these roads quickly become pitted and bumpy and require ever more frequent road grading. County road commissions have found it ever more challenging to meet these road improvement needs, since road improvement revenues are growing more slowly than needs.

SPRAWL AND WATER QUALITY

This rural residential development also threatens the health of the State's rural tributary streams. As impervious surfaces such as roads, rooftops, and even manicured lawns increase, storm water runoff causes flooding and reduced water quality. Studies by HRWC and others have shown that once 8 – 10% of a watershed becomes impervious, the receiving stream begins losing the ability to support aquatic life.

Other findings include:

- Transportation-related impervious surfaces comprise 63-70% of total imperviousness.
- Transportation-related imperviousness is a source of higher pollutants than rooftop imperviousness.
- Large lot developments may keep rooftop imperviousness down, but transportation imperviousness to accommodate houses (longer roads, driveways, more parking) increases.
- Large-lot subdivisions increase imperviousness by 10-50% compared to subdivisions that group or cluster homes together.
- Compact development patterns are the best way to assure imperviousness levels stay low. Per-site imperviousness may be high, but regional imperviousness will remain low. This especially reduces transportation-related imperviousness.
- Best Management Practices (BMPs) like detention ponds are important to mitigate impacts of development, but they alone will

not maintain water quality at levels found in watersheds that are under 10% impervious.

PLANNING AND ZONING TOOLS TO PROTECT WATERSHEDS AND MAINTAIN GRAVEL ROAD QUALITY

HRWC has developed a methodology to determine the current imperviousness of watersheds, and the future imperviousness the watersheds will experience if land is developed according to existing community plans and zoning. HRWC and the Planning and Zoning Center have developed planning options to encourage growth in areas where infrastructure exists to handle increased stormwater runoff, and to insure that any new developments in rural areas take into account their impact on streams.

The Planning & Zoning Center has similarly developed a methodology to determine the current capacity of a community's gravel roads, and the future capacity they will experience if land is developed according to community planning and zoning. They have developed planning options for communities to either ensure that proper infrastructure improvements are funded to improve gravel roads so they can carry the new development, or to plan for growth so that it occurs where infrastructure can better accommodate it.

> "[This analysis] gives us data where we presently don't have any to consider impacts of new development on imperviousness and gravel road capacity." -- township zoning administrator.

KEEP IN MIND

This Guidebook offers a consistent, research-based approach to land planning with specific regard to water quality and gravel road capacity issues. As you use the Guidebook for your community, keep in mind these qualifiers: we do not suggest that imperviousness and gravel road capacity are the only or most important variables to consider when doing rural planning. Rather these two variables are frequently forgotten or ignored in planning and zoning. If ignored, they have the potential to undermine many rural planning objectives.

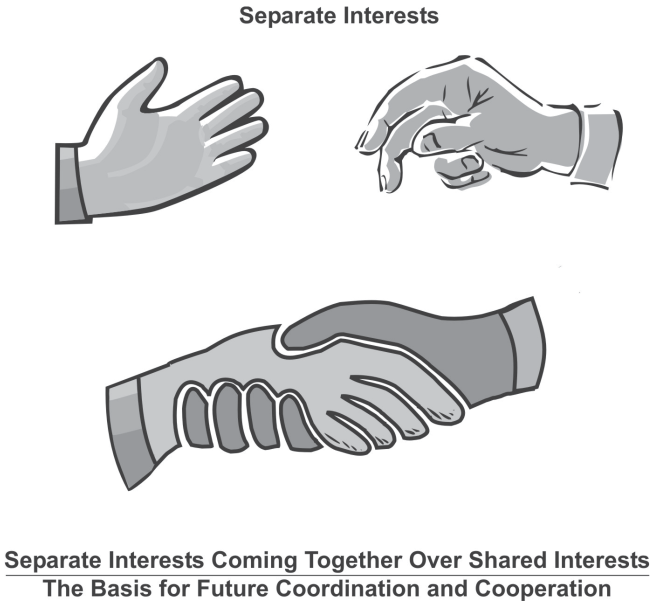
Also, not all rural land is equal on these measures. Imperviousness may be more important in some places than gravel road capacity and vice versa.

The purpose of this Guidebook is not to prevent new development, but to match levels of development to the natural system's ability to absorb runoff and to the gravel roads' ability to handle traffic.

Using these tools to better manage growth must be done for legitimate reasons as granted by state laws enabling local planning and zoning – that is, those reasons must include protecting public health, safety, and welfare. If used to drive or keep certain land uses out of a community, it may be overstepping the bounds of local planning and zoning authority.

A message frequently repeated throughout the Guidebook is that communities will have the greatest success in preserving water quality and gravel road capacity by working cooperatively with other interested organizations. In particular, important groups to include on the team that coordinates land use decision-making affecting water quality in an area include local and county governments, watershed councils, drain commissioners, and local environmental protection organizations. On the gravel road side, communities can work together with the County Road Commission to coordinate land use and road improvement decisions so that new development does not overrun gravel road capacity. The Guidebook encourages communities to work in partnership together rather than separately to achieve common objectives as illustrated in Figure II (page 4).

Figure II: Cooperation.



Source: Planning and Zoning Center, Inc.

ORGANIZATION OF THIS GUIDEBOOK

This Guidebook is organized in a way that will allow the reader to use it in several different ways:

- Part I provides information regarding the importance of imperviousness and traffic capacity to planning and zoning. It provides the background, or justification, for the methods described in this Guidebook.
- Those already familiar with these issues can turn directly to Part II, which gives a synopsis of the project's major findings and recommendations regarding impervious surface and gravel road capacities and how communities can use these concepts in their planning and zoning.
- To learn how to duplicate the analyses performed in the pilot communities in other communities, turn to Parts III and IV, which describe in detail the impervious surface and gravel road capacity methodologies. These Parts provide the data necessary to perform the methodologies, and they give guidance on how to obtain further data.
- Part V provides additional resources, contacts, publications, etc. that may be of value to the interested reader.
- The Appendices on the accompanying CD gives sample ordinances and other useful documents.

Part I. Why Care about Impervious Surface and Gravel Road Capacity

The focus of this Guidebook is on identifying and preserving capacity in two key systems—watersheds and gravel roads. *"Capacity" refers to the limit of use of a resource or infrastructure above which there is a noticeable degradation in the quality of the resource or level of service of the infrastructure.*

WHY BE CONCERNED ABOUT IMPERVIOUSNESS?

The Values of the Natural Watershed

In an undeveloped watershed, most rain and snow falling on the watershed either infiltrates into the ground or is taken up by vegetation. Much of the water that infiltrates into the ground eventually makes it into streams or lakes through groundwater seeps, or springs. Water taken up by vegetation cycles back into the atmosphere through evapotranspiration (see Figure I-1, page 6).

Because of these processes, runoff from natural areas is negligible, except after the largest storms. Ecologically intact systems provide a number of services to the community, including; groundwater recharge, pollutant removal, temperature reduction, erosion control, air purification, flood and drought control, wildlife habitat, increased property values, and recreation.

> **NOTE:**
> A detailed description of the research behind the conclusions summarized in this Part appears in *Watershed Planning: Determining Impervious Surface Capacity to Better Manage Growth at the Rural/Urban Fringe*, by Kris Olsson, Huron River Watershed Council (Appendix A), and *Gravel Road Capacities as Tools to Guide Local Planning and Zoning at the Rural/Urban Fringe*, by Mark Wyckoff and Michele Manning, Planning and Zoning Center, Inc. (Appendix B).

Imperviousness and Water Quality

As development within a watershed increases, it brings with it an increase in impervious surfaces. Water runs directly off these surfaces and into lakes and streams. This causes many problems for the stream and its inhabitants (Bird, et. al, 2000). In highly impervious watersheds, the stream receives a flood of runoff water just after rainfalls or large snowmelts, but is deprived of water during dry times (see Figure I-2, page 6).

Both the high flows and the low flows are problematic for the stream. The high flows can damage aquatic habitats and scour the banks, while low flows deprive aquatic wildlife of water and oxygen. Runoff water is also much warmer than groundwater, and carries with it soil and whatever substances it may pick up from the landscape along the way, such as fertilizer, pesticides, oils, and other pollutants. The system loses its capacity to provide the ecological services mentioned above.

Many studies have shown a correlation between imperviousness and a wide variety of measures of water quality, including stream temperature, biodiversity , and pollution (Schueler, 1995). These studies have shown a remarkable consistency in that, when the amount of imperviousness in a watershed exceeds about 8 – 10%, streams start to show negative impacts. Above these imperviousness levels, water quality degrades. It is easiest to analyze and monitor land use and impervious surfaces at the subwatershed level. A subwatershed is a small area of not more than 10 square miles (generally) within a much larger watershed (see Figure I-3, page 7).

Water Quality and Residential Development

These levels of imperviousness are reached very easily with minimal development. Studies of the amount of impervious surfaces created by different types of residential development show that watershed imperviousness exceeds 10% once residential densities pass a threshold of about 1 dwelling unit per 2.5 acres (U.S.D.A. 1986).

Transportation and Imperviousness

The components of imperviousness are made up primarily of rooftops and the transport systems (roads, driveways, parking lots) built up with development. This transport component makes up 63-70% of the impervious area created by development (City of Olympia, 1994; Cappiella and Brown, 2001). This uneven distribution is even more pronounced in rural and suburban areas, where roads must be longer to reach homes further apart, driveways must be longer to reach homes set back further from roads, and parking lots must be larger to accommodate more cars, since alternative modes of transport are less common or nonexistent (Schueler, 1995) (see Figure I-4, page 7). In addition, water running off of roads and parking lots is more polluted than water running off of rooftops (Schueler, 1995; The Village Project, 2000).

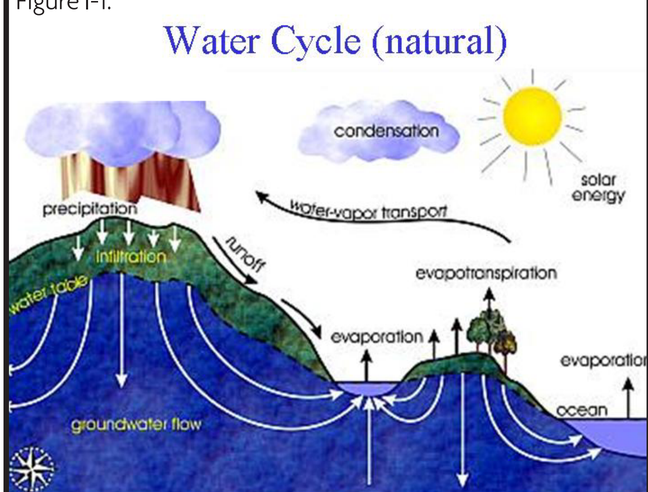
> **WHAT IS IMPERVIOUSNESS?**
> Impervious surfaces include rooftops, roads, driveways, sidewalks, parking lots and other surfaces that prevent rainfall and snowmelt from infiltrating into the ground.

Therefore, it is highly effective to focus planning and zoning strategies on reducing impervious surfaces related to transportation, both because those strategies would address the larger proportion of the impervious surfaces, and because roads and parking lots have a higher impact on water quality than do rooftops.

An Ounce of Prevention

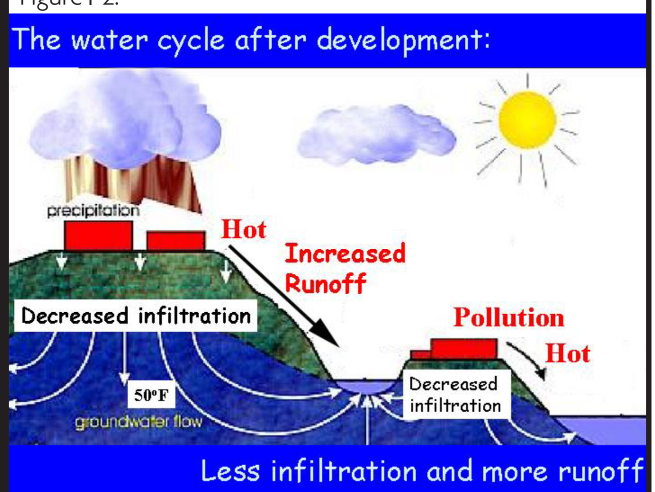
An ounce of prevention is worth much when it comes to land use planning and water quality. It is less expensive and better for the creek to plan ahead by identifying areas for compact development and protecting open space that maintains the natural water cycle. By contrast, having to treat water runoff from development that has already occurred is much more expensive. For instance, the City of Ann Arbor has engaged in a restoration plan for the Mallett's Creek Watershed, in the Huron River Watershed. Impervious

Figure I-1.



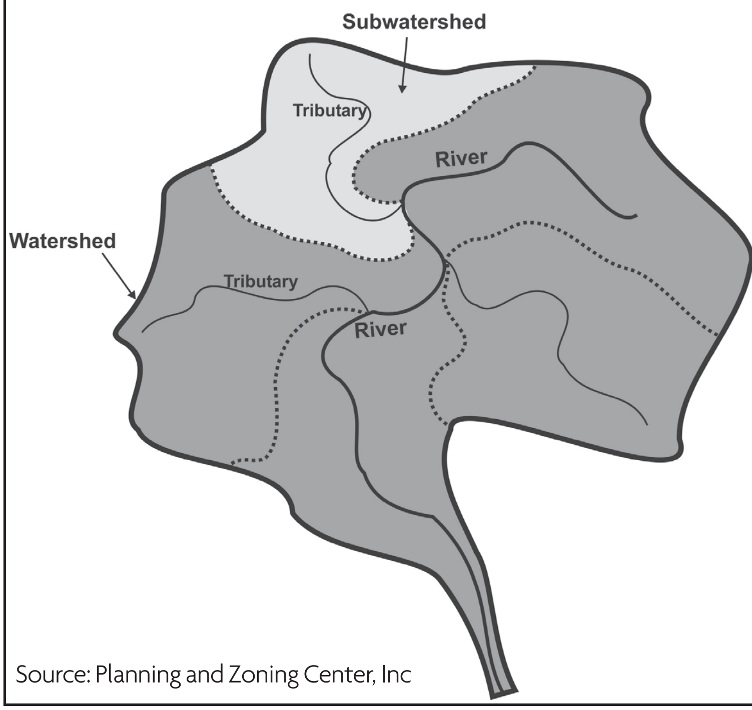
Source: Nonpoint Source Education of Muncipal Officials, University of Connecticut.

Figure I-2.



Source: Nonpoint Source Education of Muncipal Officials, University of Connecticut.

Figure I-3: Subwatershed Delineation



Source: Planning and Zoning Center, Inc

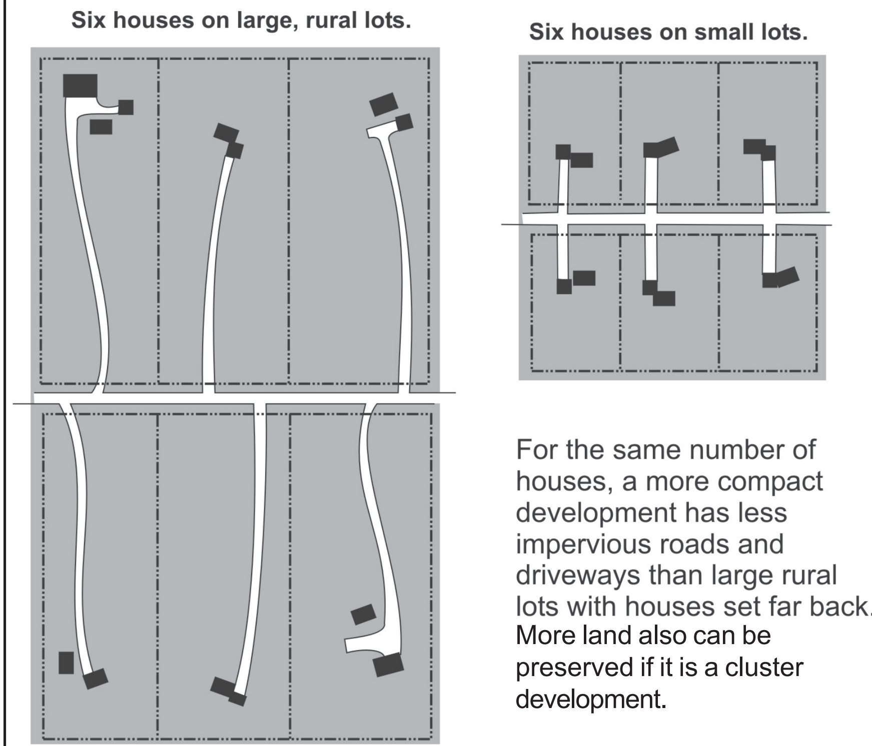
Also, while stormwater treatment practices can mitigate impacts of development, they alone will not serve to maintain or restore watershed quality to that of an undeveloped watershed. Pollutant levels running off of a developed site with stormwater treatment practices in place will still exceed levels running off of an undeveloped site (Schueler, 1995).

Disconnect: Land Use Decisions and Water Quality Management

The responsibility for managing waterways is that of the Michigan Department of Environmental Quality and the County Drain Commissioner. Yet local governments have the responsibility to plan and zone for the use of the land that drains into those waterways. As described above, these local land use decisions have an enormous effect on water quality.

surfaces cover 37% of the Mallett's Creek Watershed, and it has experienced most of the problems outlined above for highly impervious watersheds. Restoration activities are slated to cost over $24 million over 6 years (Washtenaw County, et. al., 2000). The Rouge River Watershed, which drains much of the metropolitan Detroit area, is highly degraded. In order to address the flooding, water pollution, loss of biodiversity, and loss of recreational opportunities caused by decades of urbanization that did not take imperviousness into account, federal, state, and local governments have had to commit billions of dollars towards restoration activities, including the building of multi-community stormwater detention basins. Costs for these basins alone have ranged between $1 and $3 billion (Hufnagel, et. al., 1997).

Figure I-4. Imperviousness on Large Lots.



Source: Planning and Zoning Center, Inc.

Obviously, there is a great need for local governments and County Drain Commissioners to coordinate and cooperate in the process of making decisions within their individual scope of responsibility if common objectives are to be achieved. Part III describes a way in which this can happen to the benefit of all parties.

Imperviousness and Federal Regulations

New federal stormwater regulations (Phase II of the National Pollutant Discharge Elimination System of the Clean Water Act) will require many communities to undergo a permitting process for stormwater pollution. The tools described in Parts II and III, and the sample ordinances included in the Appendices can help communities develop and implement these requirements.

WHY BE CONCERNED ABOUT GRAVEL ROAD CAPACITY?

What is Gravel Road Capacity and Why is it Important?

Gravel road capacity is the desired maximum daily traffic volume above which a gravel road is considered no longer well-suited for safe, cost-effective maintenance and comfortable use. It is important because when new development exceeds gravel road capacity, then there are likely to be:

- new safety issues,
- additional pressure on the limited public moneys for gravel road improvements,
- further pressure on the relationship between local governments and road authorities, and
- negative impacts on rural character.

Safety Issues

The physical characteristics of gravel roads are not well-suited for safe high volume traffic. Gravel roads are often narrow, with frequent curves, hills and limited sight distance. Inad-

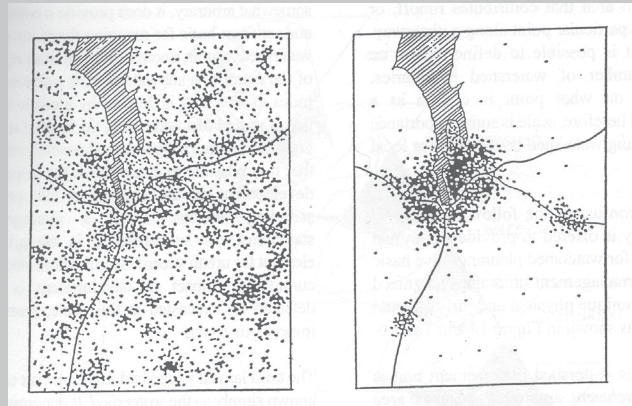


Figure I-5. Dispersed Versus Concentrated Development at the Regional Scale. Source: Schueler, 1995.

HIGH DENSITY DEVELOPMENT CAN BE GOOD FOR THE WATERSHED

The best way to keep impervious surfaces in a watershed below the 10% threshold is to group development into higher densities on smaller areas, preferably areas that already have infrastructure in place to accommodate it. This is because the impervious surface threshold is so easily reached with conventional, cookie-cutter style zoning. As development density decreases, a longer and wider road, driveway, and parking network must be built to accommodate it (along with the accompanying commercial services and employment centers developed along with the new subdivisions), which means an actual *increase* in imperviousness to accommodate those households. In fact, research shows that subdivisions designed in a typical pattern, where one single family residence is located on its own lot, increase imperviousness by 10 - 50% compared to developments that group the same number of households onto smaller areas (South Carolina Coastal Conservation League, 1995) (see Figure I-5).

equate drainage and a poor quality road surface are common problems. They are almost always in a rural area often populated with wildlife and livestock nearby. With such characteristics, travel at high speeds is a dangerous combination. However, when vehicles generated by new development push a gravel road over capacity, the additional traffic results in more dust or mud (depending on the season), and significantly greater risk of crashes—especially if drivers travel too fast. Where the gravel road is designed for very low volume use, it takes little increase in traffic before safety issues start to arise. In contrast, the ability of a paved road to accommodate the impacts of new development are usually considerably greater without suffering the maintenance and safety problems of a gravel road.

Limited Amount of Money for Road Improvements

Years of increases in the number of drivers, vehicles, road miles traveled, costs of road maintenance and improvements, and relative declines in the amount of money available to maintain or improve roads have left gravel roads at the bottom of the funding barrel when it comes to road improvements. The situation is not likely to change soon given that high crash locations, high volume roads and more new development in rapid growth metro areas all require the bulk of County Road Commission funds to be spent on paved roads in these areas, as opposed to on maintaining or improving gravel roads in more rural areas.

While high volume gravel roads become a burden to grade on a regular basis, it is still much cheaper than paving the road. Table I-1 (page 10) illustrates the range of typical costs to maintain a comfortable and safe ride on a gravel road in contrast to paving the road. Once a road is paved, maintenance costs will fall for a number of years, unless traffic volumes increase rapidly. However, the capital necessary to pave gravel roads is in very short supply across the entire state.

