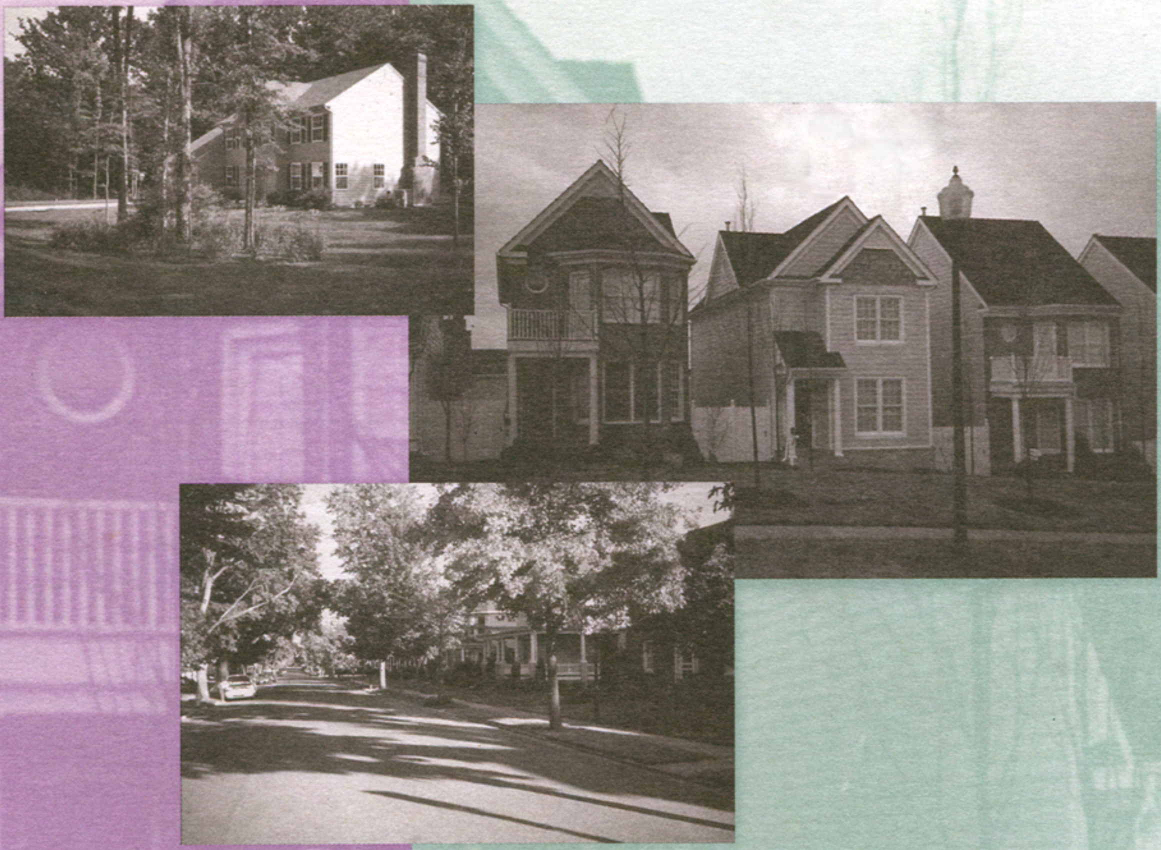
Prepared by the
Center for Watershed Protection
8390 Main Street Ellicott City, Maryland 21043

Prepared for the
Site Planning Roundtable



BETTER SITE DESIGN:
A Handbook for Changing Development Rules in Your Community

with assistance from
The Morris and Gwendolyn Cafritz Foundation
US EPA Office of Wetlands, Oceans, and Watersheds
Chesapeake Bay Trust
Turner Foundation
Chesapeake Bay Program

CENTER FOR WATERSHED PROTECTION

Better Site Design: A Handbook for Changing Development Rules in Your Community

PREPARED BY THE
Center for Watershed Protection
8391 Main Street
Ellicott City, Maryland 21043
(410) 461-8323 phone
(410) 461-8324 fax
www.pipeline.com/~mrrunoff/