According to the Washtenaw, Livingston, Eaton and Ingham County Road Commissions, reconstruction and paving a county road typically costs between $300,000 and $870,000 a mile, but can rise to $1,200,000 a mile if there are serious wet soil or similar problems (such as the need to remove considerable muck soils to a great depth and replace with more stable material). In contrast, if a road is already paved, the cost to put a chip overlay on top is about $40-50,000 a mile. Gravel road maintenance is highly weather related. Wetter conditions and higher volumes require more grading, but long dry periods also raise significant need to control for dust, especially with higher volumes.

These costs suggest that local officials place greater importance on encouraging new development where roads are paved and other services are adequate, because that allows available road dollars to be spent where the needs are already the greatest. On the other hand, if a community is planning or has zoned land for a high enough density that a gravel road would be way over capacity and should be paved, then the development approval should not occur until the developer, Road Commission and local government are all in agreement about when the gravel road will be paved and who will pay for it. Table I-2 (page 11) presents a graduated range of options for upgrading a gravel road that the Livingston and Washtenaw County Road Commissions are using as a guide.

Disconnect: Land Use and Transportation Decisions

The last paragraph reveals one of the great ironies and perhaps the biggest challenges in addressing gravel road problems. The responsibility for managing rural roads in general and for maintaining most gravel roads in rural areas is that of the County Road Commission. Yet local governments have the responsibility to plan and zone for the use of land adjoining gravel roads. Land use decisions affect gravel road capacity, and improvements to roads (such as paving them) increase ease of access and, over time, can result in more pressure for development. Often there is a disconnect between local governments and county road commission decisions. The result too often is that local governments approve development where county roads are inadequate, or are not planned for improvement for several decades. This increases pressure on shrinking road improvement funds. This is especially significant in a political climate that is beginning to emphasize maintaining existing roads first over increasing road capacity, since there are inadequate funds to maintain all the existing paved roads in Michigan (let alone the gravel ones).

Obviously, there is a great need for local governments and County Road Commissions to coordinate and cooperate in the process of making decisions within their individual scope of responsibility if common objectives are to be achieved. Part IV describes a way in which this can happen to the benefit of all parties.

Relationship to Rural Character

The last major reason to be concerned about diminished gravel road capacity is the impact that a changed roadway will have on rural character. A very large part of the reason people say they move to low density lots along gravel roads is because of the rural character. Almost all the rural character one sees traveling to and from a place is viewed from public roads. Thus, if the road is widened and the large trees and their canopy are removed to improve sight distance and clear space next to the road, or if it is straightened and paved, it will lose much of its rural character. A newly paved road will also accommodate vehicles at a higher speed and serve to induce more development to the area. This increased development can diminish the rural character that enticed people to move there in the first place and is often proclaimed as a fundamental part of the local Comprehensive Master, or Future Land Use Plan.

Similarly, keeping impervious surface levels low preserves rural character, so local policies that maintain the capacity of existing gravel roads also complement local efforts to preserve water quality and rural character.

Table I-1 Maintenance and Paving Costs for Gravel Roads

Road Type	1978 (cost per mile)	2002 (cost per mile)
Gravel Road Grading	--	$100 (no gravel) -$1,000 (with additional gravel)*; dust control varies from $310/mile for contract brine, versus $830/mile for calcium chloride**; ditch cleaning is highly variable**
Collector Road Paving	$75,081 ($14.22/lf)[0]	$276,000-$400,000***
Residential Road Paving	$37,540 ($7.11/lf)[0]	$260,000-$870,000***
Road Widening (per lane)	--	$186,500-$420,000***
New Freeway	--	$2,500,000****

Sources: [0]Urban Development Cost-Revenue Model. Tri-County Planning Commission, 1978; *Washtenaw, Livingston, Eaton, and Ingham County Road Commissions; **dust control costs from Washtenaw County Road Commission, 2003; ***Square Foot Costs 2002. RS Means Co. Inc. 2002.; ****freeway costs from MDOT, 2001.

Table I-2: Potential Gravel Road Improvements Based on Existing Traffic Volumes

Design Feature	Under 400 vehicles per day	400 to 800 vehicles per day	800 to 1000 vehicles per day	Over 1000 vehicles per day
Surface (with adequate substructure)	4" Natural Gravel	6" 23A Gravel	6 to 8" 23A Limestone	• Requires improved design • Paving likely • Traffic impact analysis of project necessary to determine options and allocation of responsibility for making and paying for improvements
Surface (with adequate substructure)	4" 23A Gravel	6" 23A Gravel (consider sand sub base)	6 to 8" 23A Limestone (consider sand sub base or biaxial geogrid)	
Drainage	Eliminate ponding water	Eliminate ponding water and erosive cuts in the roadway	Establish roadside ditches	
Width	18'-20'	24'-28'	30'-34'	
Clear Zone	As required for maintenance	As required for maintenance and outside of flow lines	Beyond flow line of the ditch	
Vertical Alignment Stopping Sight Distance Goals	35 mph	35 mph	45 mph	

Source: Source: Livingston County Road Commission.

Part II: What is Important About the Research Findings

This Part of the Guidebook briefly presents the key findings of the research that provided the basis for this Guidebook and will help the reader determine the following:

- Whether a local community Master Plan or zoning ordinance has densities that preserve or diminish the long-term ability of the community to preserve water quality and/or the capacity of its gravel roads; and
- Whether the community needs to replicate the research process presented in Parts III and IV or simply integrate what has been learned (as described in this Part) into the local planning process.

KEY FINDINGS

These key findings have wide applicability and great significance in Michigan. This is because so much of the land at the urban/rural fringe is in headwaters parts of watersheds where much of the land has little impervious surface and is served by gravel roads that often have little excess capacity. The research demonstrates that even at low densities residential development :

- Can negatively impact a subwatershed with good water quality; and
- Can exceed the capacity of a gravel road.

That is largely because both systems have limited excess capacity in their base condition. Of course, such a statement begs two questions:

How much residential development does it take for impervious surfaces to start to degrade a stream?

Once a primarily low density residential area exceeds 10% imperviousness, stormwater runoff can degrade the quality of a stream, if the original stream condition was good. Ten percent imperviousness is equivalent to building out at a density (number of dwelling units per acre) of about 1 dwelling unit per 2.5 acres, 256 dwelling units/square mile. Once density exceeds about 1 dwelling unit per acre, then imperviousness can exceed about 20%. Imperviousness exceeds 25% at about 2 dwelling units/acre. It exceeds 50% at about 7 dwelling units per acre. Table II-1 illustrates common residential densities relative to impervious capacity.

How much residential development does it take to exceed gravel road capacity?

Table II-1 Percent Impervious Surface for Various Residential Densities

Land Use	Density (Dwelling units /ac)	Minimum Lot Size (in acres)	Impervious (%)
Low Density Res.	0.1	10	2.4[c]
	0.2	5	5[c]
	0.333	3	8[c]
	0.5	2	12[a]
	1	1	20[a]
	2	.5	25[a]
Medium Density Res.	4	.25	38[a]
High Density Res.	5-7	Varies	50[b]
Multi-family Townhouse	>7	Varies	65[a]
Mobile Homes	8-9	Varies	60[b]

[a]Source: USDA Soil Conservation Service (USDA, 1986)
[b]Source: Rouge Program Office, Detroit, MI (Kluitenberg, 1994)
[c]Source: Extrapolated from USDA Soil Conservation Service (USDA, 1986)

Project researchers have discovered that once an area builds out with a density greater than one dwelling unit per 6.67 acres adjacent to the best class of gravel road (Level A), the capacity of the road for traffic is exceeded. On an average class gravel road (Level C), the capacity at buildout is exceeded at about one dwelling unit per 10.67 acres. On the worst class of gravel road (Level E), if the density at buildout exceeds one dwelling unit per 32 acres, gravel road capacity is exceeded. Table II-2 illustrates common residential densities relative to gravel road capacity.

These are sobering findings! Most residential development in rural areas in the lower peninsula of Michigan occurs at a density from 1 dwelling unit per 1 acre to 1 dwelling unit per 10 acres. Yet based on these findings, most of this development is at a density in excess of the capacity of either the watershed, or gravel road serving it if all the land is developed at the zoned density. ***If communities care about water quality, or about preserving the capacity of or the character of low density rural areas served by gravel roads, these findings suggest that communities should reexamine existing plans and zoning densities in rural areas.*** This would involve giving serious consideration to adjusting permitted densities to either accommodate new rural residential development at much lower densities, or start using development design standards that minimize damage to the watershed and/or result in road improvements to a gravel road as new development occurs, so that it can safely and conveniently accommodate more traffic.

The rest of Part II will explain these key findings in more detail. Parts III and IV of this Guidebook describe the actual steps to replicate the process used by project researchers and to tailor analysis to an individual community.

IMPERVIOUS SURFACE CAPACITY IN SUBWATERSHEDS

The research underlying the impervious surface capacity part of this project is based on a watershed planning strategy developed by the Center for Watershed Protection, in Ellicott City, Maryland. The foundation of the strategy is that communities can protect their sensitive watersheds while encouraging growth in areas that have the infrastructure to accommodate the runoff. Huron River Watershed Council staff refined the strategy for use in this project as described in the separate white paper entitled *Watershed Planning: Determining Impervious Surface Capacity to Better Manage Growth at the Rural/Urban Fringe.* A copy of the white paper can be found on the CD accompanying this Guidebook (Appendix A).

The imperviousness methodology presented in this Guidebook involves the following elements:

- Delineation of subwatershed boundaries;
- Analysis of land use within each subwatershed;
- Identification of imperviousness by land use type;
- Calculation of existing imperviousness levels by land use type;
- Calculation of imperviousness at buildout (if all the land in the community is developed as zoned);
- Comparison of existing imperviousness to

Table II-2 Common Residential Densities Relative to Gravel Road Capacity

Gravel Road Type	Dwelling Units to be Built on 640 acres	Traffic Generated (vehicles/day)	Maximum Dwelling Units per acre
A	100	800-1000	1 du/6.67 acres
B	80	600-799	1 du/8.0 acres
C	60	400-599	1 du/10.67 acres
D	40	200-399	1 du/16.0 acres
E	20	0-199	1 du/32.0 acres

Source: Planning & Zoning Center, Inc. Gravel Road Capacity Research, 2003

projected imperviousness and determination of subwatersheds that would be over or under capacity at buildout;
- Examination of alternative approaches to integrate the new information into local plans and zoning regulations; and
- Local action on the selected alternative.

The cornerstone of the strategy is to plan based on watershed boundaries, since these are the boundaries that are relevant to determining water quality. The Center recommends that watersheds be classified into the following three categories (Center for Watershed Protection, 2003):

Photo II-1. A Huron River Tributary Whose Watershed is Less than 10% Impervious.

Source: HRWC.

1. *Sensitive streams* are under 10% imperviousness in the watershed and typically have good water quality, good habitat structure, and biological communities if riparian zones are intact and other stresses are absent. Sensitive streams will typically be in rural areas that have not seen a great deal of development and may contain significant natural areas. In these areas, the community would set goals to maintain existing watershed hydrology by keeping impervious surface levels in the watershed below 10%. See Photo II-1.

2. *Impacted streams* have 10 to 25% imperviousness in the watershed and show clear signs of degradation and only fair in-stream biological diversity. Impacted streams have already seen some measure of development. The community's main goal in these watersheds would be mitigation of the impacts of that and any new development through site design that minimizes imperviousness, stormwater BMP's and restoration of natural areas. See Photo II-2.

3. *Non-supporting streams* have more than 25% imperviousness in the watershed, a highly unstable channel and poor biological condition supporting only pollutant-tolerant fish and insects. The community's goal for these watersheds is restoration and pollution reduction. The Center for Watershed Protection and many other planners recommend that these watersheds be target areas for urban infill development (Schueler, 1995). See Photo II-3.

Photo II-2. A Huron River Tributary Whose Watershed is 15% Impervious.

Source: HRWC.

If the goal of the community is to preserve water quality in a watershed around a sensitive stream, it needs to keep imperviousness under 10%. If there are watersheds in the community where imperviousness is already over 25%, and urban services are available, concentrating new development there is better than it allowing it to occur in another watershed classified as sensitive.

Photo II-3. A Huron Tributary Whose Watershed is Over 25% Impervious.

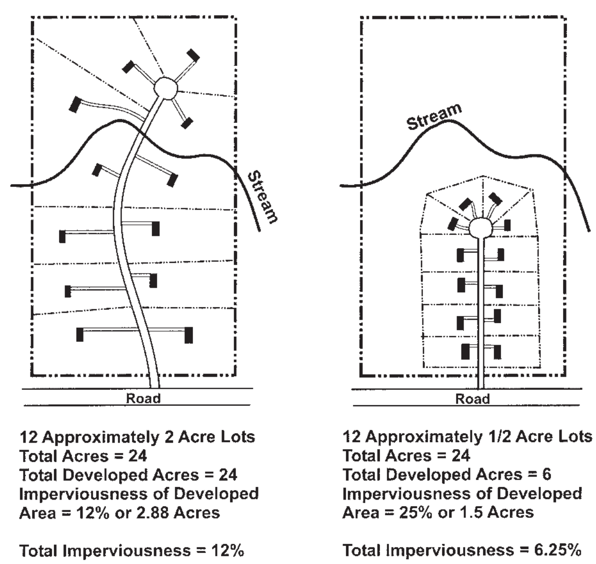
Source: HRWC.

KEEP IN MIND

It is important to realize that the data used in this study assumes an average amount of impervious surface for all land development of a particular type. However, every development is different, and there are designs that result in less imperviousness than others, and some that are far less than averages. Most of these alternative designs involve significant clustering of dwellings and preservation of large amounts of permanent open space on a site (usually well in excess of 50%). Clustering involves increasing density on a part of a parcel so as to keep another part undisturbed. See Figure II-1. Development that utilizes stormwater best management practices (BMPs) AND clustering with more than 50% open space will result in less imperviousness than historic averages. In addition, the land can accommodate higher densities of development if the buildings are built taller and no more impervious surface is created for parking or other uses (such as swimming pools or tennis courts).

Figure II-2 (page 17) illustrates different ways in which new development can be organized within an entire subwatershed. Each option increases the density on a part of the subwatershed, while keeping larger portions of remaining open space undisturbed. Obviously, the number of people that can be accommodated can be very high, even when the amount of undeveloped land is high. Thus, the issue is less one of total dwelling units or total population, rather it is the design of the development: how much total impervious surface and how much land is preserved in open space. The problem of course, is that many rural communities do not want development in a form other than the typical cookie cutter, large minimum lot size development that preserves open space only as lawns, and which, because of long driveways and new access roads serving few dwellings, results in a large amount of impervious surface for the number of dwelling units involved. Some resources at the end of this Guidebook provide examples of various development designs that have low imperviousness and less negative impact on water quality.

Figure II-1. Clustering Can Significantly Reduce Impervious Surfaces.

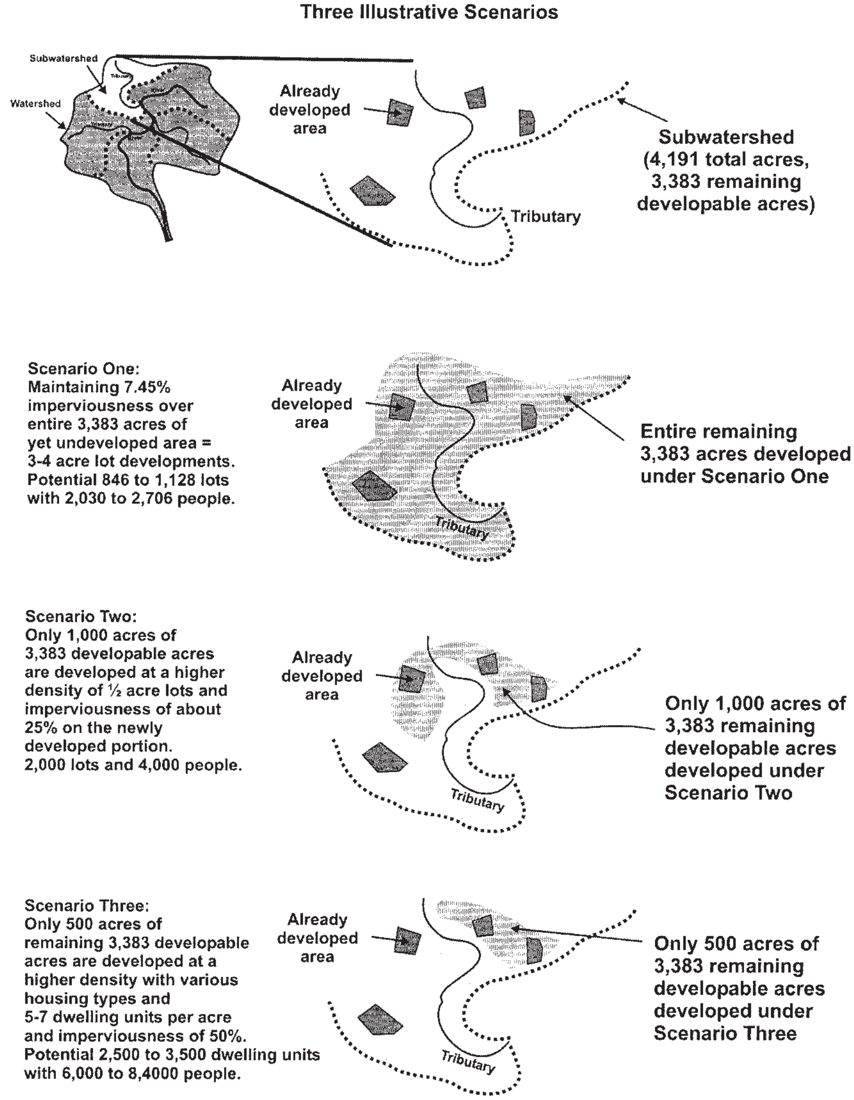


Source: Planning and Zoning Center, Inc.

IMPLEMENTATION OPTIONS

Following is a list of five regulatory and five non-regulatory options for communities that wish to protect subwatersheds from too much impervious surface in the future. These options are described in more detail at the end of Part III. Sample ordinance language is provided in Appendix C.

Figure II-2. Three Different Ways in which New Development can be Organized within an Entire Subwatershed.



Source: Planning and Zoning Center, Inc.

Regulatory Options

The principal regulatory options to enhance water quality protection by reducing impervious surfaces are listed below. Only the first option is directly tied to the data and findings generated by the research that underlies this Guidebook. Thus the other options can be implemented without replicating the research described in Part III of this Guidebook.

- Adopt new impervious surface standards and conduct impervious surface analysis as part of the zoning review and approval process.
- Adopt or link to an existing stormwater management ordinance.
- Provide incentives for clustering with large amounts of open space in the rural areas of the community.
- Establish buffers along streams and other waterbodies by means of a natural features setback ordinance.
- Link to a TDR program for those parts of the community where open space is desired to be permanently protected.

Non-Regulatory Options

Following are common and effective non-regulatory options to help preserve water quality.

- Educate the public, land owners and developers about the purposes, benefits and procedures associated with any of the regulations listed above, if they are adopted;
- Promote better site design focussing on minimizing development impacts on water quality;
- Initiate permanent preservation of some open space through conservation easements, donations or fee simple purchase;

- Begin or enlarge participation in land conservancy, PA 116 or farmland Purchase of Development Rights (PDR) programs for those parts of the community where open space is desired to be permanently protected; and
- Prepare and annually update a capital improvement program for water quality and coordinate with the Drain Commissioner.

The above listed non-regulatory options are likely to have as much benefit in some communities as the regulatory options may have in others. However, the most effective programs to limit imperviousness will involve one or more of the regulatory options and one or more of the non-regulatory options.

GRAVEL ROAD CAPACITY

The research that underlies the gravel road capacity part of this project is loosely based on a PAS report on "trafficsheds" by Lane Kendig and published by the American Planning Association (Kendig, 1999). The specific gravel road capacity methodology used to classify gravel roads was jointly developed by staff of the Livingston and Washtenaw County Road Commissions and by associates of the Planning & Zoning Center, Inc. A separate white paper entitled *Gravel Road Capacities as Tools to Guide Local Planning and Zoning at the Rural/Urban Fringe* describes the research methodology in detail (Appendix B.)

The gravel road capacity methodology presented in this Guidebook involves the following elements:

- A detailed inventory of the characteristics of gravel roads;
- The creation of a standard classification system of gravel roads based on those characteristics;
- The classification of all gravel road segments using the standard system;
- Comparison of traffic volumes to road segments and creation of a capacity range by class of gravel road;
- Comparison of existing traffic volumes to projected volumes based on a buildout analysis of existing zoning and determination of road segments that would be over or under capacity at buildout;
- Examination of alternative approaches for integrating the new information into local plans and zoning regulations; and
- Local action on the selected alternative.

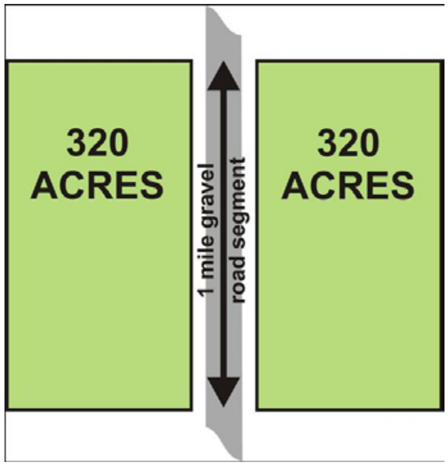
The cornerstone of this strategy is the classification of existing gravel road segments into five types (A-E) and the identification of various maximum traffic volumes associated with each road type (see Table II-2, page 17). This is a level of service (LOS) system for gravel roads. This relationship of gravel roads to traffic volumes is easiest to understand from the following hypothetical example. Imagine a one mile gravel road segment that is part of a longer gravel road. On each side of the road are 320 undeveloped acres (640 acres or one square mile total). There are no intersecting public roads, so 100% of the new dwelling units only have access to the gravel road. Also, the example assumes 100% of the travel on the gravel road is associated with vehicle trips that originate on the abutting 640 acres (in other words, there are no through trips). See Figure II-3 on page 19.

Obviously there is some through traffic on all but dead-end gravel roads. However, travel on a gravel road is not as pleasant as on a paved road, and results in increased "wear and tear" on vehicles, so drivers tend to travel the shortest distance on a gravel road possible. This makes most gravel roads purely local roads whose primary purpose is to provide access to abutting property. This is in contrast to a paved county road which, if it is a major primary road, has as a principal purpose serving through traffic.

A road segment that is over capacity now or at buildout means:

- Any new development gaining access from that gravel road segment will contribute to the accelerated decline of the road surface,

Figure II-3: Hypothetical Example of Gravel Road Access



Source: Planning and Zoning Center, Inc.

more dust, more complaints and the need for more frequent maintenance;

- A range of road improvement options should be available if new development is feasible or desired;
- The road should be considered for paving as soon as possible if existing traffic volumes are over 1,000 vehicles per day; and
- A community should consider whether the area is overzoned (too much development allowed) relative to the capacity of the gravel road. If it is, then one of the regulatory options describe in this Guidebook should be explored.

One of the simplest approaches to preventing overcapacity would be to allow road commissions to make a determination of gravel road capacity each time a new development is proposed and to prohibit the development, or conditionally approve it (based on various road improvements being made by the developer) if it would exceed available capacity. This is analogous to existing regulations for septic systems, floodplains, water wells, stormwater runoff, wetlands, high risk erosion areas, and sand dunes. However, this would require a change in Michigan Public Act 200 of 1969 to ensure its validity and is not likely to happen in the near future.

In general, other regulatory approaches involve reducing allowable development density until road capacity improvements occur, or shifting development to areas where roads are paved and other urban services are available. These options are presented and analyzed in more detail in Appendix C.

KEEP IN MIND

There are three important qualifiers to consider. First, there is almost always some through traffic on gravel roads, even though it is usually not much, except where a short gravel road segment connects two paved roads. Where there is through traffic on a gravel road, the road capacity is being used by others, not just by those with land adjacent to the road. This involves another set of considerations the reader must take into account when establishing capacity and especially when assigning any unused capacity.

Second, it is important to periodically update key maps described in Part IV as land use and roads change. That way capacity measures will be reevaluated as development occurs and as gravel road improvements are made.

Third, these findings should not be interpreted as saying that any particular zoning density is or is not "good" or "correct," or "bad" or "incorrect". Rather, these findings reveal the points at which road capacities are exceeded under the purest of circumstances. If there are good reasons why buildout density cannot or will not be achieved in a particular area (e.g. extensive unbuildable land relative to existing parcel sizes, shapes or ownership, and no potential to achieve the highest permitted zoning density), then there is more actual capacity than what Figure II-3 (page 19) reveals. Project researchers are not saying that 1 dwelling/5 acres or 1 dwelling/10 acres is maximum or optimal under certain circumstances. Our research only reveals the density range at which road capacity will be consumed depending on the classification of the gravel road.

There are many factors that go into setting minimum lot sizes in rural areas, e.g., preserving farmland, forest land or wildlife habitat, the availability of public facilities and services, suitability of soils, presence of floodplain or wetland, etc. Gravel road capacity and imperviousness are two additional factors that should also be considered.

BUILD UP AND IN, NOT OUT

Project researchers strongly recommend communities plan for higher densities where services exist (water, sewer, paved roads) and keep density low in rural areas—at least at levels that won't exceed the capacity of the gravel road, unless the developer and Road Commission are willing to work out a way for the road to be paved and the developer uses designs which ensure no degradation of water quality. In short, we recommend the establishment of densities in rural areas that are consistent with natural resource management, rural character preservation, environmental quality and the availability of public facilities and services. Clustering, purchase of development rights (PDR) and transfer of development rights (TDR) all can be used to implement these recommendations. One of the most promising of these techniques is transfer of development rights. TDR allows landowners of rural land to capture the development value of land by selling development rights to developers who are allowed to build at a higher density in a part of the community where public facilities and services are adequate to accommodate the higher density. See Figure II-4.

IMPLEMENTATION OPTIONS

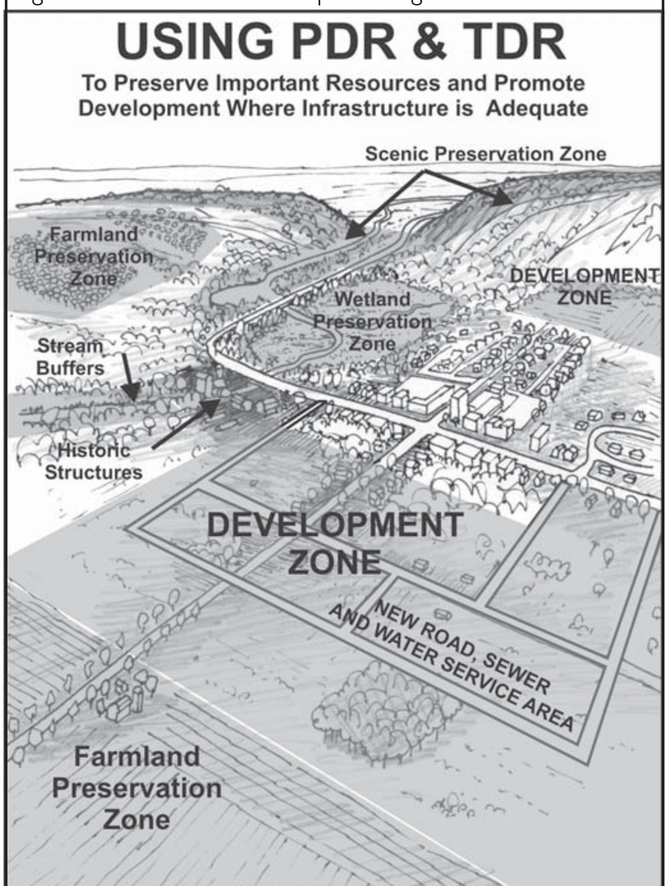
Following is a list of six regulatory and four non-regulatory options for communities that wish to ensure that the capacity of gravel roads is not exceeded as new development occurs. These options are described in more detail at the end of Part IV. Sample ordinance language is provided in Appendix C.

Regulatory Options

The principal regulatory options to protect gravel road capacity are listed below. The second, third and fourth options are all directly tied to the data and findings generated by the research that underlies this Guidebook. The other options can be implemented without replicating the research described in Part IV of this Guidebook.

1. Initiate enhanced permit coordination between local governments and the County Road Commission to ensure that as new development is reviewed and approved, it either does not exceed gravel road capacity, or improvements are

Figure II-4. Transfer of Development Rights.



Source: Planning and Zoning Center, Inc

made to the gravel road to stay within the limits of the newly created capacity.

2. If lawful, link to new Road Commission standards tied to gravel road capacities (analogous to septic system, floodplain or wetland regulations). This is likely to require changes to Michigan Public Act 200 of 1969.
3. Tie the "by right" density of new development to existing available gravel road capacity, and then permit a higher density of development only if the road is adequately improved, and probably only if it is paved.
4. Adopt an adequate public facilities ordinance with one part focused on gravel roads. Under such ordinances, all new development is required to be served by adequate public facilities before development can occur.
5. Add incentives to the zoning ordinance to concentrate development or transfer development rights where facilities are adequate.
6. Either require, or provide strong incentives for clustering where access is from paved roads.

Non-Regulatory Options

Following are common and effective non-regulatory options that would help preserve gravel road capacity.

1. Educate the public, land owners and developers about the purposes, benefits and procedures associated with any of the regulations listed above, if they are adopted.
2. Initiate permanent preservation of some open space through conservation easements, donations or fee simple purchase.
3. Begin or enlarge participation in land conservancy, PA 116 or farmland PDR programs for those parts of the community where open space is desired to be permanently protected.
4. Prepare and annually update a capital improvement program for gravel roads and coordinate with the county road commission.

The above listed non-regulatory options are not as likely to have as much benefit as the regulatory options. However, the most effective programs to limit gravel road capacity will involve one or more of the regulatory options and one or more of the non-regulatory options.

REMAINING CHAPTERS

The rest of this Guidebook consists of instructions on how to replicate techniques used to establish imperviousness (Part III) and gravel road capacity (Part IV) in your community. Whether a community needs to do all the background research and follow every step of the suggested process depends on how it plans to use it. If the research is done to support new regulations, the community probably needs to do all recommended steps. If the use is just for planning and analysis, then whether all steps are followed depends on how close the community in question is to the characteristics of pilot communities. If a community is not close in characteristics to the pilots (like a municipality in a distant desert western state) then there is likely a need to repeat the research first and adapt the methodology to meet local circumstances.

The Community Will Likely Use Parts III and/or IV if:

- Community has characteristics similar to those of the pilot communities.
- Community wants to develop local zoning regulations that are based on subwatershed types and/or gravel road classification schemes described in Parts III and IV, respectively.

To Use Parts III and/or IV, Community also Must:

- Have GIS capability in-house or it is available through the County, Regional Planning Commission or a consultant.

The Community Will Not Likely Need to Replicate the Process in Parts III and IV if:

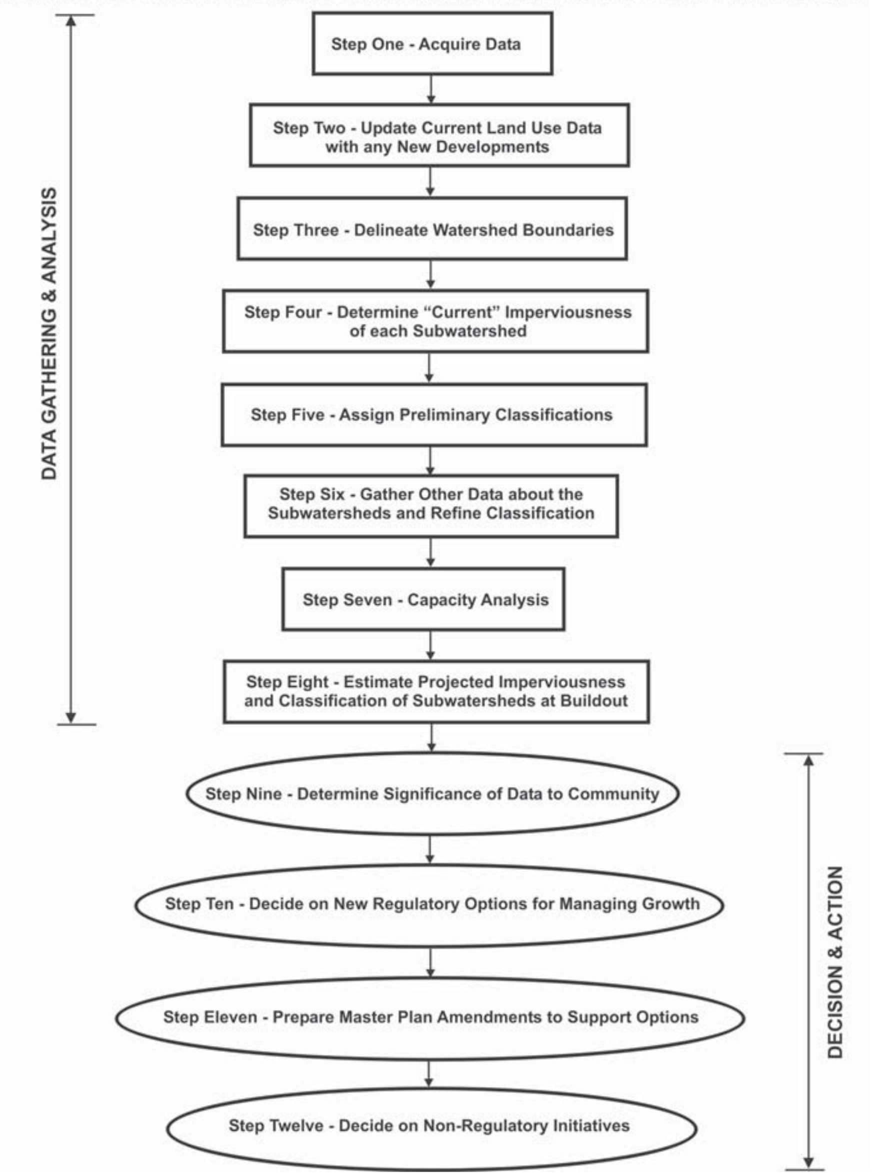
- Community only intends to use the information for planning purposes.
- Community only intends to use an implementation option that does not rely on a subwatershed type and/or gravel road classification scheme described in Parts III and IV, respectively.

Part III: Calculating Impervious Surface Capacity

HOW WOULD A COMMUNITY CONDUCT AN IMPERVIOUS SURFACE CAPACITY ANALYSIS?

Part II of this Guidebook gave the compelling reasons for a community to be concerned about impervious surface capacities. This section of the Guidebook explains how to conduct an impervious surface capacity analysis and integrate the findings into local plans, zoning and nonregulatory initiatives. Figure III-1 lists the steps to be followed. Appendix L includes all the tables used in this analysis to help in performing the analysis in the community of interest.

Figure III-1.
12 STEPS TO INTEGRATING IMPERVIOUS SURFACE CAPACITY ANALYSIS INTO LOCAL PLANS AND ZONING



Source: Planning and Zoning Center, Inc.

USE OF GIS

Project researchers used ArcView GIS 3.2 to perform the impervious surface capacity analysis. Other GIS programs can perform the same functions. If the reader does not have GIS, please refer to the Center for Watershed Protection's *Watershed Vulnerability Analysis* (Center for Watershed Protection, 2002)(see Appendix D), which describes alternative methods.

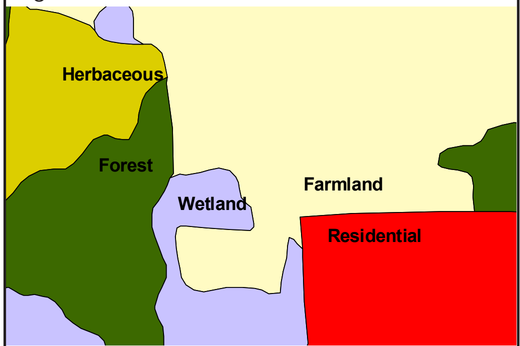
STEP ONE – ACQUIRE DATA

Before beginning the imperviousness capacity analysis, it will be necessary to acquire a number of datasets:

1A. Land use/cover.

Land use data for all counties in Michigan is available from the Michigan Geographic Data Library (http://www.mcgi.state.mi.us/mgdl/). The data is interpreted from aerial photos. Various years are available, depending on the county. Figure III-2 (page 24) shows an example. County planning or GIS departments may have more up-to-date land use/cover data, so check with them, as well. For counties served by the

Figure III-2. Land Use/cover Data GIS Theme.



Source: HRWC

Southeast Michigan Council of Governments (SEMCOG) (Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne counties), land use/cover data is available for the year 2000. This was the dataset used for this project.

Table III-1. Imperviousness Coefficients

Land Use	Impervious Surface %
Multifamily Residential	51.40
Single Family Residential (under 4 DU/acre)	19.00
Single Family Residential (over 4 DU/acre)	38.00
Mobile Home	60.00
Commercial	56.20
Mixed Use (Commercial and Residential)	76.30
Shopping Center / Mall	80.00
Secondary / Neighborhood Services	88.00
Institutional	28.00
Office	65.90
Industry	75.90
Industrial Park	65.90
Air Transportation	16.80
Rail Transportation	52.90
Road Transportation	52.90
Communications	52.90
Utilities	65.90
Public	11.00
Outdoor Recreation	10.90
Cropland	2.00
Nonforested Open	2.00
Woodland	2.00
Sand and gravel Pit	2.00
Outdoor recreation	11.00
Wetland	2.00

1B. Imperviousness coefficients.

In order to determine the imperviousness of an area, it is necessary to link land use/cover with imperviousness. Table III-1 shows the imperviousness coefficients used for this research project. The Rouge Program Office, in Detroit, Michigan developed these coefficients by measuring impervious surfaces on aerial photographs of various land uses in Southeast Michigan (Kluitenberg, 1994).

Table II-1 (page 13) shows the imperviousness coefficients used for all the residential land uses examined in this research project.

1C. Watershed boundaries.

The imperviousness capacity methodology includes dividing up the watershed of interest into subwatersheds of about 10 square miles each. These subwatershed boundaries may already exist for the watershed of interest; check with the local watershed council, county planning and/or environmental department, and the Michigan Geographic Data Library.

1D. Digital USGS topographic map (a "DRG").

For this study, project researchers delineated subwatersheds using a digital USGS topographic map (see Figure III-3, page 25). Digital topographic maps are available from the Michigan Geographic Data Library, or the USGS web site (http://ac.usgs.gov/mac/isb/pubs/factsheets/fs08801.html).

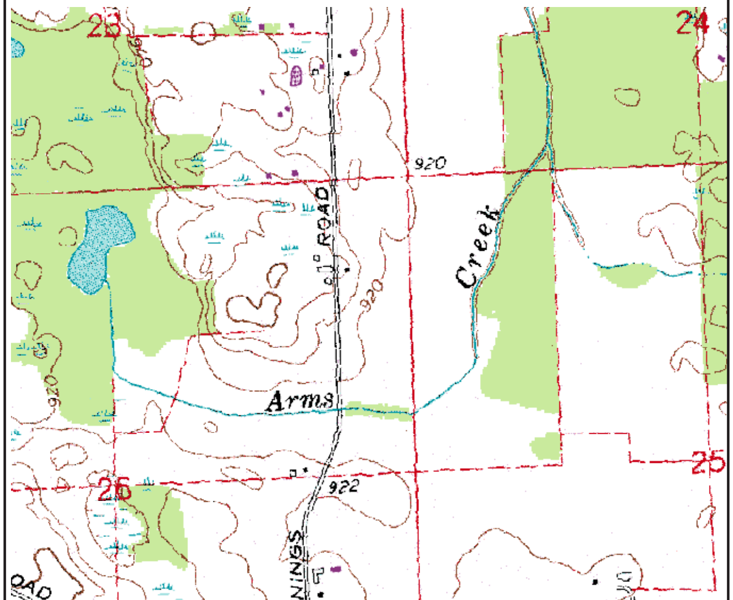
1E. Hydrography (waterways).

These are available from the Michigan Geographic Data Library.

1F. Future land use map from the local Master Plan and zoning maps and classifications.

In order to perform a "build out analysis" of the community or communities of interest, zoning and/or future land use plan maps will be necessary. These are available from each community of interest; however, it might be more efficient (especially when performing a capacity analysis for several communities) to obtain these maps from the county planning department. If the maps are not available as GIS files, it will be necessary to digitize them from paper maps.

Figure III-3. "DRG," a Digital Image of USGS Topographic Maps.



Source: HRWC.

1G. Tables that provide the information about each zoning classification regarding allowable density.

For the zoning classifications, communities often call these tables "schedule of zoning area, height, and bulk regulations," "schedule of regulations," or "tables of dimensional requirements."

Table III – 2. Datasets Needed for Analysis

Dataset	Availability	Notes	Status
Land use/cover	Michigan Geographic Data Library: http://www.mcgi.state.mi.us/mgdl/ SEMCOG: www.semcog.org County planning departments		
Impervious surface coefficients	Table III-1 Table II-1		
Watershed boundaries	local watershed council county planning or environmental departments Michigan Geographic Data Library		
Digital USGS topographic map	Michigan Geographic Data Library USGS: http://mac.usgs.gov/mac/isb/pubs/factsheets/fs08801.html		
Hydrography	Michigan Geographic Data Library		
Future land use map	County planning departments Local community planning departments		
Zoning density tables	County planning departments Local community planning departments		
Public lands	Michigan Geographic Data Library Southeast Michigan Greenways Collaborative: http://www.greenwaycollab.com/		

1H. Public lands.

GIS maps of state-owned lands are available from the Michigan Geographic Data Library. In Southeast Michigan, all lands in some sort of protected status (including local parks and conservancy land) is available from the Southeast Michigan Greenways Collaborative (http://www.greenwaycollab.com/).

Table III-2 (page 25) lists the above datasets, where they might be available, and columns to assist in keeping track of efforts to gather and enter the data into the computer.

STEP TWO – UPDATE CURRENT LAND USE DATA WITH ANY NEW DEVELOPMENTS

Depending on the date of the land use/cover data available for the "current" imperviousness analysis and the amount of time available for the project, it may be possible to update the land use/cover data by gathering information about:

- Significant land use changes that may have occurred since the land use/cover information was created;
- Significant land use changes planned by the community, such as developments "in the pipeline" of the approval process;
- Plans for properties owned by the community, such as schools, sports complexes, and parks;
- Properties with conservation easements;
- Plans for large tracts held by individual landowners;
- Current and planned transportation corridors; and
- Open space plans.

Any new information will probably not be in a digital format, so it will be necessary to digitize it into the land use/cover dataset from paper maps.

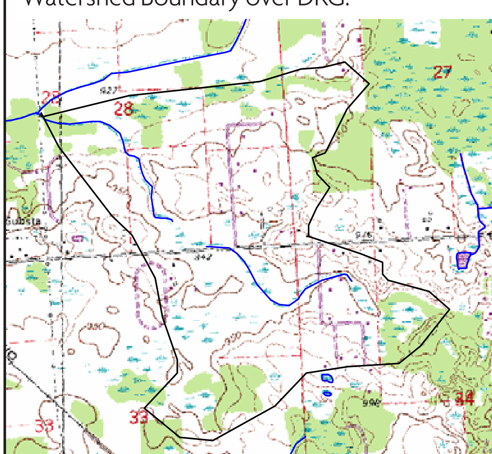
STEP THREE – DELINEATE WATERSHED BOUNDARIES

The imperviousness capacity methodology includes dividing up the watershed of interest into subwatersheds of about 10 square miles each.

This is because:

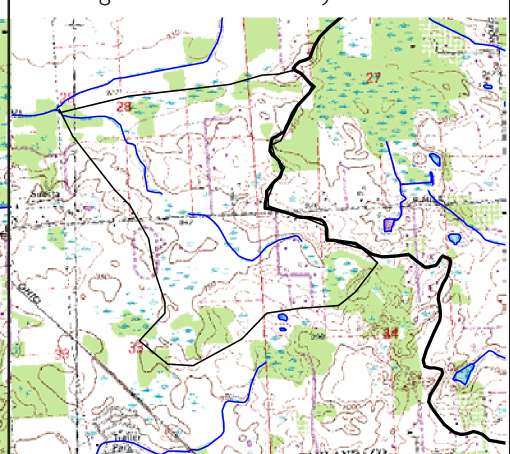
- This scale is more amenable to watershed planning.
- The influence of impervious cover on hydrology, water quality, and biodiversity is most apparent at this scale.
- Subwatersheds of this size are small enough that there is less chance for multiple pollutant sources (e.g.agricultural runoff, point

Figure III – 4. GIS Operator Draws Watershed Boundary over DRG.