PREPARED FOR THE

Site Planning Roundtable

WITH ASSISTANCE FROM
The Morris and Gwendolyn Cafritz Foundation
US EPA Office of Wetlands, Oceans, and Watersheds
Chesapeake Bay Trust
Turner Foundation
Chesapeake Bay Program

AUGUST 1998

Printed on Recycled Paper

CENTER FOR WATERSHED PROTECTION

PREFACE

This document is the culmination of the Site Planning Roundtable, a consensus process initiated to create more environmentally sensitive, economically viable, and locally appropriate development. The primary audience for this manual is the local planner, engineer, developer, and official involved in the designing and building of new communities. This manual continues the Center's efforts to protect streams, rivers, and estuaries by advancing innovative and effective resource management techniques. It is hoped that through application of the Model Development Principles presented in this document, conservation of natural areas and prevention of stormwater pollution will become an integral part of new development.

Primary funding support for the preparation of this manual has been provided by The Morris and Gwendolyn Cafritz Foundation; the US EPA Office of Wetlands, Oceans, and Watersheds; the Chesapeake Bay Trust; the Turner Foundation; and the Chesapeake Bay Program.

PROJECT TEAM

Whitney Brown
Deb Caraco
Richard Claytor
Peg Hinkle
Hye Yeong Kwon
Tom Schueler
Chris Swann
Jennifer Zielinski

ACKNOWLEDGMENTS

Preparation of this manual would not have been possible without the contributions of many experts from the planning, design, development, and environmental professions. The Center especially would like to acknowledge the invaluable assistance provided by the members of the Site Planning Roundtable. Their dedication and insight throughout the Roundtable process was instrumental in crafting this document.

Ken F. Kobetsky, PE
American Association of State Highway Transportation Officials

Cheryl Kollin, ASLA, ISA
American Forest Association

Christopher J. Gribbs, Assoc. AIA
American Institute of Architects

Jeffrey Soule, AICP
American Planning Association

Sarah L. Layton
American Public Works Association

Tina Yin
American Rivers

Kyle Schilling, PE, DEE
American Society of Civil Engineers

J. William Thompson, ASLA
American Society of Landscape Architects

Menchu Martinez
Chesapeake Bay Program

Nancy Jacobsen
Community Associations Institute

Edward T. McMahon, JD
The Conservation Fund

Bruce G. Douglas, AICP
Office of Comprehensive Planning County of Fairfax, VA

Joseph H. Necker, Jr., PE
Howard Research & Development Corporation, an affiliate of the Rouse Company

Lisa M. Fontana
Institute of Transportation Engineers

Kendra J. Briechle and Barbara Yuhas
International City/County Management Association

Andrew Zepp
Land Trust Alliance

Steven Z. Kaufman, JJD
Linowes & Blocher

Douglas E. Lohmeyer, PE
Loiederman Associates, Inc.

Dean D. Dubbe, PE
Michael T. Rose Company

Derrick P. Berlage, Councilmember
Montgomery County Council

Donald L. Woodsmall, Esq.
Natelli Communities

Robert McNamara, AICP
National Association of Home Builders

Roger Platt
National Realty Committee

Diane Cameron and Peter Lehner
Natural Resource Defense Council

Larry S. Coffman
Prince Georges County, Department of Environmental Resources

J. Glenn Eugster and Jamal Kadri
U.S. EPA Office of Sustainable Ecosystems & Communities

John L. Cochran
U.S. Fire Administration

Michael Pawlukiewicz
Urban Land Institute

Lowell W. Adams, PhD
Urban Wildlife Resources

We would like to extend special appreciation to the chairs of the Research Subgroups: Lisa Fontana (Habitat for Cars), Roger Platt (Habitat for Nature), and Richard Claytor (Habitat for People). Special thanks are also extended to Randall Arendt (Natural Lands Trust), Diane Cameron (formerly of Natural Resource Defense Council), Rod Frederick (EPA, Nonpoint Source Control), Abigail Freidman (National Association of Counties), Robert Goo (EPA, Office of Wetlands, Oceans, and Watersheds), and Peter Hawley (American Planning Association) for their constructive insight. Our deep appreciation is extended to Bob Hoyt (Maryland Department of the Environment) and the staff and students of Widener University Law School for their research into public liability issues.