Source: HRWC.

Figure III – 5. GIS Operator Can Add to Existing Watershed Boundary.



Source: HRWC.

sources, etc.) to confuse management decisions.

- Subwatersheds of this size are more likely to be contained in one or just a few political jurisdictions, making it easier to advocate and adopt planning and zoning changes.
- Subwatersheds of this size are more manageable in terms of monitoring, mapping, and other watershed assessment steps.

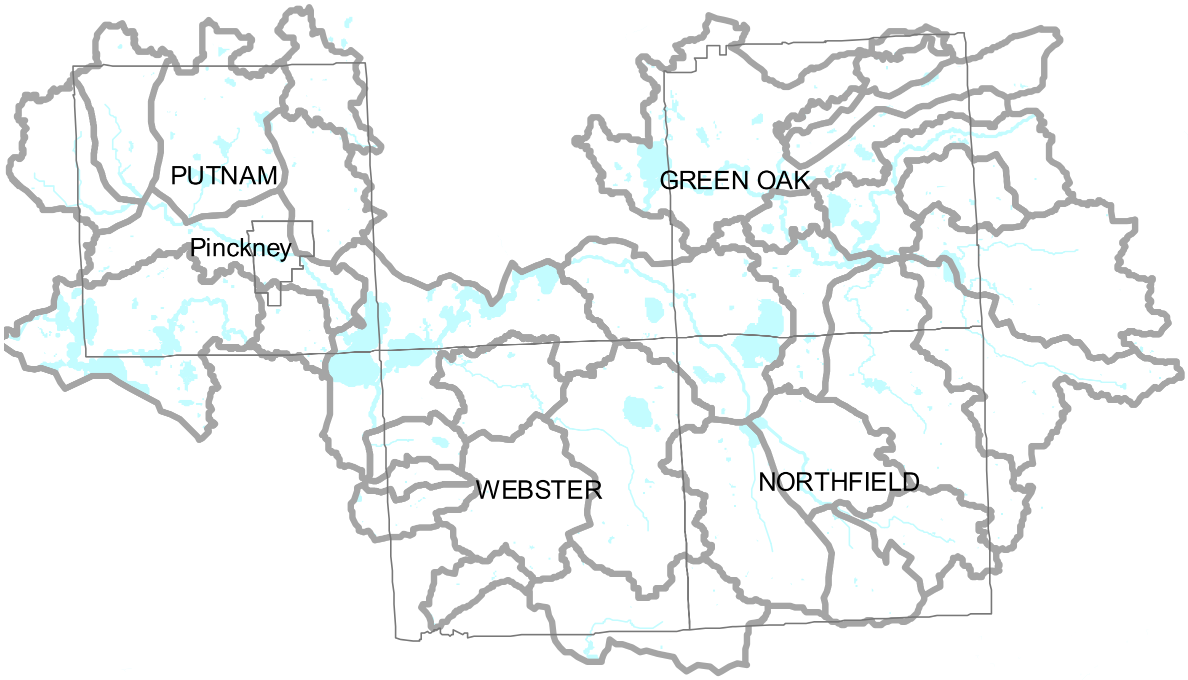
To delineate subwatershed boundaries, start with the watershed boundary map acquired from the data search conducted in Step 1. There may already be some subbasins delineated but they will most likely not be to a small enough scale.

Overlay this watershed boundary map onto the topographic DRG image. Also, overlay the waterways map. Begin to delineate the subwatersheds. The idea is to create watershed boundaries for the smaller tributaries of the watershed of interest. For any given tributary, find the point where the tributary enters into the larger stream network and begin digitizing there. Work up hill from that point, connecting all the high points (the circles) on the map (see Figure III – 4, page 26). If delineating subwatersheds from an already existing watershed boundary map, the digitizing job will be simpler, since digitizing will be limited to splitting existing watershed boundaries (see Figure III-5, page 26). For a more detailed description of delineating watersheds, see Appendix D.

After digitizing subwatersheds for the smaller tributaries in the watershed of interest, there will be gaps near the main stem of the stream or river. These are watershed boundaries, but they are boundaries of water that drain directly to the river (see Figure III-6, page 28). These boundaries become their own subwatersheds to be used in the capacity analysis.

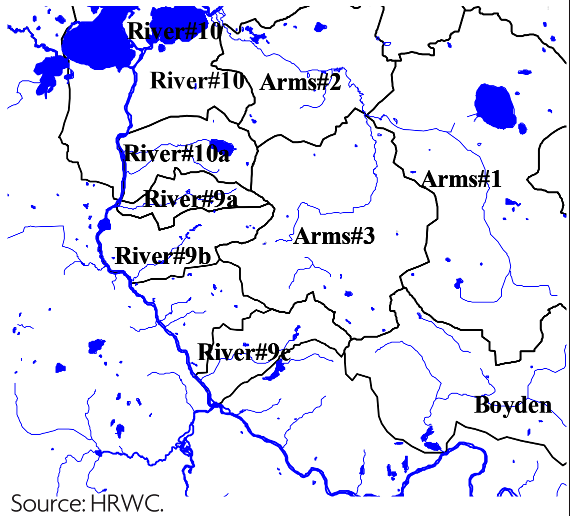
Not all the subwatersheds in the pilot communities are 10 square miles. Due to variation in hydrology and topography, it may be difficult to keep to this "rule." Luckily, it is not a hard and fast one. Aim for the 10 square mile size, but realize that in some cases, this will be difficult to do. Map III-1 (page 27) shows the

Map III – 1. Final Subwatershed Boundaries for the Pilot Communities.



Source: HRWC.

Figure III – 6. Some Watershed Boundaries Represent Direct Drainage to the Main Stem of the River.



Source: HRWC.

subwatershed map of the four pilot communities studied in this project.

SOME TIPS ON TABLES IN GIS

Project researchers found that ArcView 3.2 was very particular about the format of the imperviousness coefficients table. The table, created in Microsoft Excel, needed to be a "dbf" format. To do this, project researchers used Excel to convert the spreadsheet to a dbf. It was very important to ensure that the fields in the Excel spreadsheet had the proper format. For instance, it is necessary to ensure that the imperviousness field in the imperviousness coefficients table is defined by Excel as a number (to define a field as a number, go to Format\cell and choose "number," and choose the number of decimal points desired.)

STEP FOUR – DETERMINE "CURRENT" IMPERVIOUSNESS OF EACH SUBWATERSHED

In order to determine how much more impervious surface a subwatershed can accommodate, it is necessary to determine how much of the subwatershed is currently covered with impervious surfaces.

4A. Remove water and wetlands from the land use/cover map

Using GIS, remove polygons designated as water or wetlands from the land use/cover map.

Note: While water surfaces are impervious in a hydrologic sense, they do not generally have similar consequences on stream quality, watershed health, or pollutant loading as impervious cover such as roads, parking lots and rooftops. Also, including lakes and wetlands would skew watersheds with more lakes and wetlands towards higher imperviousness levels.

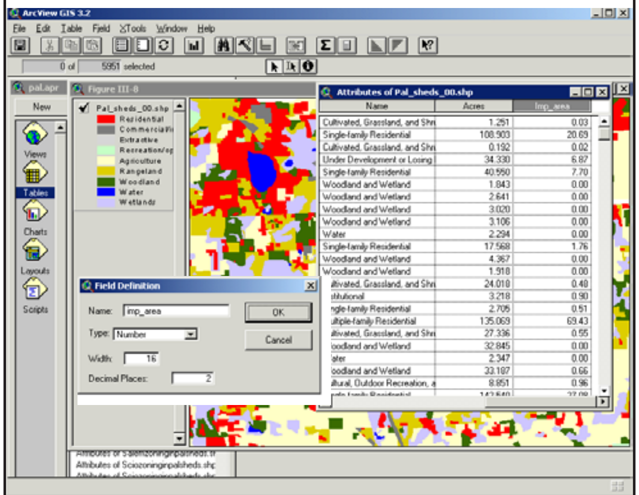
4B. Associate land uses with impervious surface coefficients.

In order to associate each land use with an imperviousness percentage it will be necessary to attach the "imperviousness coefficients" table acquired in Step 1 (See Table III-1, page 24) to the attribute table of the land use/cover theme created in Step 4A.

4C. Intersect the land use/cover with the subwatershed boundaries.

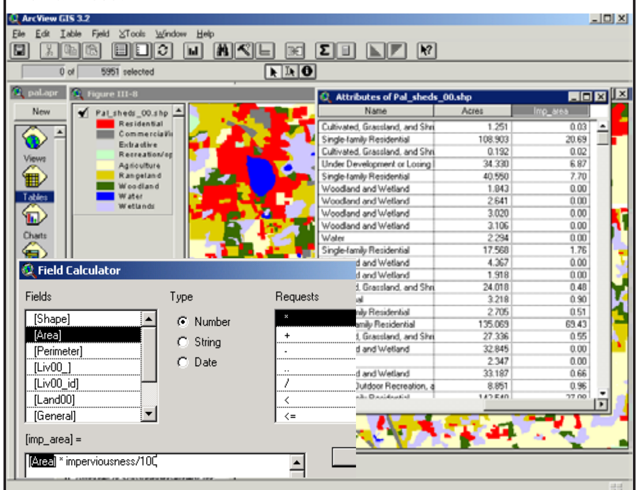
Using either the "geoprocessing wizard" (an extension included with ArcView 3.x software) or the "Xtools" extensions in ArcView (see Appendix E) intersect the subwatershed boundaries with the land use/cover theme to obtain a theme that shows land uses for each subwatershed.

Figure III-7. ArcView Operations to Add a New Field to a Table.



Source: HRWC.

Figure III-8. ArcView Operations to Perform a Calculation for a Field.



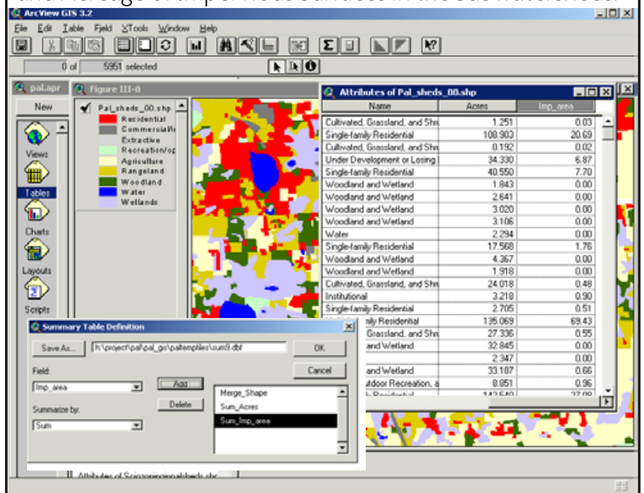
Source: HRWC.

4D. Find amount of impervious surface in each land use polygon.

In the table in this new subwatershed land use theme, add a field, "impervious area," and use the following calculation:

imp_area = area*imperviousness/100
This will yield the actual impervious area in each land use polygon (Figures III-7 & III-8).

Figure III-9. ArcView Operations to Summarize Acreage and Acreage of Impervious Surfaces in the Subwatersheds.



Source: HRWC.

4E. Find the percentage of impervious surface in each subwatershed.

Perform the "sum" command on the subwatershed field, and find the sum of impervious area and the sum of total area. (Figure III-9).

Open the new summed table, create a new field, "imperviousness%," and use the following calculation:

Imp% = (sum_impervious_area/sum_area)*100

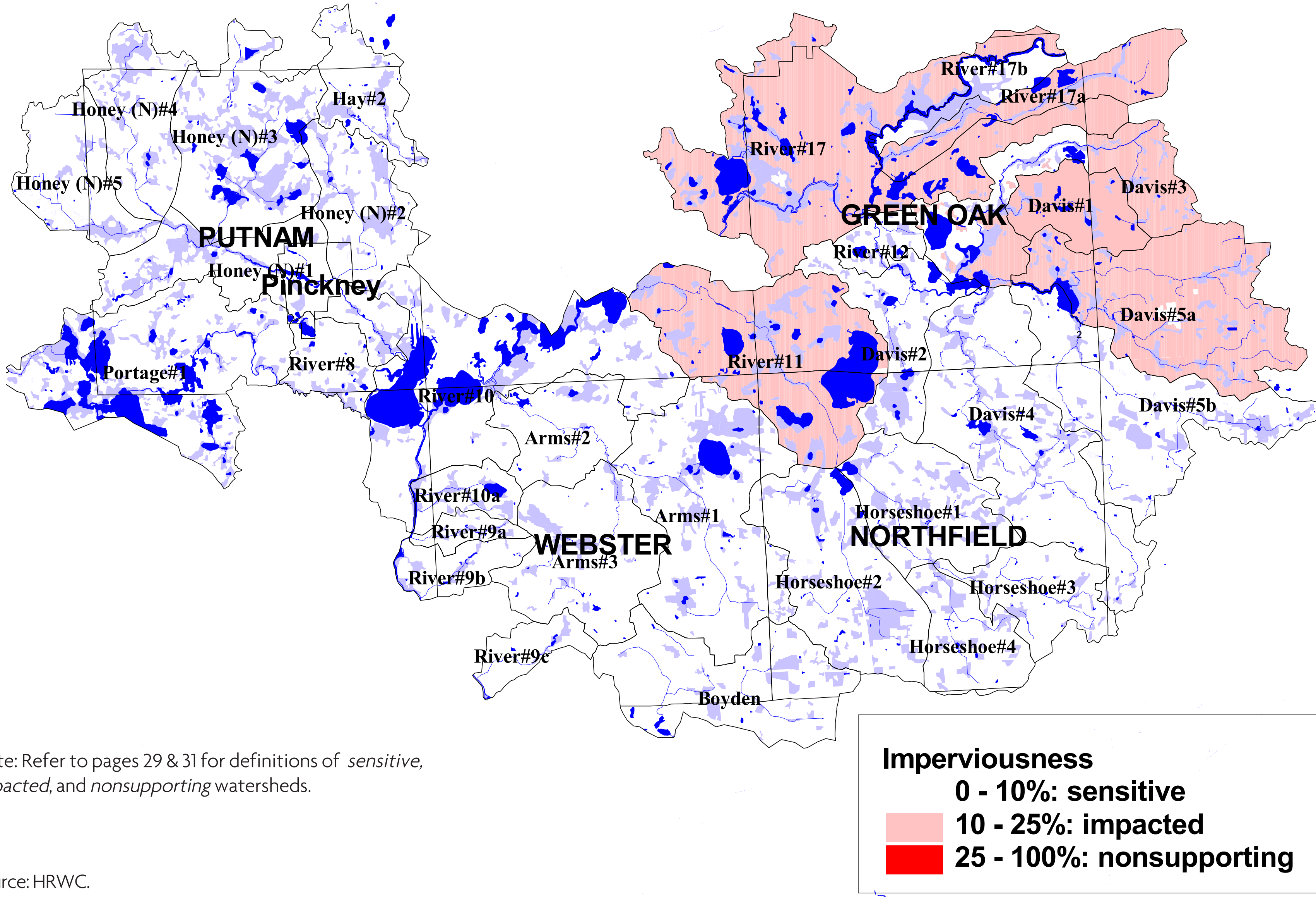
Now, this theme contains the imperviousness percentage for each subwatershed by classification type ("sensitive," "impacted," "nonsupporting"). Map III-2 on the next page shows the final map.

STEP FIVE – ASSIGN PRELIMINARY CLASSIFICATIONS

As described in Part II, the impervious surface capacity analysis includes dividing subwatersheds into three categories:

Sensitive streams have watersheds that are under 10% impervious surfaces and typically have good water quality, good habitat structure, and diverse biological communities if riparian zones are intact and other stresses are absent. Sensi-

Map III-2. Current Imperviousness Calculated for the Subwatersheds in the Pilot Communities.



Note: Refer to pages 29 & 31 for definitions of *sensitive*, *impacted*, and *nonsupporting* watersheds.

Source: HRWC.

tive streams will typically be in rural areas that have not seen a great deal of development and may contain significant natural areas. In these areas, the community would set goals to maintain those watersheds' hydrology by keeping impervious levels in the watershed below 10%.

Impacted streams have watersheds that are 10 to 25% impervious surfaces in the watershed and show clear signs of degradation and only fair in-stream biological diversity. Impacted streams have already seen some measure of development. The community's main goal in these watersheds would be mitigation of the impacts of existing and any new development through site design that minimizes imperviousness, stormwater treatment, and restoration of natural areas.

Non-supporting streams have watersheds that are more than 25% impervious surface, a highly unstable channel and poor biological condition supporting only pollutant-tolerant fish and insects. The community's goal for these watersheds is restoration and pollution reduction. The Center for Watershed Protection and many other planners recommend that these watersheds be target areas for urban infill development (Schueler, 1995).

Fill in Table III-3 with the subwatersheds just created in Step 4.

STEP SIX – GATHER OTHER DATA ABOUT THE SUBWATERSHEDS AND REFINE CLASSIFICATION

While the imperviousness of a watershed has a direct relation to its ecological quality, it is not

Table III-3. Subwatersheds, Current Impervious Surface Percentage, and Preliminary Classifications.

Subwatershed	Current Impervious Surface %	Preliminary Classification (sensitive, impacted, nonsupporting)

the only factor to consider when deciding on watershed planning goals. For instance, a watershed may be just over 10% impervious, which would put it into the "impacted" category.

The Center for Watershed Protection lists many factors a community might consider to aid in the final decision over whether a subwatershed should be classified as sensitive or impacted when it is on the border line (see Appendix D for further discussion of these factors).

If any of the following factors are known to be the case, the Guidebook user would likely keep a subwatershed that is just over 10% in the sensitive category:

- Reported presence of rare, threatened or endangered species in the aquatic community (e.g., freshwater mussels, fish, crayfish or amphibians);
- Confirmed spawning of sensitive fish species.
- Fair/good, good, or good to excellent macroinvertebrate scores;
- More than 65% of Ephemeroptera, Plecoptera, and Tricoptera (EPT) species present in macroinvertebrate scores;
- No barriers impede movement of fish between the subwatershed and the mainstem;
- Stream channels show little evidence of historic alteration (ditching, enclosure, tile drainage or channelization);
- Water quality monitoring indicates no standards violations during dry weather;
- Stream and floodplain remain connected and regularly interact;
- Subwatershed drains to a downstream surface water supply;
- Stream channels are generally stable, as determined by the Rosgen level III analysis or a similar geomorphic analysis; stream habitat scores should rate at least fair-to-good;
- Subwatershed contains documented rare, threatened and endangered plant or animal populations;
- Wetlands, floodplains and/or beaver complexes make up more than ten percent of subwatershed area;
- Inventoried conservation areas comprise more than ten percent of watershed area;
- More than 50% of the riparian corridor has forest cover, and is either publicly owned or regulated;
- Large contiguous forest tracts remain in the watershed, and more than 40% of the watershed is in forest cover;
- Significant fraction of subwatershed is in public ownership and management;
- Stream buffers form a continuous network throughout subwatershed;
- Subwatershed is connected to the watershed through a wide, undisturbed corridor that allows for wildlife access;
- Farming, ranching and livestock operations in the watershed utilize best management practices; or
- Prior development in the subwatershed has utilized stormwater practices for both quality and quantity control;

Use these, or any other criteria deemed important for the community, to adjust the initial classifications determined in Step 5.

STEP SEVEN – CAPACITY ANALYSIS

Now that each subwatershed has a current impervious surface percentage and an impervious surface-related classification, it is time to perform the capacity analysis.

In order to do this, it will first be necessary to perform another GIS operation:

7A. Find the area of land left in the subwatersheds that is still buildable:

Erase from the subwatershed land use theme (created in Step 4C) land already built (land classified as some kind of residential, or commercial, or any kind of developed land) and public lands.

Table III-4. Impervious surface capacity analysis

A	B	C	D	E	F	G	H	I
Subwater -shed	**Current Imperviousness %**	**Current imperviousnes s category**	**Total area of subshed**	**Acres buildable land left**	**Impervious acres built in shed so far:**	**Total Imperviousness capacity**	**Additional impervious acres subshed can handle:**	**Remaining Impervious surface capacity (%):**
Delineated in Step 3	**Calculated in Step 4E**	**Decided upon in Step 5**	**Calculate d in Step 4C**	**Calculated in Step 7**	**Calculated in Step 4E**	**D*10/100**	**H = G – F**	**I = H/E *100**
Arms#3	3.99	Sensitive	4191.92	3383.10	167.26	419.19	251.93	7.45

Table III-4 (page 33) shows the analysis and the numbers for one of the subwatersheds in the pilot communities, along with blank rows to add more subwatersheds. In order to determine the capacity of each subwatershed of interest, perform the following calculations:

7B. Column B is the current percent of impervious surface in the subwatershed, determined in Step 4.

7C. Column C is the current classification assigned to the subwatershed determined in Steps Five and Six.

7D. Column D is the total area of the subwatershed, listed in the attribute table of the subwatershed land use theme created in Step 4C.

7E. Column E is the area of land left in the subwatershed that is still buildable (just calculated above.)

7F. Column F is the total area of impervious surface in the subwatershed so far.

Obtain this number by finding the total of the impervious area field in the subwatershed land use theme in Step 4E.

7G. Column G is the total impervious surface capacity.

Multiply the total area of the subwatershed (D) by the threshold percentage of impervious surface under which the community wants the subwatershed to remain. For instance, if the community desires a subwatershed to remain "sensitive," the threshold impervious surface percentage would be 10%:
Column G = D*10/100

7H. Column H is the additional amount of impervious surface the subwatershed can accommodate before it passes the threshold.

Subtract the amount of impervious surface currently in the subwatershed from the total amount of impervious surface the subwatershed can accommodate and remain "sensitive:"
Column H = G – F

7I. The last column (I) gives the percent of impervious surface any additional development must be limited to if the subwatershed is to maintain its desired classification.