TABLE OF CONTENTS

CHAPTER 1

CHANGING THE RULES TO PROTECT THE ENVIRONMENT

More than 1.5 million acres of land are developed each year in the United States. Development alters the surface of the land by replacing natural cover with roof tops, roads, parking lots, and sidewalks. These hard surfaces are impermeable to rainfall and are collectively known as impervious cover.

Recent watershed research has shown that impervious cover has a profound and often irreversible impact on the quality of our nation's aquatic resources. More than thirty different scientific studies have documented that stream, lake and wetland quality declines sharply when impervious cover in upstream watersheds exceeds 10 percent (see Table 1). The strong influence of impervious cover on aquatic systems presents a major challenge to communities interested in sustainable development.

Table 1: Impacts to Aquatic Resources Due to Impervious Cover, A Summary of Research

1. Higher peak discharge rates and greater flooding
2. More frequent bankfull flooding
3. Lower stream flow during dry weather
4. Enlargement of the stream channel
5. Greater streambank erosion
6. Increased alteration of natural stream channels
7. Less large woody debris (LWD) in streams
8. Loss of pool and riffle structure
9. Increased number of stream crossings, with greater potential to affect fish passage
10. Degradation of stream habitat structure
11. Decline in stream bed quality (imbedding, sediment deposition, turnover)
12. Fragmentation of the riparian forest corridor
13. Warmer stream temperatures
14. Greater loads of stormwater pollutants
15. Bacterial levels that exceed recreational contact standards
16. Lower diversity of aquatic insects and freshwater mussels
17. Lower diversity of native fish species
18. Loss of sensitive fish species (e.g., trout, salmon)
19. Lower spawning success of anadromous fish
20. Decline in wetland plant and animal diversity

At the same time, many communities are discovering that their own development rules create needless impervious cover. The term "development rules" refers to the often bewildering mix of subdivision codes, zoning regulations, parking and street standards, and other local ordinances that collectively shape how development happens. These rules create the wide streets, expansive parking lots, and large-lot subdivisions that crowd out natural areas and open space.

Another characteristic of local development rules is that their complexity and inflexibility often make it difficult and even impossible to design sites to protect the quality of streams, lakes and wetlands. Innovative developments simply cannot be approved in many communities, and require a greater investment of time, money, and perseverance in others. The message is clear. We cannot protect the quality of the local environment unless we manage impervious cover and we cannot reduce impervious cover until we systematically reform the local development rules that are responsible for creating it.

This document outlines a process for changing the rules. It starts by presenting a series of model development principles that outline a fundamentally different way of developing land and designing our communities (Chapter 2). These principles were developed over the course of two years by a group of over thirty influential individuals from various organizations from around the nation. Taken together, the principles reduce impervious cover, conserve natural areas and prevent stormwater pollution from new development, while at the same time maintaining quality of life within our communities.

A four-step process is recommended to adapt local development rules to more closely conform to the model development principles. The four steps are:

Step 1: *Find Out What the Development Rules are in Your Community*

Step 2: *See How Your Rules Stack Up to the Model Development Principles*

Step 3: *Consider Which Development Rules Might Be Changed*

Step 4: *Start a Local Roundtable Process*

This document is designed to guide the reader through this lengthy but important process.

STEP 1: FIND OUT WHAT THE DEVELOPMENT RULES ARE IN YOUR COMMUNITY

The purpose of the first step is to find out what the actual development rules are in your community. In most cases, this will require an extensive search to find the key local documents that influence how land is developed in your community (Table 2). Few communities include all of their rules in a single document, so the search can take some time. It may be helpful to enlist the talents of a local land planner, land use attorney, or civil engineer in your search, since they work under the rules every day and are often familiar with local practices. It is also helpful to find out which local agencies and authorities actually administer and enforce each of the development rules at this stage. Be forewarned. It is not uncommon to find more

Table 2: Key Local Documents
Zoning Ordinances
Subdivision Codes
Street Standards
Covenants
Fire Codes and Standards
Parking Requirements
Building Regulations/Standards
Stormwater Management Ordinances
Buffer or Floodplain Regulations
Environmental Regulations

than a dozen different local and state agencies that exert some authority over development rules in your community.