Divide the additional area of impervious surface column (H) by the area of buildable land left in the subwatershed (E) and multiply by 100:
Column I = H/E *100

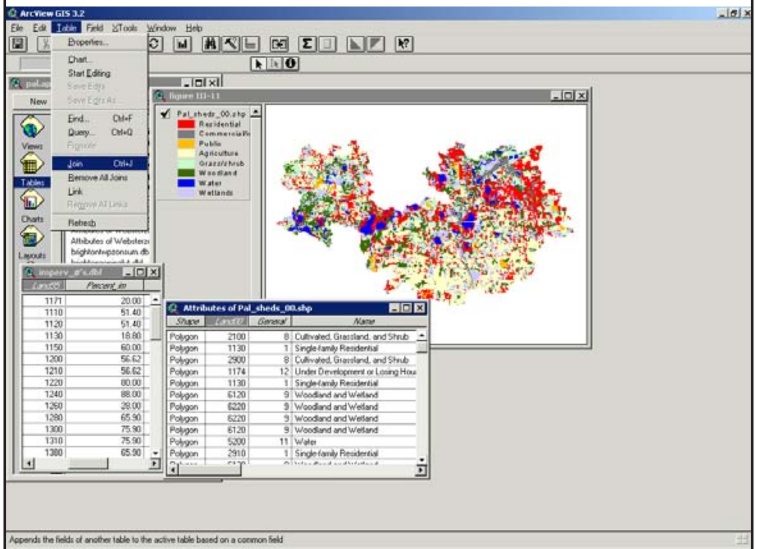
Column I of Table III-4 provides an average imperviousness that development on the remaining buildable land in any subwatershed must be limited to if a community wishes to keep that subwatershed in its current category (whether it is sensitive or impacted). This imperviousness limit, or capacity, can be interpreted several ways. Figure II-2 (page 17) illustrates three different ways to visualize what this can mean for how the remaining land in a subwatershed can be developed. Taking subwatershed Arms #3 (from the pilot communities) as an example from Table III-4 (page 33), it shows three different ways to develop the 251.93 additional impervious acres that subwatershed can handle and still remain in the sensitive category.

It is important to note that Figure II-2 (page 17) is for illustration purposes only. It does not take into account commercial, industrial, or institutional land uses that would inevitably develop along with residences, which would increase imperviousness even more. The population each example would accommodate illustrates that it is possible to accommodate population growth much more efficiently with properly placed high density development. When instituting actual planning and zoning decisions, communities will of course be taking many other factors besides imperviousness into account, and these factors will help determine the mix of lot sizes, development designs, development locations within any given subwatershed, and the total population for which the community will be planning.

STEP EIGHT - IMPERVIOUSNESS AND CLASSIFICATION OF SUBWATERSHEDS AT BUILDOUT

Step 4 revealed the approximate amount of impervious surface in the subwatersheds of interest given current land uses. What does the future hold for the subwatersheds, if the community's current land use policies remain as they are?

Figure III-10. GIS Operation to Join Impervious Surface Table to Land Use/Cover Theme.



Source: HRWC.

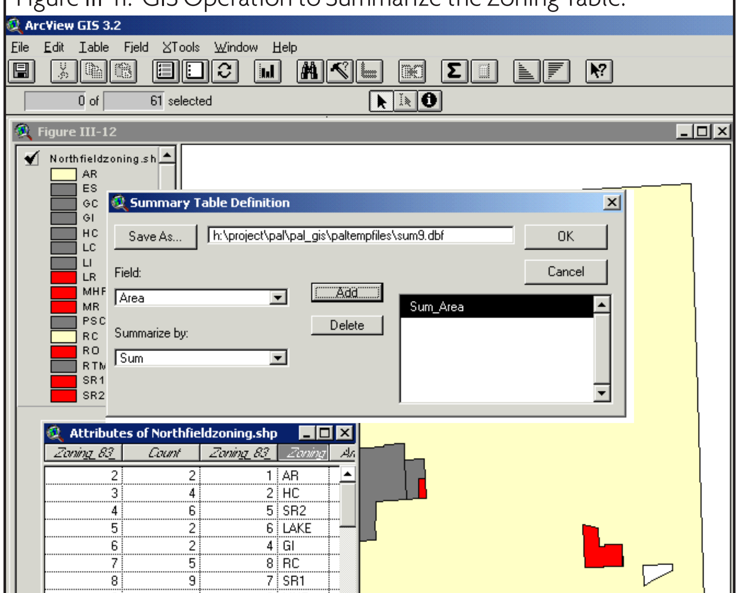
To answer this question, determine the projected amount of impervious surface in the subwatersheds using current zoning policies (also known as a "buildout analysis"). This series of steps can be repeated using the future land use maps to establish buildout of planned land uses as well.

8A. Create a theme of currently built land uses.

Select the land uses from the land use/cover theme that represent developed, or built, land, and make this a new theme. Join the impervious surface percentage table to this theme. This theme now will give an impervious surface percentage for each polygon in the built land use map (Figure III-10).

8B. Create a theme (or themes; one for each community encompassed by the subwatersheds) of projected impervious surface area for the undeveloped land.

Figure III-11. GIS Operation to Summarize the Zoning Table.



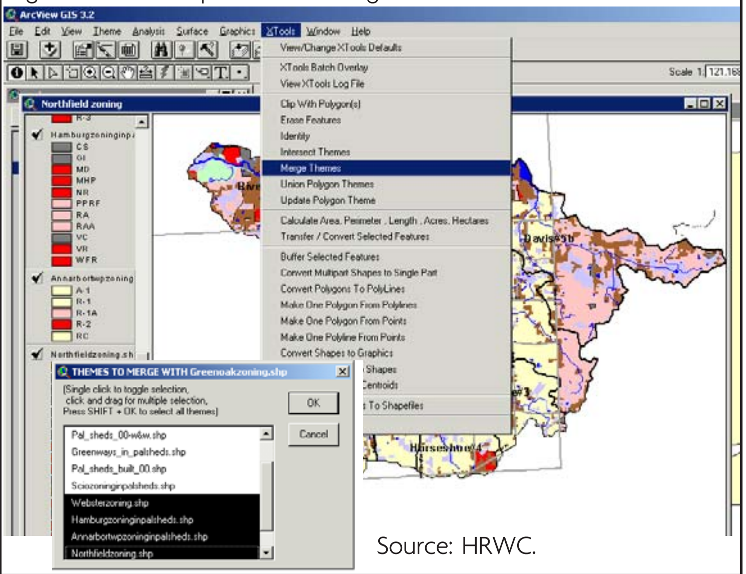
Source: HRWC.

Use the zoning maps obtained for each community in the subwatersheds of interest.

For each community zoning map, summarize the attribute table of the zoning map by zoning classification (Figure III-11).

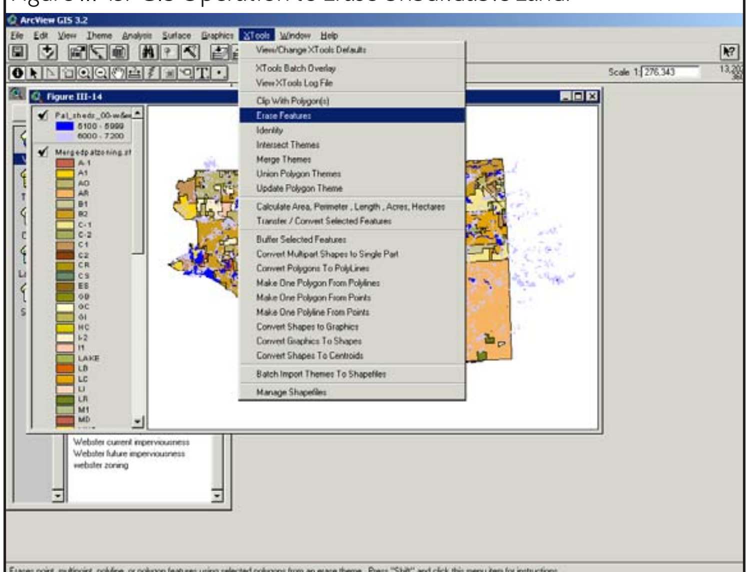
Using the information obtained in Step 1G, add a field to that table that gives the lot size or density allowed by that zoning.
Add another field to the table that gives the impervious surface percentage for each zoning classification, based on the allowable density. Tables II-1 (page 13)

Figure III-12. GIS Operation to Merge Themes.



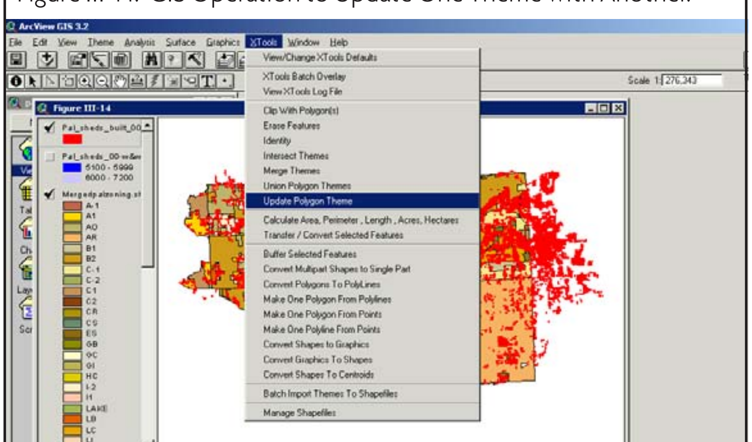
Source: HRWC.

Figure III-13. GIS Operation to Erase Unbuildable Land.



Source: HRWC.

Figure III-14. GIS Operation to Update One Theme with Another.



Source: HRWC.

and III-1 (page 24) give the impervious surface percentages used in the research project.

Note: if conducting this analysis for more than one community, make sure to be consistent about the names and formats of the added fields. Also, make sure the impervious surface percentage field is the same name and format as that field in the table in the built land use theme. The next step will be to merge the community maps together with their attached tables. The fields in the tables must be the same name and format.

Join this table to the zoning map theme. This theme now will give an impervious surface percentage for each polygon on the zoning map.

8C. If conducting this analysis for more than one community, merge all the zoning map themes together, using the Xtools extensions merge command.

This new theme gives the zoning classifications, allowable densities, and impervious surface percentages of each zoning district in each community (Figure III-12).

8D. Remove unbuildable land (water, wetlands, and public lands) from the merged zoning map.

Select water and wetlands from the land use/cover theme, and make this a new theme. Use this theme to erase these areas from the merged zoning map theme, using the Xtools extensions erase command (Figure III-13).

Similarly, erase the public lands theme from the merged zoning map theme.

The new theme now shows the zoning in all the communities of interest with unbuildable land taken out.

8E. Update the merged zoning map theme with the built land theme.

Using the Xtools extension, update the merged zoning map theme (created in Step 8D) with the built land use theme (created in Step 8A) (Figure III-14).

The new theme now contains the built land uses along with the impervious surface percentage associated with each polygon; and the unbuilt zoning classifications along with the impervious surface percentage associated with each of those polygons.

8F. Calculate impervious surface area for each polygon in the "built & zoning" theme created in Step 8E.

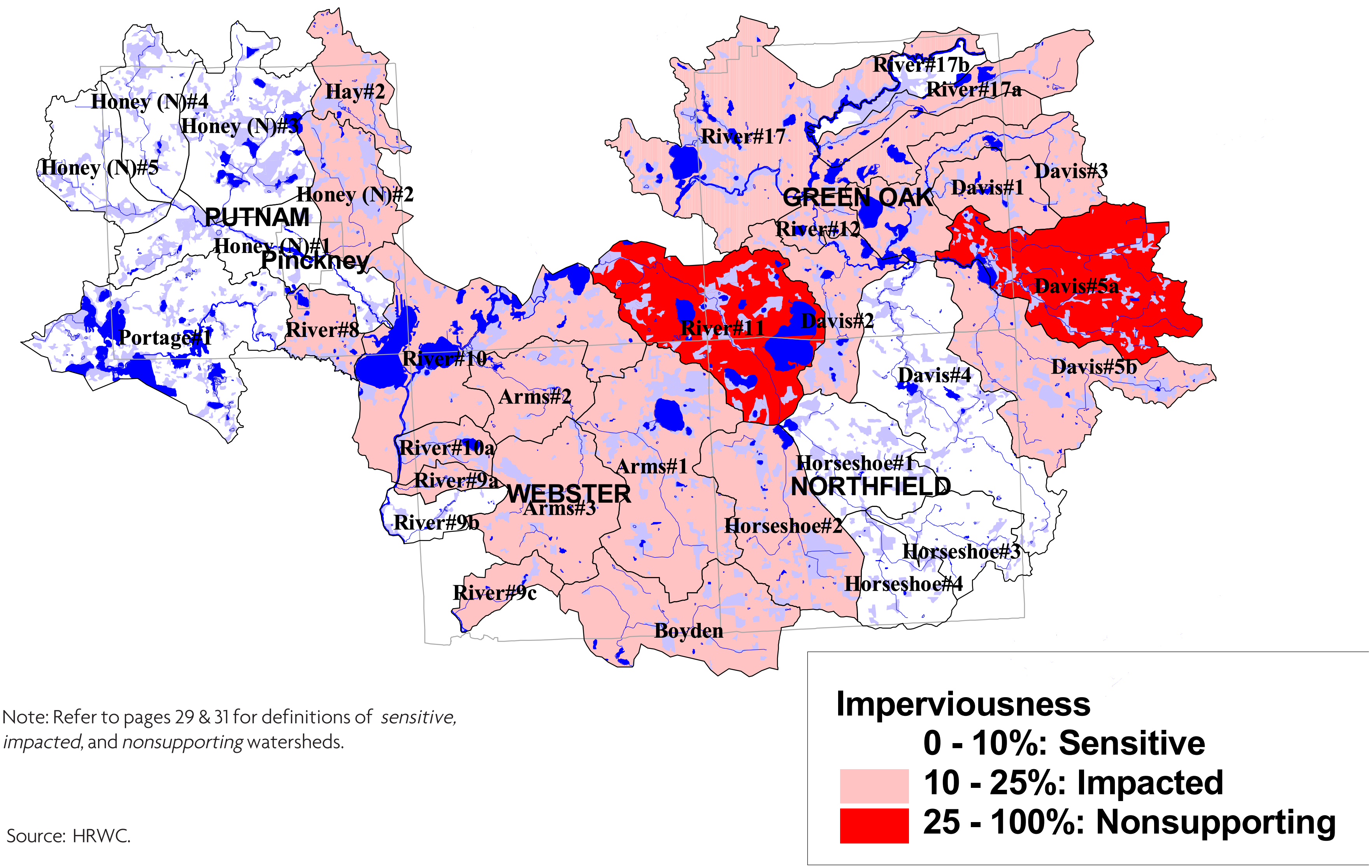
Create a new field in the built and zoning theme (created in Step 8E) that will give the area of impervious surface in each land use or zoning polygon. Perform the following calculation:

Impervious_area = area*impervious%/100

Table III-5 Buildout Analysis Steps

Step	GIS Themes/Tables Needed	GIS Processes to Complete	GIS Themes Created
8A. Create a theme of currently built land uses.	Land use/cover. Impervious surface table.	Theme properties. Convert to shapefile.	Currently built land uses.
8B. Create a theme of projected impervious surface area for the undeveloped land.	Zoning. Zoning "schedule of regulations".	Summarize zoning table. Add fields to that table. Attach table to zoning theme.	Zoning map(s) now has new data attached to it.
8C. Merge all the zoning map themes together.	Zoning.	Merge.	All zoning maps together in one theme.
8D. Remove unbuildable land from the merged zoning map	Merged zoning (from 8C). Land use/cover. Public lands.	Theme properties. Convert to shapefile. Erase.	Water & wetlands. Public lands. Merged buildable zoning.
8E. Update the merged zoning map theme with the built land theme.	Merged buildable zoning. Currently built land uses.	Update.	Built land uses + unbuilt zoning.
8F. Calculate impervious surface area for each polygon in the "built & zoning" theme.	Built land uses+unbuilt zoning.	Create new field.	Built land uses + unbuilt zoning now has new data.
8G. Find the projected impervious surface percentage for each subwatershed.	Built land uses + unbuilt zoning. Subwatersheds.	Intersect. Summarize table.	Subwatershed impervious%.

Map III-3. Projected Imperviousness Calculated for the Subwatersheds in the Pilot Communities.



Note: Refer to pages 29 & 31 for definitions of *sensitive, impacted*, and *nonsupporting* watersheds.

Source: HRWC.

8G. Find the projected impervious surface percentage for each subwatershed.

Intersect the theme created in Step 8F with the subwatershed theme.

Perform a summary on the subwatershed field in the table of this new theme. Find the sum of the area and the sum of the impervious area, and make this summary a new theme.

Open up the table in this new theme, add a field, impervious%, and calculate:

Impervious% = (sum_impervious_area/ sum_area)*100.

This theme now shows the impervious surface percentage for each subwatershed.

Table III-5 (page 37) lists all the steps described above.

Map III-3 (page 38) shows the classification of each subwatershed at zoning buildout for the four pilot communities. Compare this map to Map III-2 (page 30). Note the number of subwatersheds that will change from sensitive to impacted if land is developed as presently zoned. Likewise, look at the current impervious surface theme created in Step 4 for the communities of interest and compare that to the buildout impervious surface theme created in Step 8.

STEP NINE - DETERMINE SIGNIFICANCE OF DATA TO COMMUNITY

Once the impervious surface capacity and the buildout analyses are complete it is time to decide if the current zoning in the community is appropriate for maintaining the desired subwatershed classifications, or if the community has "overzoned" for the capacity of some of the subwatersheds. Before considering initiating planning or zoning changes, consider the question -- Where a subwatershed will fall from one classification to a more impaired classification (e.g. new development will cause a "sensitive" watershed to fall to an "impacted one) at buildout under existing zoning—is this important to the community? Why?

For example, if the subwatershed is already urban and in the "nonsupporting" classification, additional runoff may be acceptable to the community, as long as proper sanitary and stormwater sewers are in place. But if the subwatershed is rural and the water quality is high, the community may be unwilling to accept degradation in the water quality and in the ecological integrity of the streams in the watershed.

What changes could the community make to prevent undesirable degradation of water quality? Fill in Table III-6 (page 40) for each subwatershed of interest to determine the community's need or desire for making planning and zoning changes to maintain their streams' water quality.

The following options are worth considering:

- Reduce density overall to keep amounts of impervious surfaces below the threshold level over the entire area of the subwatershed;
- Transfer density from more sensitive subwatersheds to less sensitive subwatersheds;
- Concentrate density in development sites in order to leave the majority of a site undeveloped, and thus reduce impervious surfaces overall;
- Preserve currently undeveloped land in an undeveloped state either through purchase of development rights or outright land acquisition; or
- Add significant urban infrastructure (e.g. sewers) in areas where the percent impervious surface is projected to increase in order to mitigate impacts to streams

It will be important to include neighboring jurisdictions in impervious surface capacity discussions, since watershed boundaries do not obey municipal boundaries. If one community has decided to encourage development, a downstream community will feel the impacts of the resulting increased impervious surfaces as the water quality in their streams suffers.

STEP TEN – DECIDE ON NEW REGULATORY OPTIONS FOR MANAGING GROWTH

If protecting existing water quality and the ecological integrity of streams is important, what options are available to achieve the desired outcome? Below are the options that the project researchers and pilot communities decided to focus on. The white paper *Watershed Planning: Determining Impervious Surface Capacity to Better Manage Growth at the Rural/Urban Fringe* (Appendix A) contains a more complete listing of planning and zoning options. Appendix F contains many of the sample ordinances listed in the white paper.

Refer to Appendix C for more detailed descriptions of each option described below, as well as sample ordinance language for their adoption.

Photo III-1. Parking Lots, Often Much Larger Than They Need To Be, Create Unnecessary Impervious Surfaces.

Source: Washtenaw County Drain Commissioner.

Photo III-2. Stormwater is a Major Pollutant in Michigan's Waterways.

Source: HRWC.

Option One

Adopt new impervious surface standards and conduct an impervious surface analysis as part of zoning review and approval process. The community could create overlay zones that correspond to the subwatersheds and require developments within those subwatersheds to limit impervious surfaces based on the impervious surfaces capacities determined by this methodology. Or, each zoning district in the community could have an impervious surface, or lot coverage limit (see Photo III-1).

Option Two

Adopt or link to an existing stormwater protection ordinance. Grand Traverse, Benzie, Wayne, Washtenaw, Livingston, and some other counties have developed stormwater management rules to mitigate the impacts of the impervious surfaces that come with development. These rules apply to county drains. Communities could link local zoning decisions to decisions by a County Drain Commissioner under a County Stormwater Management Ordinance. If the county does not have such rules, or a county-wide ordinance, the community could adopt its own ordinance (see Photo III-2).

Option Three

Provide strong incentives for clustering with large amounts of open space in the rural areas of the township. Most Michigan communities are required to offer clustering as an option in residential districts. If the developer chooses to use the option in a township or a county, the developer must agree to permanently preserve at least 50% of the site in permanent open space. Cluster developments can result in less impervious surface than the same density spread evenly across the land becauseless space is used for roads and driveways. If a community wants to reduce impervious surface, encouraging cluster developments is a good idea (see Photo III-3).

Photo III-3. Clustering Residences Together Can Preserve Open Space and Minimize Impervious Surfaces.

Source: HRWC.

Photo III-4. Natural Vegetative Buffer.

Source: Northeastern Illinois Planning Commission and Chicago Wilderness.

Option Four

Establish buffers along streams and other waterbodies. One of the simplest ways to improve infiltration of stormwater runoff is to provide ample space between impervious surfaces and waterbodies. This is usually done by buffer strip or setback requirements. There are two common approaches. The first is a buffer strip comprised of natural vegetation. It is especially well suited in rural areas where land near streams and creeks is presently in a natural vegetated state. The second option is a setback from designated natural features (see Photo III-4).

Option Five

Link to a transfer of development rights (TDR) program for those parts of the community where open space is desired to be permanently protected (see Figure II-4, page 20). This last option requires the existence or creation of a TDR program. Land in a sensitive subwatershed would be permanently preserved by allowing landowners to sell development rights to developers who would build at a higher density in parts of the community where there were adequate public facilities to accommodate the impacts of the more intense development. In most cases this means transferring development rights across a jurisdiction boundary (such as between a township and a city). This would require a complicated intergovernmental agreement, or new legislation. If the township has an urban area with public sewer service and a very rural area it wishes to protect, and is willing to allow a higher density in the urban area when development rights are purchased in the rural area, then a local TDR program could be established under the existing Township Zoning Act. The feature article by Gerald Fisher in the March 2003, *Planning & Zoning News* explains how to do this (see Appendix G).

Engage in dialogue around each option, particularly the pros and cons and relevant legal considerations for each within your community.

Factors to consider include:
- Willingness to assume legal risk associated with a relatively new regulatory approach (as with Option One);
- Capability of zoning staff to administer new provisions;
- Commitment of governing body and zoning staff to consistently enforce new regulations (as with Options One through Five);
- Whether there is an opportunity to link and coordinate with a county stormwater management ordinance, or if a local ordinance should be adopted (Option Two);
- Whether the community is willing to offer any (or more) incentives for clustering to achieve water quality benefits;
- Whether adopting buffer strip provisions will be adequate (hundreds of communities have done so), or whether a new sensitive natural features ordinance is necessary; and
- Whether there is support for creating a TDR program in the community or region.

TIPS WHEN CONSIDERING ZONING AMENDMENTS:
- Choose the particular techniques that are best suited to achieve the community's desired objectives.
- Be sure the municipal attorney is involved in the review and drafting of the options prior to adoption.
- Adapt the sample ordinance language in Appendix C to best fit your community's needs and to minimize legal risks.
- Monitor implementation and refine ordinance language as needed to best achieve the community objectives.

Some communities may feel comfortable adopting some or all of these regulatory approaches, while others may feel more comfortable using the impervious surface capacity analysis only as a planning tool. This decision will be up to each community, but it should be made after consultation with adjoining jurisdictions so there is a coordinated approach – especially where communities share the same watershed.

STEP ELEVEN – PREPARE MASTER PLAN AMENDMENTS TO SUPPORT OPTIONS

11A. Amend the local Master Plan.

If the community decides to pursue any of the zoning options listed in Step 10, it will be necessary to also amend the local Master Plan (also known as the Future Land Use, Comprehensive, or Growth Management Plan) to provide a basis for any zoning amendments and to keep zoning consistent with the Master Plan. Be sure the purposes for pursuing the desired outcome are clearly stated and relate to other relevant sections of the Master Plan (such as the description of existing community character and infrastructure improvements sections). Appendix K includes sample Master Plan elements for use with the zoning options presented in Step 10.

11B. Use impervious surface capacity analysis results in the Master Plan.

If the community decides not to pursue regulatory options, it would still be useful to include the impervious surface capacity analysis results in the Master Plan, and use them as general planning tools.

In general, it is important that the Master Plan include language clearly stating community goals for maintaining and improving watershed quality; specify areas the community will encourage development and areas it will encourage preservation of open space; and identify natural areas and open spaces it is important to protect in order to preserve their ecological functions. Appendix K provides sample language that will be useful in this regard.

Appendix H, *Addressing Imperviousness In Plans, Site Design and Land Use Regulations*, and I, *Tools for Protection of Open Space, Water Quality, and Rural Character,* describes specific Master Plan revisions communities can make to incorporate concern about impervious surfaces.

Appendix J is Acme Township's Master Plan, which has language that other communities may find useful as a model.

STEP TWELVE – DECIDE ON NON-REGULATORY INITIATIVES

In addition to incorporating impervious surface analyses into the Master Plan, there are other non-regulatory initiatives the community may wish to take. These include beginning, or enlarging participation in land conservancy, PA 116 or farmland PDR and inter-jurisdictional TDR programs in those parts of the community where open space is desired to be permanently protected.

Another option is to educate the public, land owners and developers about the purposes, benefits and procedures associated with limiting impervious surfaces, protecting water quality and, if relevant, new adopted regulations.

Finally, preparing and annually updating a capital improvement program and coordinating improvements with the county drain commissioners would be recommended. See Appendix K for sample Master Plan language to encourage these initiatives. Also see Part V: Additional Resources, for many more materials to assist with non-regulatory initiatives.

Part IV: Calculating Gravel Road Capacity

HOW WOULD A COMMUNITY CONDUCT A GRAVEL ROAD CAPACITY ANALYSIS?

Part II of this Guidebook gave the compelling reasons about why a community should be concerned about gravel road capacities. This section of the Guidebook explains how to conduct a gravel road capacity analysis and integrate the findings into local plans, zoning and non-regulatory initiatives. Figure IV-1 lists the steps to be followed.

USE OF GIS

Project researchers used ArcView GIS 3.2 to perform elements of the gravel road capacity analysis. Other GIS programs can perform the same functions.

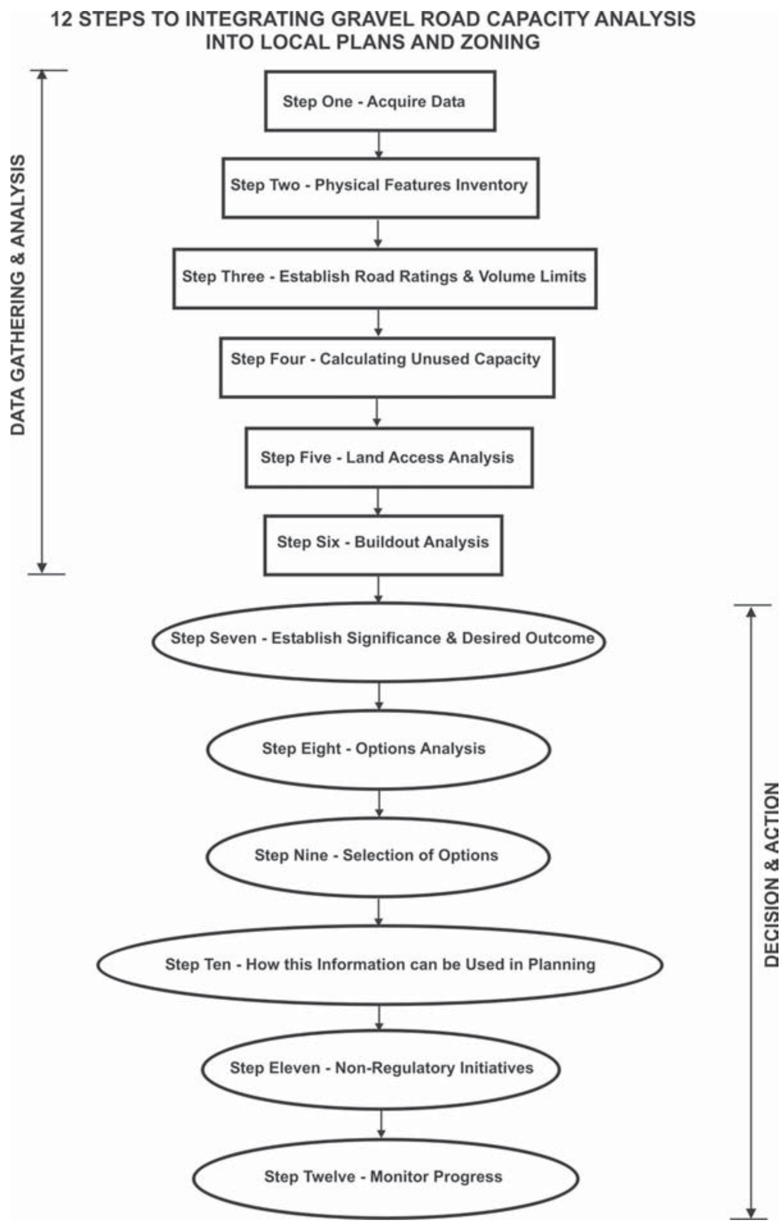
STEP ONE: ACQUIRE DATA

The first step in setting capacity levels on gravel roads is to conduct an inventory of traffic volumes and physical features of those roads. But other data needed later should also be gathered at the outset. This includes zoning and master plan data from the participating communities or from the county; parcel data (mapped and preferably digitally) is also needed.

1A. Collect data on traffic volumes on each gravel road segment.

If this data has never been collected before, set out traffic counters (shown in Photo IV-1) for twenty-four hour periods to collect traffic volume data. Don't bother trying to get directional counts, since too many people drive in the center of gravel roads for directional counts to be accurate. Thus, total vehicle counts are often all that is reliable.

Figure IV-1.



Source: Planning and Zoning Center, Inc.

Photo IV-1: Traffic Counter on a Gravel Road.

Photo: Julie Nixon, Washtenaw County Road Commission

If it is the first time collecting traffic volume data, it will be necessary to create a road segment database. Table IV-1 (page 46) illustrates the sample spreadsheet to create a local gravel road capacity analysis. It gives guidance on the first six steps in this part of the Guidebook. Appendix L includes a Microsoft Excel template for this Table, which will aid in creating your own traffic database.

You may also need to delineate the road segments themselves, if the community or road commission has not created such segments already. Make the segments about one mile in length from one major intersection to the next. For example, Twelve Mile Road in Livingston County was cut into two road segments, one from Rushton Road to Peer Road and one from Peer Road to Dixboro Road (Table IV-2, page 46).

HELPFUL HINT:
The Washtenaw and Livingston County Road Commission staff conducted their inventories of these physical features for the four pilot townships in early winter months when staff had more flexible time. The Livingston County Road Commission used Microsoft Access to create forms for data entry in the field. Then they were able to enter the data collected directly into the forms to create a database.

The road segments can be demarcated using a paper map or a map in GIS.

If gravel road inventories are already available, make sure the data is relatively recent (within the past three to five years to be reliable). If major development has taken place along or near the corridor or if the overall traffic volumes within the area have risen substantially in recent years, it will be necessary to update the data.

Typically the only data recorded regarding a gravel road is the last date of maintenance and the type of work performed on it, such as grading or adding more gravel.

However, not all gravel roads are alike. To put them all into one category when studying traffic volumes assumes that all gravel roads can handle similar amounts of vehicle traffic—which they cannot. That means a systematic inventory and classification of each gravel road segment is needed. Figure IV-2 (page 47) presents a sample inventory sheet for the data collection process (also see Appendix M for the complete sheets used for the data inventory in the pilot project). Use these sheets as a guide and modify them for use in the community of interest. After the data collection process is complete for every gravel road segment in the community, move to the next step, which is scoring the data.

STEP TWO- PHYSICAL FEATURES

After gathering the inventory data, the Livingston and Washtenaw County Road Commission staffs identified five key physical feature variables for each gravel road segment that were the most representative of the characteristics of each road segment:

- Width
- Surface type
- Width of the clear zone next to the road
- Speed of comfortable travel on the road
- Road drainage

Table IV-1: Sample Spreadsheet of Data to be Entered and Calculated as a Part of the Steps in the Guidebook

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Road Segment Name**	**Actual Volumes**	**Road Segment Start Point**	**Road Segment End Point**	**Physical Features Score**	**A through E Rating**	**Overcapacity**	**Unused Capacity (Trips per Day)**	**Number of DU's with Unused Capacity (assumes 10 trips per day)**	**Buildable Acres**	**DU's per Buildable Acres with Unused Capacity**	**Zoning Min lot size**	**Zoning DU's per acre**	**Difference (Capacity density-zoning density)**
2	To be entered (see Step 1)	To be collected and entered (see Step 1 A)	To be entered (see Step 1 A)	To be entered (see Step 1A)	To be calculated from the inventory sheets (see Step 2 B)	To be calculated (see Step 2B)	To be calculated (see Step 3A)	To be calculated (see Step 4)	To be calculated (see Step 4)	To be calculated (see Step 5)	To be calculated (see Step 5)	From the Zoning Ordinance	To be calculated (see Step 6 and conversion table in Appendix _)	Subtract Column K from Column M (sse Step 6)

Table IV-2: Sample Traffic Count Database.

Livingston County Road Commission
24-Hour Traffic Counts for Selected Location

FROM: **1999** TO: **2002**

COMMUNITY	LID	SEMID	ROAD NAME	DIR	AT	BETWEEN	AND	DATE	TOTAL
GREEN OAK TWP	4	4	10 MILE	2-WAY		PEER	DIXBORO	6/5/2000	11,645
GREEN OAK TWP	6	6	10 MILE	2-WAY		RUSHTON	PEER	7/7/1999	8,104
GREEN OAK TWP	6	6	10 MILE	2-WAY		RUSHTON	PEER	6/5/2000	10,037
GREEN OAK TWP	9	9	12 MILE	2-WAY		PEER	DIXBORO	6/5/2000	289
GREEN OAK TWP	10	10	12 MILE	2-WAY		RUSHTON	PEER	6/5/2000	323
GREEN OAK TWP	16	16	8 MILE	2-WAY		CITY/TWP LINE	LEMEN	5/15/2002	6,542
GREEN OAK TWP	19	19	8 MILE	2-WAY		RUSHTON	EARHART	6/8/2000	1,154
GREEN OAK TWP	24	24	9 MILE	2-WAY		FIELDCREST	EAST SHORE	8/22/2000	6,839
GREEN OAK TWP	32	32	9 MILE	2-WAY		MARSHALL	RUSHTON	10/5/2000	4,743
GREEN OAK TWP	33	33	9 MILE	2-WAY		EAST SHORE	MARSHALL	8/21/2000	5,098

Source: Livingston County Road Commission.

Figure IV-2: Sample of Inventory Sheet from Livingston County Road Commission.

Livingston County Road Commission
Gravel Road Inventory Field Worksheet

Segment and Location:

Road Name: ____________ Township: ____________ Section: ______

Beginning of Segment: ____________ End of Segment: ____________

Length of Segment (in feet): ________ Road Classification: ☐ Primary ☐ Local

Physical Features:

Width of Segment: ☐ less than 18' ☐ 18' to 24' ☐ greater than 24'

Type of Surface Material: ☐ Earth ☐ Natural Aggregate ☐ Limestone ☐ Other

Comments: ____________

Type of Roadside Vegetation: ☐ Brush ☐ Wooded ☐ Cropland/Pasture ☐ Lawn ☐ Other (Specify) ☐ Varies (Specify)

Comments: ____________

Width of Clear Zone: ☐ less than 5' ☐ 5' to 10' ☐ greater than 10'

Type of Clear Zone Obstruction: ☐ Cut-slope ☐ Fill-slope ☐ Trees ☐ Other ☐ None

Comments: ____________

Road Alignment Classification: ☐ Complex ☐ Moderate ☐ Slight

Do roadside ditches exist along the majority of the road segment? ☐ Yes ☐ No

Is roadside drainage adequate? ☐ Yes ☐ No

If no, state reason: ____________

Source: Planning and Zoning Center, Inc.

These five characteristics (or variables) were scored to create a gravel road classification system. Each variable has a continuum with three elements; with the first being the lowest quality and the third being the highest. If all five variables for a given road segment scored a one, then the total score for the five variables is a 5 (lowest). If every variable scores a 3 the total score for the segment is a fifteen (highest).

2A. Use the following rating system to score the gravel road segments you inventoried in the first step.

Five key variables rated:

Surface type
Rating = 1 if the existing surface is earth
Rating = 2 if the surface is gravel
Rating = 3 if limestone

Road width
Rating = 1 if the average width of the road segment is under 18 feet
Rating = 2 if the width is 18 to 24 feet
Rating = 3 if the width is over 24 feet

Adequate drainage
Rating = 1 if drainage was determined to be inadequate with Average Daily Traffic (ADT) volumes over 400. "Inadequate" drainage applies to areas with significant ponding several days in a row, or a non-functioning ditch or culvert.
Rating = 2 if drainage was determined to be inadequate but ADT volumes were under 400
Rating = 3 if the road segment had adequate drainage

Width of clear zone (area at side of road)
Rating = 1 if width of clear zone is less than 5 feet
Rating = 2 if width is 5 to 10 feet
Rating = 3 if width is over 10 feet

Road alignment rating (comfortable travel speed—considering levelness, hills, valleys and curves)
Rating = 1 if under 25 mph
Rating = 2 if about 35 mph
Rating = 3 if about 45 mph

Physical features ratings:
Now tabulate a score for each of the gravel road segments in your community. Column A in Table IV-3 shows some of the physical features scores

Table IV-3: Sample Table from Project Research-Part I.

	A	B	C	D	E	F
1	Physical Features Score	Name	Actual Volumes	Start	End	Overcapacity
2	13	Cedar Lake	453	Burgess	Schafer	0
3	10	Cedar Lake	372	Patterson Lake	Monks	0
4	10	Patterson Dri	722	Patterson Lake	End	1
5	10	Mower	258	Cedar Lake	Pinckney Limit	0
6	10	Monks	219	Kelly	Cedar Lake	0
7	6	Doyle	35	Patterson Lake	Kelly	0
8	9	Tiplady	136	Silver Hill	Dexter Town Hall	0
9	12	Tiplady	657	Dexter Town Hall	Toma	0
10	11	Tiplady	255	Toma	Dexter-Pinckney	0
11	10	Dexter Town	657	Tiplady	County Line	1
12	15	Peer	815	Twelve Mile	Ten Mile	0
13	8	SCULLY	54	GREGORY	N. TERRITORIAL	0
14	12	SCULLY	433	N. TERRITORIAL	VALENTINE	0
15	9	EARHART	337	N. CHURCH	N. TERRITORIAL	0
16	10	8 MILE RD	1,602	EARHART	DIXBORO	1

of gravel road segments in the pilot communities. For Peer Road, row 12 in Table IV-3, the physical features rating was a perfect 15 from the inventory sheet. For Tiplady Road, from Silver Hill to Dexter Town Hall, the road segment received a 9 score, but from Dexter Town Hall to Toma Road, the road conditions improved to score a 12.

2B. How do the roads rate?

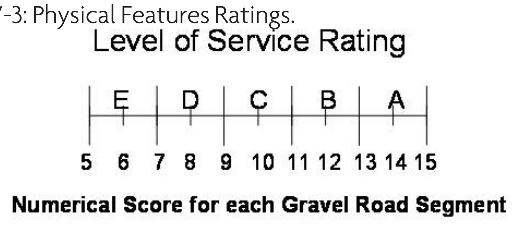
Adding up the score for the gravel road segment inventory sheet using the ratings system outlined will yield a level of service rating (a numerical score) from 5 to 15 for each gravel road segment. On Table IV-1 (page 46) enter the physical features score for each gravel road segment in Column E. The numerical score corresponds to an A through E rating for each gravel road segment. Figure IV-3 depicts how the 5 through 15 score corresponds to the A-E rating, with 5 being the lowest or an E and 15 being the highest or an A. Sort out all of the ratings on gravel road segments in your community from A to E and summarize them in a table, as done for Putnam Township, one of the pilot communities in Figures IV-4. Then insert the rating for each road segment in the Column F of Table IV-1 (page 46).

Overall, for the four pilot communities the county's averages were very similar. Livingston County's gravel road segments averaged a 10.82 score and Washtenaw County gravel road segments averaged a 9.97 score.

Once you have rated all of the gravel road segments, map them in GIS to give a visual reference to the road ratings (see Map IV-1, page 49). If a community doesn't have GIS, this map could easily be drafted on paper.

What does a gravel road segment of each of the gravel road ratings look like?

Figure IV-3: Physical Features Ratings.



LOS rating from 5 to 15 creates a numerical score for each gravel road segment

Source: Planning and Zoning Center, Inc.

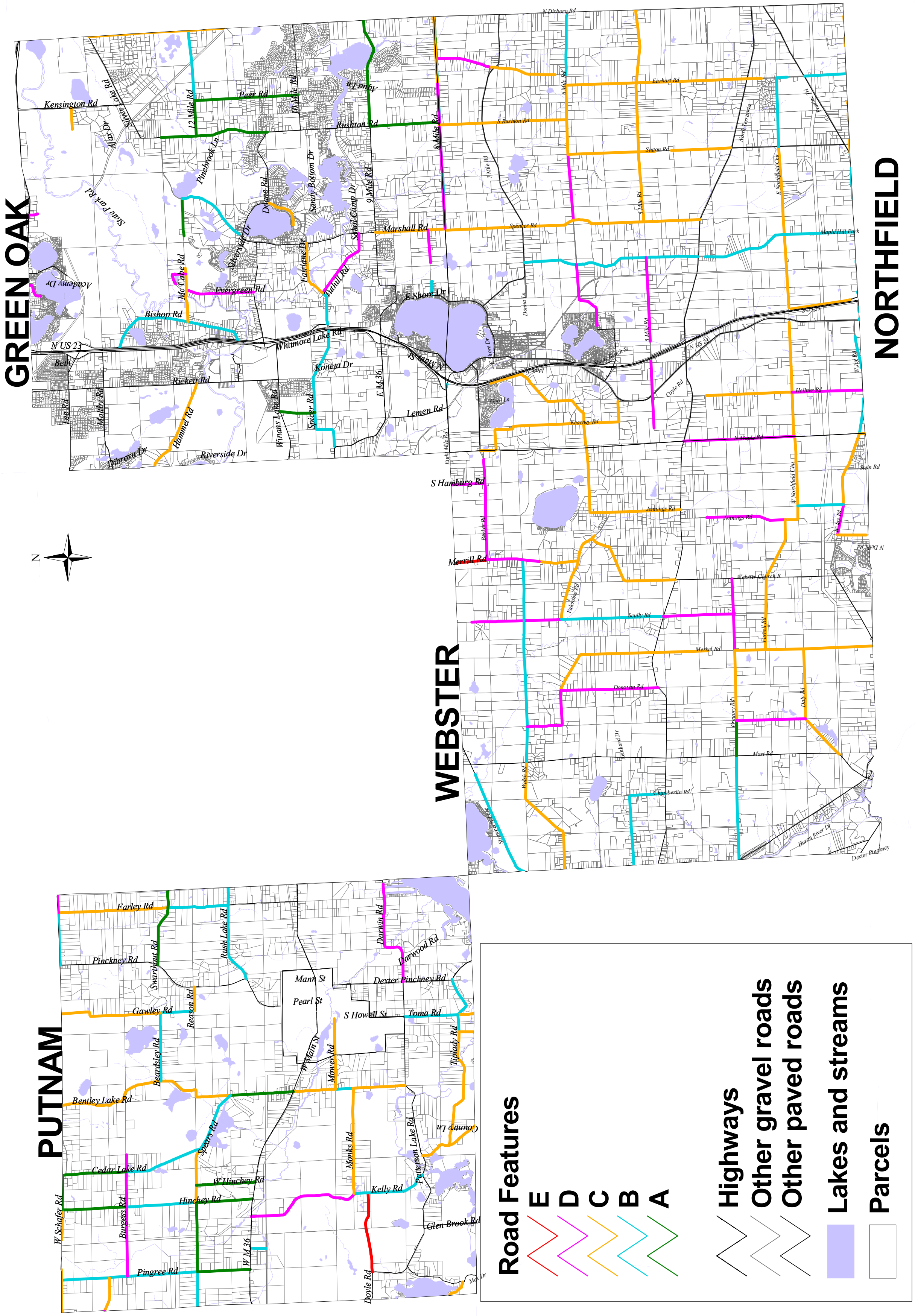
Figure IV-4: Putnam Township A through E Scoring.