Step 2: See How Your Rules Stack Up To the Model Development Principles

Once you locate all of your development rules, you can begin to compare them with the model development principles. We have developed a simple worksheet to make this comparison easy. The worksheet is presented in **Chapter 3**, and it allows you to compare local development rules against 77 site planning benchmarks. Each benchmark asks a single question about local site design practice, such as the minimum diameter of cul-de-sacs, the minimum width of streets, etc. If the local development rule compares favorably with the site planning benchmark, points are then awarded. The total number of points possible for all of the site planning benchmarks is 100. The overall score provides a general indication of your community's ability to support environmentally sensitive development. As a general rule, if the score is lower than 80, then it may be advisable to systematically reform your local development rules. The worksheet also helps to identify specific site development rules that may be candidates for change.

Step 3: Consider Changing Some Local Development Rules

Does it really make sense to change a particular development rule? Given how much effort is needed to change development rules, it is important to evaluate which ones are really worth it. Also, the fact that a local development rule does not conform to a model development principle doesn't always mean that the rule should be or can be changed. More research is still needed to examine the rationale behind both local development rules and the model principles.

In addition, advocates of change need to satisfy a broad range of community concerns, such as how the changes will impact the cost of development, local liability, property values, public safety, and a host of other factors. To guide the process of change, we have prepared a series of summary sheets on the 22 model development principles in **Chapter 4.** Each summary sheet begins with background on both the conventional and recommended site planning practice. The summary sheets also profile the most common objections and concerns associated with the recommended site planning practice. Economic data, environmental research, marketing studies and public surveys that pertain to the site planning practices are reviewed, and local case studies are presented. Each summary sheet also contains a "Where to Get Started" section that recommends more detailed references and resources to consult during your research. Some of this information can be complex and highly technical, so a **glossary** is provided to explain some of the planning and engineering terminology.

Step 4: Start a Local Roundtable

The process to reform local development rules is called a local site planning roundtable. It is a consensus process to make better choices in the design of local communities. The primary tasks of a local roundtable are to systematically review existing development rules in the context of the model development principles, and then determine if changes can or should be made to the rules.

Perhaps the most critical factor in the success of a roundtable is getting the right people to the table. Participants should include key players from the local government, development and environmental communities. It is vitally important to get every local agency with authority for development review to the table. Diverse representation outside of government is also needed in order to obtain the broad consensus needed to achieve sweeping change. Some possible participants that could be invited to a local roundtable are listed in Table 3.

Table 3: Potential Members of a Local Roundtable

Planning Agency or Commission	Land Use Lawyers
Department of Public Works	Engineering Consultants
Road or Highway Department	Homeowner Associations
Developers	Chamber of Commerce
Land Trusts	Elected Officials
Realtors	Urban Forester
Real Estate Lenders	Site Plan Reviewer
Civic Associations	Stormwater Management Authority
Fire Official	Municipal Insurance
Health Department	Watershed Advocates
	Residents/ Land Owners

Elected leaders can play an important role in the success of a local roundtable. In particular, they are needed to give a strong charge to the roundtable that reform is welcomed and will be acted upon. After all, elected officials will ultimately be asked to vote on the proposed changes. They can also ensure that the many local agencies involved in development review get to the table and stay there.

An outside facilitator is often needed to guide and structure the roundtable process. This third party helps to ensure that all views and perspectives are considered, and guides the participants toward consensus and action.

The first phase of a roundtable involves identifying the development rules which could potentially be changed. The site planning worksheet and summary sheets can be helpful in screening the development rules.

The second phase of a roundtable involves finding out which agencies of local government have the actual authority to make a change to the development rules. In some cases, no authority currently exists, so the roundtable must consider whether a new one should be created. In other cases, a local government may find that they have no real authority to make changes to a development rule (e.g., a state agency such as the Department of Transportation has reserved the authority).