- 56 Gravel Road Segments

Physical Features Ratings	Number of Gravel Road Segments
A	9
B	20
C	20
D	6
E	1

Source: Planning and Zoning Center, Inc.

Map IV-1: Map of A through E Ratings.



Source: HRWC.

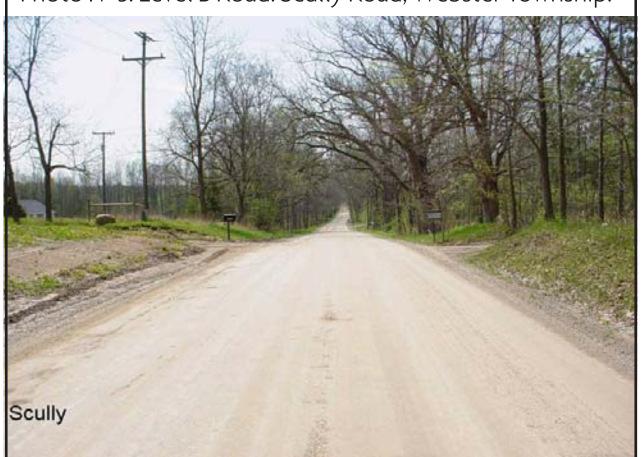
Photo IV-2 represents a gravel road segment classified as Level A: This road almost has the appearance of a paved road. There are many layers of hard packed limestone chips. The widths are wide enough to allow traffic to travel at moderate speeds without slowing down. The surface has been treated to stabilize dust and provide proper drainage. There is no sign of road distress.

Photo IV-2: Level A Road-Pingree Road, Putnam Township.

Source: Livingston County Road Commission.

Photo IV-3 is a gravel road segment rated Level B: This road has a good crown and drainage. There may be some loose aggregate or slight washboarding. The width still allows for vehicles to travel in both directions without slowing down for each other.

Photo IV-3: Level B Road: Scully Road, Webster Township.



Source: Livingston County Road Commission.

Photo IV-4 is a gravel road segment rated Level C: This road's width does allow for two-way traffic, but only at slow speeds. The aggregate surface is fairly loose which can mean moderate dust and an obstruction of vision. Moderate washboarding (1 to 2 inch holes) may be present. Also, drainage may be a concern in small areas of the roadway, particularly in springtime months and after heavy rains.

Photo IV-4: Level C Road: Fairlane Road, Green Oak Township.

Source: Livingston County Road Commission.

Photo IV-5 (page 50) is a gravel road segment rated Level D: This road has significant ponding problems after rains much of the year. This

Photo IV-5: Level D Road: Five Mile Road, Northfield Township.

Source: Washtenaw County Road Commission.

road's width is too narrow for two-way traffic. There is loose aggregate which causes excessive dust in dry times. Potholes, rutting and washboarding may be fairly severe on these roads. Culverts and/or ditches may not be present along the entire roadway or may be partially failing.

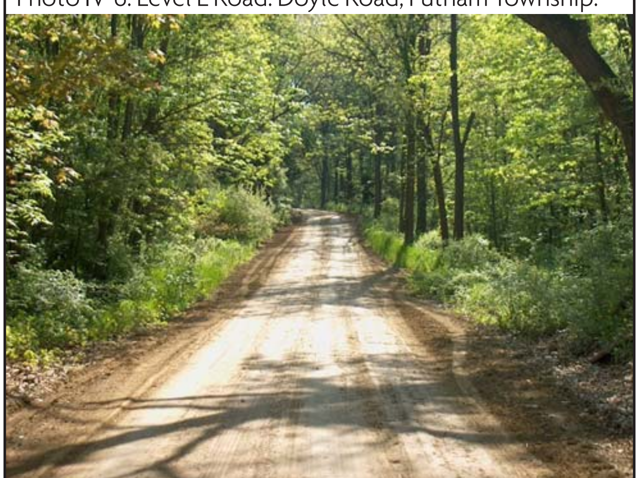
Photo IV-6 is a gravel road segment rated Level E. The road may be closed at times due to drainage problems or severe potholes. Widths do not allow for two-way traffic. The limited aggregate or dirt surface may need rebuilding. Roads may have obstructions, such as large trees jutting into the roadway that require the driver to maneuver around.

STEP THREE: ESTABLISH ROAD RATINGS AND VOLUME LIMITS

Project researchers analyzed the numerical scores for each of the gravel road segments within each pilot community in numerous regression analyses. The primary regression analysis used to set the capacity threshold levels for the physical features ratings plotted the data on existing volumes against the physical features rating for all of the gravel road segments for the four pilot communities studied. The regression has a positive outcome, which means as the physical characteristics of a gravel roadway segment improve, traffic volumes also increased. (See Appendix B for a more detailed discussion of this exercise.) As the volumes increased, the gravel road conditions typically worsen, requiring extra materials and maintenance (see Figure IV-5a). Ultimately project researchers aimed at identifying a threshold level X for each gravel road rating (see Figure IV-5b). At X the condition of the gravel road can support a finite traffic volume. That point was established by the regression curves and the result is shown in Figure IV-6 (page 52).

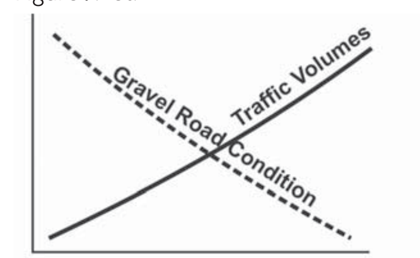
The next step in the analysis is to take these threshold levels in Figure IV-6 and apply them to the gravel road segments that have already been scored and have road volumes. Compare the road segments rated "A;" are the existing volumes over 900 vehicles per day? If so, they would be rated "overcapacity." Go on to the

Photo IV-6: Level E Road: Doyle Road, Putnam Township.



Source: Livingston County Road Commission.

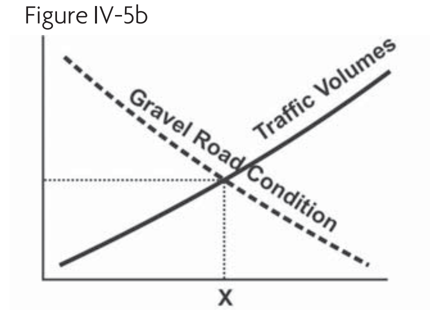
Figure IV-5a



As traffic volumes increase, gravel road conditions worsen, requiring extra materials and maintenance.

Source: Planning and Zoning Center, Inc.

Figure IV-5b



Theoretically, there is a point where the condition of the road will support a maximum amount, X, of traffic volume.

Source: Planning and Zoning Center, Inc.

CAPACITY RATINGS AND VOLUME LEVELS

The level of service standards proposed for gravel roads in this Guidebook are quite different than those for paved roads and intersections. Level of service (LOS) standards have long been assigned to paved roads, based on congestion levels. This is a well known system of A, B, C, D, E and F rated paved roads. Since congestion rarely occurs on gravel roads, a different standard needed to be introduced. The LOS standards developed in this project are based on the average daily volume levels for each rated gravel road segment (in contrast to peak hour traffic volume levels on paved roads). Remember these physical features ratings were based on the five variables that are key to gravel road capacity—1) surface type, 2) drainage, 3) road width, 4) width of clear zone, and 5) road alignment rating (comfortable travel speed). These LOS ratings are listed in Figure IV-6. For a gravel road, the daily traffic volumes that are possible, without significant road deterioration, on a particular road base and sub-base are a finite number, similar to a sewer capacity. Without repeated surface grading as volumes increase, the gravel road breaks down causing safety, comfort, dust, and cost concerns for all involved.

Figure IV-6.

Volume Levels by Gravel Road Physical Features Ratings

Physical Features Ratings (numerical score)	Midpoint Thresholds (based on existing daily traffic volumes)	Range of Acceptable Volume
A (13-15)	900	800-1,000
B (11-12.9)	700	600-800
C (9.0-10.9)	500	400-600
D (7-8.9)	300	200-400
E (5-6.9)	100	<200

Source: Planning and Zoning Center, Inc.

road segments that rated a "B," if the existing volumes are over 700 vehicles per day then they would be considered overcapacity and so on. The third column in Figure IV-6 indicates a higher maximum capacity than the midpoint threshold. This situation reflects "on the ground" reality and could be used as the threshold instead of the midpoint threshold.

Next go back to the database that was introduced in Table IV-1 (page 46). At this point in the Guidebook you should have all of the information entered into the database in Columns A through F. The next column to enter in the database is Column G which documents whether the gravel road segment is over or under these threshold levels explained in this step. The gravel roads which are overcapacity receive a "1" and those with excess capacity receive a "0." All of the roads that were calculated as "over capacity" are excluded from the rest of the calculations (through Step 6), because the traffic volumes are already over the existing capacity of the road.

STEP FOUR: CALCULATE UNUSED CAPACITY

Step three involved identifying the gravel roads that are "overcapacity." For the remaining gravel road segments there is some "unused" capacity on the road which can be calculated by subtracting the existing volumes

HERE IS AN EXAMPLE:
In the sample data in Table IV-3 (page 48), Patterson Drive (row 4), Dexter Town Hall (row 11) and 8 Mile Road (row 16) have existing volumes that are over the midpoint threshold level for a "C" rated road, which is 500 vehicles per day. The gravel roads that are overcapacity received a "1" and those with excess capacity received a "0."

from the threshold level for the gravel road rating for the segment.

4A. Calculate "unused capacity."

In Table IV-1 (on page 46) the next step is to calculate the "Unused Capacity" or Column H. Again, leave out all gravel road segments that were considered "over capacity" in Step 3. Calculate unused capacity by entering the existing threshold for the gravel road segment rating and then subtracting it from the existing volumes. For example a road segment with a "B" rating would have a midpoint threshold of 700 vehicles per day. If the existing traffic volume is 234 trips per day, then the unused capacity would be 466 trips for the road segment. Remember that number is for the gravel road segment, not the entire gravel road. Insert this number in Column H.

4B. Calculate the number of dwelling units each road segment can accomodate.

In Column I of Table IV-1 (on page 46), calculate the number of dwelling units that can be accommodated with unused capacity on the existing gravel road. Using the ITE standard of 10 trips per day per dwelling unit, calculate the number of dwelling units that could be built without exceeding existing road capacity. Divide the unused capacity in Column H by 10, or the number of trips per day associated with each household.

STEP FIVE: LAND ACCESS ANALYSIS

The next step in the analysis is to insert land access into the gravel road capacity analysis. The analysis builds on the information that is already known: the existing volumes for the gravel roads, the physical features rating for each road segment, and whether the gravel road segments are overcapacity. In this step we

HERE IS AN EXAMPLE

Table IV-4 shows the second half of Table IV-3 (page 48); the column labeled "Unused Capacity" represents the unused capacity for the sample gravel road segments from the project research. See Appendix B for the complete data calculation of "overcapacity" and "unused capacity" for the pilot communities.

Table IV-4: Sample Table from Project Research- Part II.

G	H	I	J	K	L	M
Unused Capacity (Trips per Day)	Number of DU's with Unused Capacity (assumes 10 trips per day)	Buildable	DU's per Buildable Acres with Unused Capacity	Zoning Min lot size	Zoning DU's per acre	Difference (Capacity density-zoning density)
447	44.7	265.99	0.17	1 unit per 10 acres	0.10	0.07
128	12.8	80.08	0.16	1 unit per 10 acres	0.10	0.06
0		OVERCAPACITY				
242	24.2	78.29	0.31	1 unit per .5 acres	2	-1.69
281	28.1	163.66	0.17	public land	PL	
65	6.5	15.47	0.42	public land	PL	
364	36.4	352.86	0.10	1 unit per 10 acres	0.10	0.00
43	4.3	15.13	0.28	1 unit per 10 acres	0.10	0.18
445	44.5	58.03	0.77	1 unit per 10 acres	0.10	0.67
0		OVERCAPACITY				
85	8.5	334.527	0.03	1 unit per .5 acres	2	-1.97
246	24.6	326.7975	0.08	1 unit per 2 acres	0.5	-0.42
267	26.7	361.472	0.07	1 unit per 2 acres	0.5	-0.43
163	16.3	114.8455	0.14	1 unit per 5 acres	0.2	-0.06
	OVERCAPACITY					

analyze on a parcel by parcel basis if a property takes its primary access point from a gravel or paved road or if the land has access to a gravel road which is already over capacity.

5A. Calculate the amount of buildable area with access to road segments.

Calculate the amount of buildable area on each side of a gravel road with "unused capacity" (Column J of Table IV-1, on page 46). This is probably the most complicated piece of the analysis to calculate, but with GIS, it is fairly simple. First collect the following (some of the same information was collected for the impervious surface analysis in Part III):

- A recent (within the past 2-3 years) digital parcel map;
- Digital road classifications identifying whether the road is gravel or paved. This information may be available from the county road commission, metropolitan planning commission, or the road database from the Michigan Geographic Framework, a GIS database available from the Michigan Geographic Data Library at http://www.mcgi.state.mi.us/mgdl/;
- The existing database that has been created so far, with the determination of "overcapacity" gravel road segments (Column G in Table IV-1, page 46);
- The digital land use and land cover analysis which designates buildable and unbuildable land. This is the same information used in Table III-4, Column E (page 33) as part of the impervious surface analysis; and
- The zoning map for the community along with the minimum lot sizes for each zoning classification.

In GIS, draw the parcels (or overlay if already in digital form) and paved and unpaved roads, and overlay the buildable land on top. Plot out this map.

Outline on the map:

- In red: All of the parcels that take their primary access point from a gravel road that is "over capacity;"
- In blue: All of the parcels that take their primary access point from a paved road;
- In green: All of the parcels with a primary access point from a gravel road with "unused capacity;" and
- In yellow: All of the parcels where the access point could not be determined (perhaps a corner property between a paved and gravel road). Eventually access to all parcels needs to be determined if the map is to be used for regulatory purposes.

Digitize these red, blue, green, and yellow polygons in GIS.

The green parcels need to be linked to a specific gravel road segment. Number each green area on each gravel road segment so that it can be easily transferred into the database. Refer to Map IV-2 (page 55) for the project research example.
Take the areas in green and subtract out the "unbuildable" areas, which include water, wetlands, and public lands.

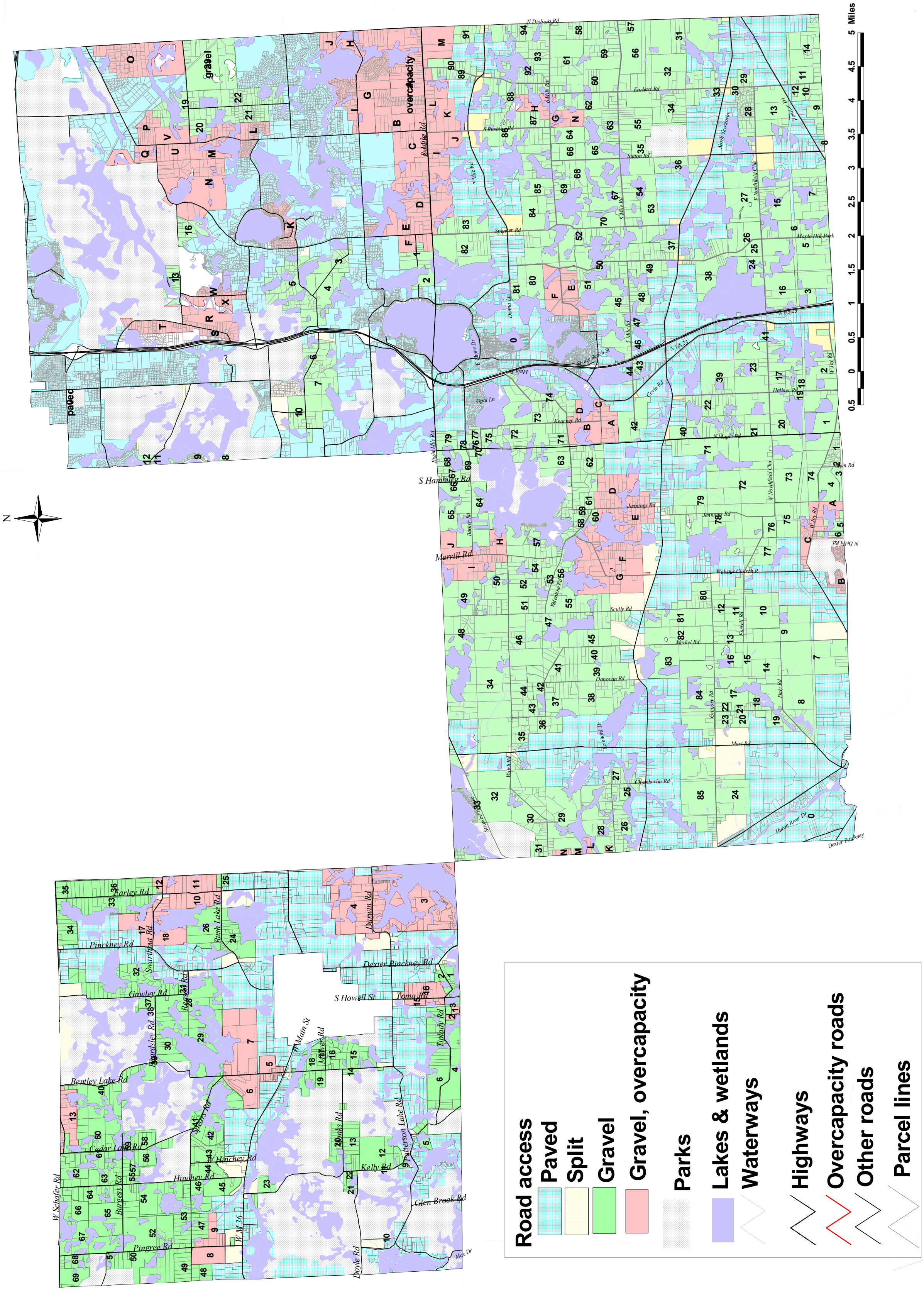
Summarize for each green area (for the area of the parcels on each side of the road) the amount of buildable acres associated with the segment. Utilize the area totals off of each side of the gravel road which should equal a buildable acre total for the road segment. Then it can be generated to complete the "buildable acres", Column J in Table IV-1 (on page 46) for each gravel road segment.

To complete Column K, "Dwelling Units per Buildable Acres with Unused Capacity" divide Column I by Column J.

STEP SIX: BUILDOUT ANALYSIS

A buildout analysis of the future land use plan and/or zoning map for a jurisdiction may help identify potential problems if road conditions are not addressed. For the most part, the pilot communities on this project have targeted planned areas for residential growth adjacent to paved roads. If sewer and water infrastructure is

Map IV-2. Pilot Communities Land Access Analysis.



Source: HRWC..

already adequate in these areas, or planned for expansion, new development will be attracted here with fewer negative impacts than if it were on prime farmland or in a sensitive environmental area. However, in many areas the project researchers found that the unused capacity on a gravel road segment was not enough to accommodate the densities the zoning ordinance allowed.

6A. Associate zoning with road segments.

Using the zoning map, compile the zoning classification along each gravel road segment. If there is more than one classification, apply the zoning classification that is associated with the most area along the gravel road segment. Go back to Table IV-1 (page 46) and enter this zoning information in Column L.

Use the conversion table if needed from Appendix N to convert the minimum lot size into a dwelling unit per acre number and enter in Column M. For example, if 1 unit per 2 acres is allowed then the number entered in Column M would be 0.5.

6B. Compare the dwelling units that can be accommodated with the existing unused capacity on the road with the number of dwelling units allowed within the zoning ordinance.

The unused capacity number (which was calculated in Column K) is subtracted from the dwelling units allowed per acre in the zoning ordinance (Column M). Enter this calculation in Column N.

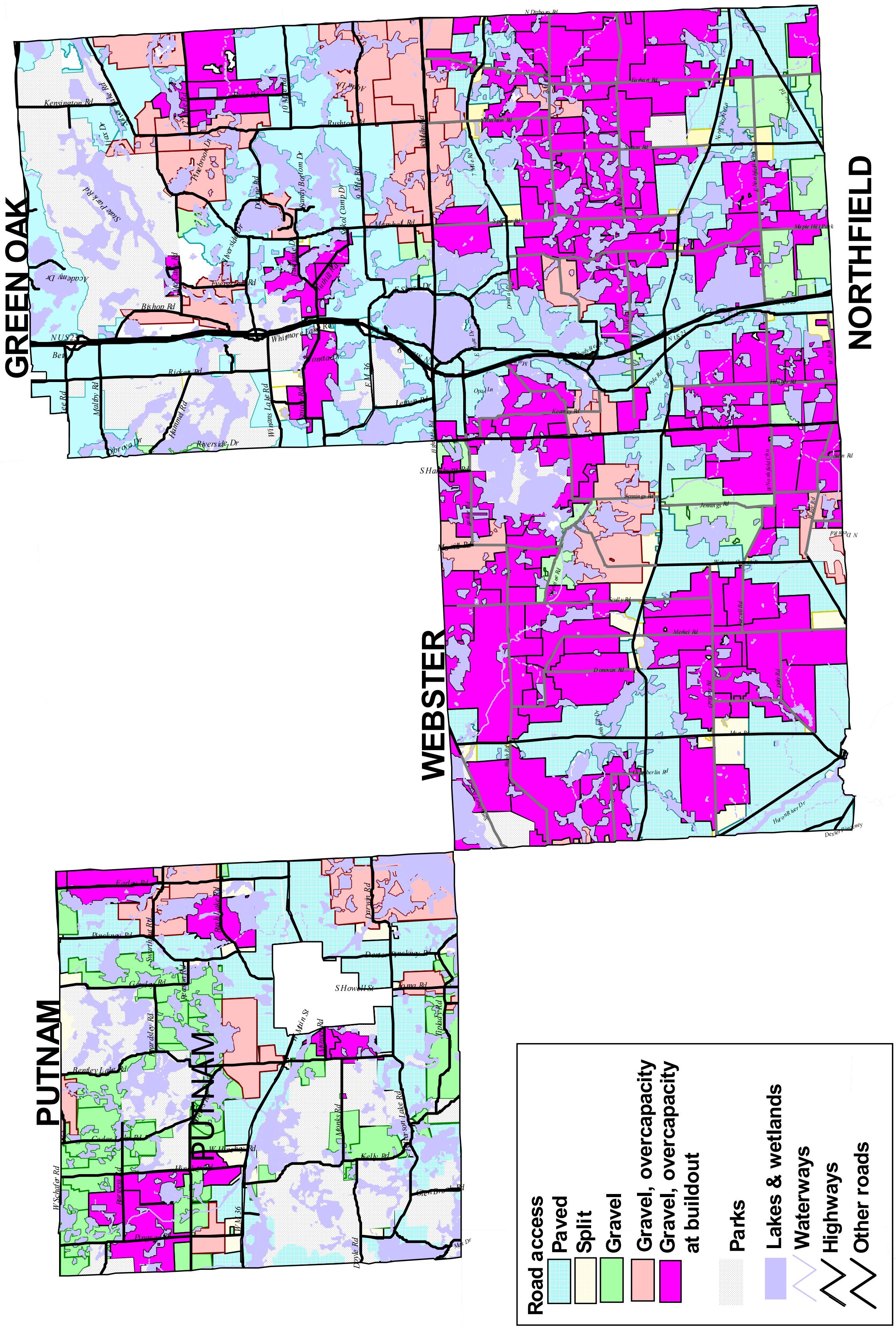
If the result in Column N is negative, then the capacity allocated in the zoning ordinance was more than the unused capacity the gravel road segment could support, if the land was built to the allowed densities. See Map IV-3 (page 57) for the result of the gravel road capacity analysis at buildout for the pilot communities.

DENSITIES MAY BE TOO HIGH FOR GRAVEL ROADS

There a couple of important findings noted by project researchers in this element of the gravel road capacity analysis. The first is the gravel roads segments that were determined to be "overcapacity," in many cases, also had existing zoning at a higher density than other rural residential areas. Therefore, those that were zoned for higher density typically developed at greater densities than other areas and therefore had more dwellings and hence more vehicular trips.

For example, Webster Township has zoned much of the land into an Agricultural classification, however the minimum lot size allowed within this class is 1 unit per 2 acres. Table 4 within Appendix B shows the results of the capacity analysis for Webster Township. The Township had ten gravel road segments that were "overcapacity" given the current daily traffic volumes and thresholds. Once the analysis was extended to look at the dwelling units that might be allowed based solely on capacity, versus what is allowed within the Webster Township Zoning Ordinance, there were only three gravel road segments that would not be overcapacity if land were built to the levels within the zoning ordinance. The analysis showed that most of the gravel roads in the Township would have capacity problems, if the current traffic levels continued and Township zoning was kept at one unit per 2 acres. These volume levels would likely lead to maintenance problems with the gravel road (rutting, washboarding, etc.) and severe pressure to pave the road over time. This could become a significant Township expense if the County Road Commission chose not to pave the roads, or lacked the resources to pave so many Township roads.

Map IV-3. Pilot Communities Land Access at Build Out.



Source: HRWC.

STEP SEVEN: ESTABLISH SIGNIFICANCE AND DESIRED OUTCOME

Once the gravel road capacity analysis is complete it may become apparent that the community has appropriate zoning for the current gravel road infrastructure in some places, but has "overzoned" for the capacity of the gravel roads in others. Before making zoning or other policy changes it is important to answer the following questions:

- Where gravel road capacity will be exceeded if developed under existing zoning—is this important to the community? Why?
- For example, if the gravel road has considerable pass-through traffic (an uncommon situation)—then the proper response should be to figure out how to get the road paved, or divert the pass through traffic onto paved roads.
- But if the gravel road is only a local road and excess capacity exists—is the community willing to accept degradation in the capacity of the gravel road as new development occurs?
- If exceeding existing gravel road capacity is undesirable, what changes could be made to prevent a negative outcome?
    - Reduce density overall. If densities in the zoning ordinance create too much traffic the community may be able to scale back zoning density.
    - Transfer density to an area where higher densities are more appropriate, such as areas with existing utilities, paved roads, etc. See later discussion on Transfer of Development Rights (TDR) and Appendix G.
    - Concentrate density where there is access to a paved road.
    - Preserve more land on low capacity area in an undeveloped state.
    - Add significant urban infrastructure (e.g. pave the roads).
    - Short of paving a road, significant improvements could be made to the gravel road to allow higher traffic volumes.

One desired outcome may already be outlined for the community within its local Master Plan (also known as the Future Land Use, Comprehensive, or Growth Management Plan). The community can go back to its Master Plan to discover how the vision it outlines relates to the gravel road analysis. Should the Master Plan vision or goals be updated or does it reflect the current community sentiment? If current, how do the gravel roads fit into the community vision? Does the community value its rural character? Or does it wish to capitalize on new growth? The Master Plan should provide many answers on how gravel road capacity issues should be addressed; if it doesn't, then it should be amended to provide that guidance. Appendix K includes sample language to amend a local Master Plan relative to gravel road capacity issues. Also see Step 10 (page 62).

Neighboring jurisdictions should be included in the gravel road discussions, just as they should be involved in the master planning process. If one community has decided to pave roads and encourage development, the neighboring community may feel increased development pressure and increased traffic. It is important to share the Master Plans of one community with neighboring jurisdictions to avoid future conflicts.

The next section presents some scenarios on how to address gravel road capacity issues.

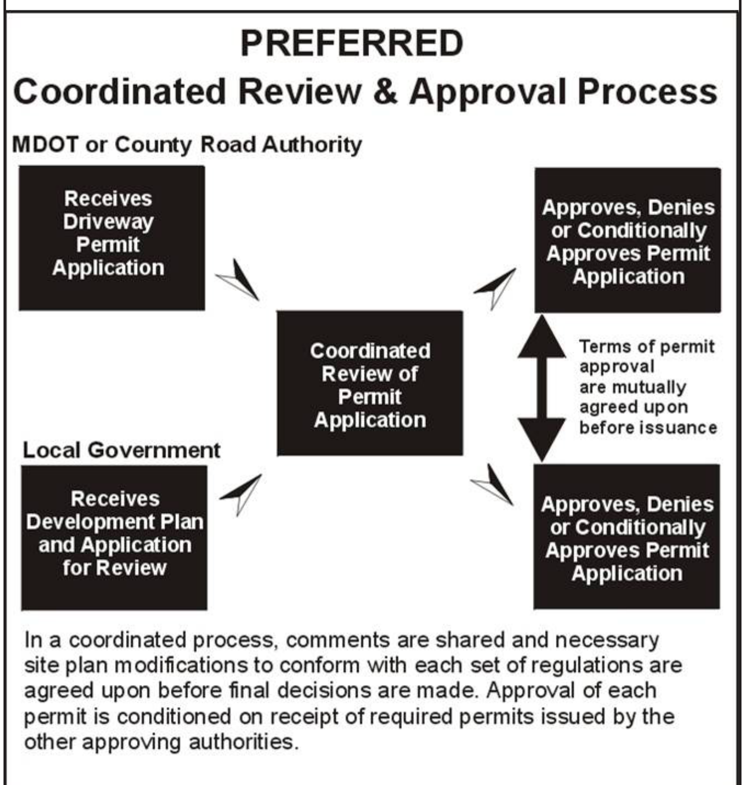
STEP EIGHT: OPTIONS ANALYSIS

If protecting existing gravel road capacity and the character of existing gravel roads is important, what options are available to achieve the desired outcome? There are several regulatory options that are available to address the management of development adjacent to gravel roads. Refer to Appendix C for detailed text on the options, as well as sample ordinance language for their adoption.

Option One

The first option to consider is enhanced permit coordination between local governments and the county road commission. The best arrangement is for the municipality to agree not to approve a site plan before the county road commission reviews the driveway permit application for the project and vice versa. Each conditions approval on the grant of a permit by the other. That would allow for the county road commission to reference the existing volumes, physical conditions and future plans for the road in question. If the municipality is targeting development for this area, the needs for infrastructure can be worked out with the county road commission and developer beforehand. Figure IV-7 illustrates the preferred coordination arrangement.

Figure IV-7: Access Management Permit Process.



Source: Planning and Zoning Center, Inc.

Option Two

If lawful, link the county road commission standards from Michigan Public Act 200 of 1969, which would require changes in the Act. See a more complete discussion of this option in Appendix C.

Option Three

"By-right" density is tied to available gravel road capacity and higher density is available by special land use permit only if the road is paved (Oakland Township approach).

In 1984, Oakland Township began feeling intense development pressure. However, 2/3 of all the Township's roads were gravel and many were in poor condition. The Township conducted a study of the gravel road problem and they found that if the properties were developed at their current zoning, the volumes created would exceed the design capacity of their gravel roads. The Township, with the assistance of the Oakland County Road Commission, set the maximum capacity level for a gravel road at 800 vehicles per day.

The Township then went through a process to make density modifications to many of the properties along gravel roads. After this was complete, in 1987 they adopted an "Ultimate Paved Road Zoning Map" which identified properties which would be eligible to receive a density modification if the road to the property was improved to a paved road. They then downzoned these parcels to establish a new lower density residential development standard. Effectively, a low density, "by-right" zoning option exists, as does a higher density option by special land use permit. Since the higher density option was never completely eliminated, there is no basis for a taking claim.

This technique has existed within the Township for nearly twenty years without any court challenges. Part of the reason that it works well is that the Township has significant development pressure and developers are willing to work together to take on the costs of paving to get projects on the ground. It has not been tried elsewhere, as far as the project researchers know. Appendix C explains a similar alternative approach and offers sample zoning ordinance language to implement it.

Option Four

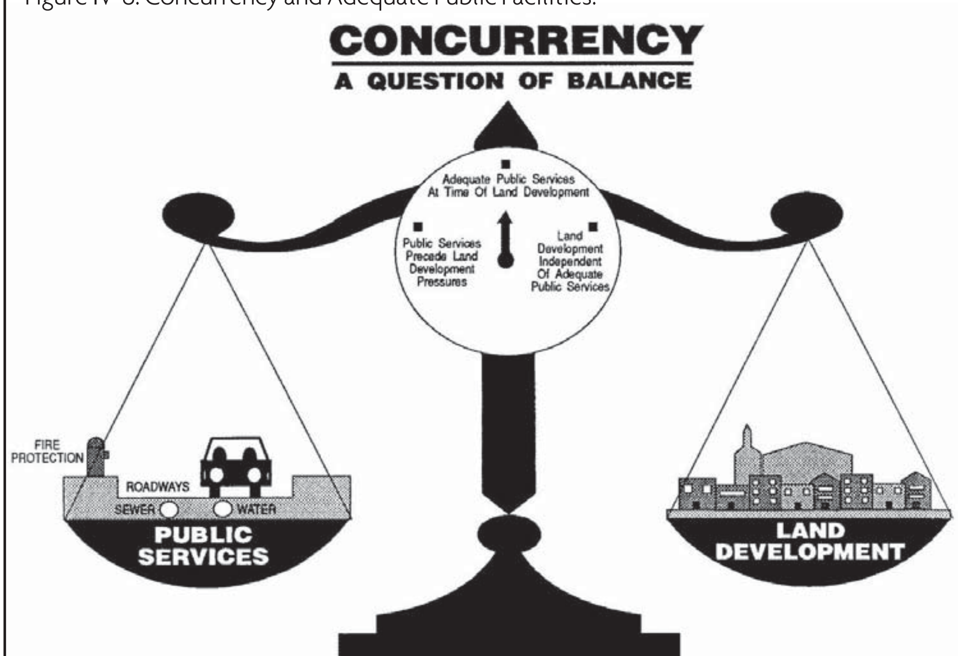
A primary disconnect in Michigan is that local governments have the authority to plan and zone for the use of land along county roads, yet the authority for making decisions on county road improvement projects is largely the responsibility of county road commissions. When local governments approve projects that reduce the capacity of a gravel road or create the need for an improvement project, the county road commission cannot prohibit the development. Somehow they are expected to solve the new capacity problem. However, road improvement funds are generally inadequate to meet all these needs. Often the disconnect leads to development occurring where county roads are already inadequate, or are not planned for improvement for several decades.

Option Four utilizes the level of service ratings and capacities from the gravel road capacities approach above, but it would also link other facility measures for adequate paved roads, sewer, water and schools. The adequate public facilities approach would require a community to adopt a capital improvement plan to have a basis for future development decisions in presently undeveloped areas. The CIP would refer to the Plan for the community to identify where future planned growth for the community would be and where growth should be limited because of inadequate facilities (see Figure IV-8). See the sample Adequate Public Facilities Ordinance in Appendix O.

Option Five

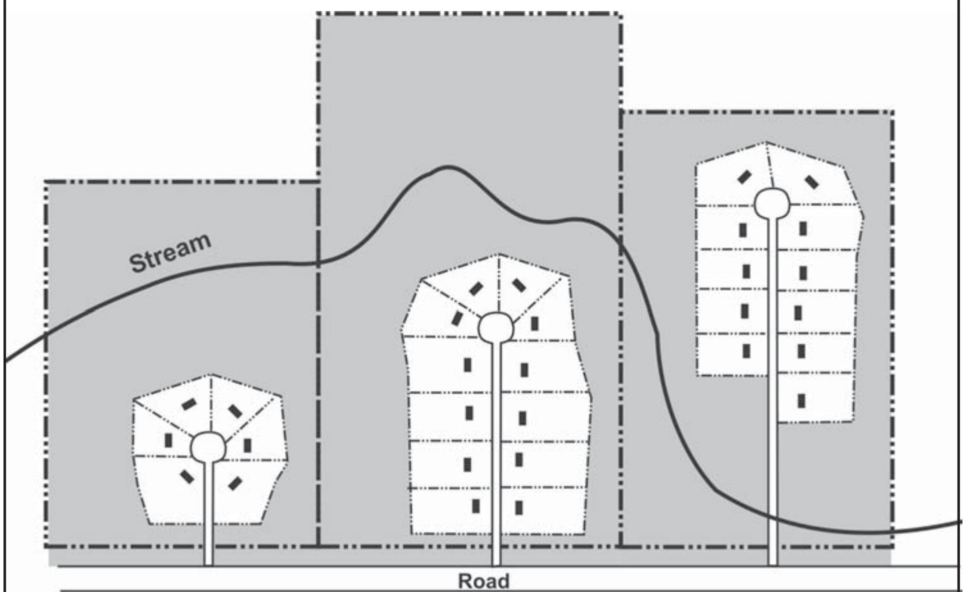
A community could create incentives to concentrate development or transfer development rights where facilities are adequate (TDR). A community, perhaps in cooperation with a neighboring community, could set up sending areas where development rights could be sold and sent to receiving areas where the public infrastructure was able to accommodate it. This allows the landowner to capture the development value without converting the land; this would keep density low in the sending area. See Figure II-4, page 20, in Part II.

Figure IV-8: Concurrency and Adequate Public Facilities.



Source: Planning and Zoning Center, Inc.

Figure IV-9: Clustering.



Source: Planning and Zoning Center, Inc.

Option Six

Clustering development where access is from paved roads and capacities are greater would relieve pressure on gravel roads (see Figure IV-9). Densities greater than the usual minimum could be used as an incentive to encourage cluster development where there was access to a paved road. Standards for the minimum amount of open space would have to be established, which could be a variation of existing Planned Unit Development (PUD) regulations.

Communities considering clustering as a way of reducing development in rural areas should adopt access management standards on their paved roads to ensure safety for new driveway construction. Refer to the Michigan Access Management Guidebook, MDOT, 2001.

STEP NINE: SELECTION OF OPTIONS

Refer to Appendix C which presents sample ordinance language for all of the regulatory options for gravel road capacities. The community should engage in dialogue around each option, particularly the pros and cons of each option.

Factors to discuss include:

- Willingness to assume legal risk associated with a relatively new regulatory approach in Michigan (Options Two through Five);
- Capability of zoning staff to administer new provisions;

TIPS WHEN CONSIDERING ZONING AMENDMENTS:

- Choose the particular techniques that are best suited to achieve the community's desired objectives.
- Be sure the municipal attorney is involved in the review and drafting of the options prior to adoption.
- Adapt the sample ordinance language in Appendix C to best fit your community's needs and to minimize legal risks.
- Monitor implementation and refine ordinance language as needed to best achieve the community objectives.

- Commitment of governing body and zoning staff to consistently enforce new regulations (Options Three through Five);
- Whether the county road commission is willing to enhance coordination of permit reviews and decisions with Townships as in Option One (both the Livingston and Washtenaw County Road Commissions are);
- Whether the community is willing to embrace a wider range of public service impacts as a part of the development review and approval process (Option Four) and whether they are willing to commit to annual capital improvement programs to ensure adequate public facilities are provided where and when the density of new development requires it;
- Whether there is support for creating a TDR program in the community or county-wide (Option Five); and
- Whether the community is willing to offer any (or more) incentives for clustering to achieve water quality benefits (Option Six).

Some communities may feel comfortable adopting some of these regulatory approaches while others may feel more comfortable using gravel road capacities as a planning tool. This decision will be up to each community, but it should be made after consultation with adjoining jurisdictions so there is a coordinated approach, especially where communities share the same gravel roads.

STEP TEN: HOW THIS INFORMATION CAN BE USED IN PLANNING

In many rural areas of Michigan gravel road capacity is an increasing concern because more and more development is occurring. Low density residential development in rural areas has forced many county road commissions into a reactive pattern of maintenance on overburdened gravel roads. County road resources are therefore utilized to do “weekly grading” on overcapacity gravel roads in order to keep the road passable. Funds are inadequate to pave even the higher volume gravel roads.

For example, the “overcapacity” gravel roads in Putnam Township, as identified in this study, were typically in areas that had higher densities (1 dwelling unit per 1-2 acres) than the remainder of the jurisdiction which was zoned 1 unit per 10 acres. The higher density zoning resulted in higher traffic volumes. In some cases, such as on Darwin Road, higher densities resulted in higher traffic on a road that does not have a high physical condition rating. The physical condition may never have been great, but most likely also degraded from overuse.

Communities can use gravel road capacities as a planning tool and analysis methodology for inclusion in the transportation section of the local Master Plan. If the community chooses not to implement the LOS standards as part of a regulatory approach, it could still utilize the gravel road LOS system to monitor “overcapacity” gravel roads. They can also utilize the LOS system (A through E ratings) to more effectively plan for growth. A community capital improvement program (CIP) which links to the local Master Plan and to the road improvement plan of the county road commission will most effectively coordinate decision-making for road funding and development.

County road commissions can also use the LOS ratings generated for this project for a future road improvement plan for county roads and to review proposed project site plans. Affected local governments and the county road commission should actively seek each other out to look at “overcapacity” areas and at various options to resolve problems associated with overuse. But they should also review areas where there is “unused capacity” on roads and discuss ways to preserve that capacity.

Within the transportation section of the local Master Plan the LOS gravel road standards could add a significant element to planned land use categories. For example, areas planned for agricultural use are a good fit for gravel roads that function quite well with low volumes. However, for an area planned for expanded development at high densities, roads within the area, and connecting roads should be planned for the appropriate added traffic volumes. This means planning for a coordinated road improvement program. Within the local CIP, consider whether the community has the funds to implement specific projects, while also considering county road commission priorities in the area.

Another option is that this LOS monitoring process could be an "in-house" planning tool to guide staff on individual land use decisions, and to allow more coordination with the County Road Commission prior to adoption of a CIP or approval of an individual project site plan.

Before amending the zoning ordinance to include any of the options for gravel road capacity analysis, it is important to amend the local Master Plan to provide a basis for the amendments and to be keep zoning consistent with the Master Plan. Be sure the purposes for pursuing the desired outcome are clearly stated and relate to other relevant sections of the Master Plan (such as the description of existing community character and infrastructure improvements sections). Also include options for improvement in the CIP and coordinate with the county road commission for CIP review. Refer to Appendix K for sample language to be inserted into your Master Plan.

STEP ELEVEN: NON-REGULATORY INITIATIVES

In addition to incorporating gravel road capacity analysis into the Master Plan, there are other non-regulatory initiatives the community may wish to take. These include beginning or enlarging participation in a land conservancy, PA 116 or farmland PDR, or inter-jurisdictional TDR programs in those parts of your community where open space is desired to be permanently protected and gravel road use can be continued.

Another option is to educate the public, land owners and developers about the purposes, benefits and procedures associated with protecting gravel road capacity, and if relevant, new adopted regulations.

Appendix K includes sample Master Plan language to encourage these initiatives. Also see Part V: Additional Resources, for many more materials to assist with non-regulatory initiatives.

STEP TWELVE: MONITOR PROGRESS

Once the community has decided on the planning, regulatory and non-regulatory initiatives it wishes to take with both impervious surface (Part III) and gravel road capacity analysis, and takes the necessary action to adopt planning and zoning amendments, and start other initiatives, it has one more important step to take. Unless data is periodically gathered and analyzed as part of an effort to monitor progress, the community will not systematically know what problems need to be addressed or refinements need to be made to the initiatives it has put into place. This effort will take time, but it will also pay important dividends by ensuring the established initiatives are best achieving their goals.

Part V: Additonal Resources

ORGANIZATIONS

Transportation-Related:

American Association of State Highway Transportation Officials (AASHTO)
444 N. Capitol St. NW Suite 249
Washington DC 20001
www.transportation.org

Transportation Research Board
500 Fifth St. NW
Washington DC 20001
www.trb.org

Land Use Planning-Related:

American Planning Association
122 S. Michigan Ave. Suite 1600
Chicago, IL 60603
www.planning.org

Institute of Transportation Engineers
1099 14th St. NW, Suite 300 West
Washington DC 20005-3438
www.ite.org

Michigan Society of Planning
27300 Haggerty Road, Suite F-30
Farmington Hills, MI 48331
www.planningmi.org

Regional Planning Commissions:

Mr. Sandeep Dey, Executive Director
West Michigan Shoreline
Regional Development Commission
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(231) 722-7878
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MACC/MPO
325 N. River Ave.
Holland, MI 49424
(616) 395-2688
Fax: (616) 396-3774

Watershed Organizations:

Center for Watershed Protection
8390 Main Street
Ellicott City, MD 21043-4605
(410) 461-8323
www.cwp.org

Huron River Watershed Council
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Executive Director
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Ann Arbor, MI 48104
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lrubin@hrwc.org
www.hrwc.org

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President
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www.mich.com/~anglers/index.htm Bellaire

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Midland, MI 48640
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Friends of the Jordan River Watershed, Inc.
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800 W. Water Street
East Jordan MI 49727
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Kalamazoo River RAP
Bob Beck
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watershed.htm

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