The longest phase of a local roundtable involves the negotiation of the changes to the development rules. It should be expected that a roundtable will need to meet many times over the course of a year to come to agreement on the changes that need to be made to the maze of codes, engineering standards, guidelines, regulations and ordinances that collectively shape local development. The devil is always in the details, so it is often useful to set up workgroups to iron out the technical language, and discuss legal and economic implications. The last phase of a roundtable is implementation. It is a good idea to combine all of the proposed changes into a unified package, so that both elected leaders and the public can understand them as a whole.

CHAPTER 2

MODEL DEVELOPMENT PRINCIPLES

Sustainable development combines economic growth with protection of the natural environment. Communities have long struggled to achieve this goal. However, many have found that their own development codes and standards can actually work against their efforts to achieve sustainable development. For example, local codes and ordinances often promulgate inflexible standards that result in highway-wide residential streets, expansive parking lots, and mass clearing and grading of forested areas. At the same time, local codes often give developers little or no incentive to conserve natural areas. Consequently, communities may need to re-evaluate their local codes to ensure better development.

The Site Planning Roundtable was convened in 1996 to examine impediments to better development at the local level and to craft model principles to promote environmentally sensitive and economically viable development. The Site Planning Roundtable represented a diverse and wide cross-section of interests involved in planning, designing and building new communities.

Nearly two years later, the Site Planning Roundtable agreed on a set of twenty-two model development principles. Applied together, the model development principles measurably reduce impervious cover, conserve natural areas and reduce stormwater pollution from new development. Application of these principles can enhance both the natural environment and improve the quality of life in local neighborhoods. Some of the documented benefits include:

- protection of local streams, lakes, and estuaries
- reduction of stormwater pollutant loads
- reduced soil erosion during construction
- reduced development construction costs
- increases in local property values and tax revenues
- more pedestrian friendly neighborhoods
- more open space for recreation
- protection of sensitive forests, wetlands, and habitats
- a more aesthetically pleasing and naturally attractive landscape
- safer residential streets
- more sensible locations for stormwater facilities
- easier compliance with wetland and other resource protection regulations
- neighborhood designs that provide a sense of community
- urban wildlife habitat through natural area preservation

The twenty-two model development principles provide design guidance for economically viable, yet environmentally sensitive development. They are designed to be used by planners, developers, and local officials as benchmarks to investigate where existing ordinances could be modified to reduce impervious cover, conserve natural areas, and prevent stormwater pollution. The model development principles, however, are not intended to be national design standards.

Model Development Principles

In many ways, the suburban landscape is a mix of three habitats. The first habitat is devoted to the automobile, and includes roads, driveways, and parking lots. The second is the habitat where we live and work, including our yards and homes. The third habitat includes the open spaces and natural areas that are relatively undeveloped. The size, appearance, location, and design of all three areas are determined in large part by local subdivision codes and zoning ordinances.

The model development principles generally fall into one of three areas which have been designated as follows:

- Residential Streets and Parking Lots
- Lot Development
- Conservation of Natural Areas

Each principle represents a simplified design objective in site planning. More detail on each principle can be found in the Site Planning Summary Sheets in Chapter 4.

Residential Streets and Parking Lots

These principles focus on those codes, ordinances, and standards that determine the size, shape, and construction of parking lots, roadways, and driveways in the suburban landscape.

1. Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.

2. Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.

3. Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.

4. Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.

5. Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.

6. The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible.

7. Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.

8. Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas.

9. Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.

10. Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

Lot Development

Principles 11 through 16 focus on the regulations which determine lot size, lot shape, housing density, and the overall design and appearance of our neighborhoods.

11. Advocate open space development that incorporates smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.

12. Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.

13. Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.

14. Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.

15. Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing both natural and recreational open space.

16. Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing rooftop runoff to the roadway and the stormwater conveyance system.

Conservation of Natural Areas

The remaining principles address codes and ordinances that promote (or impede) protection of existing natural areas and incorporation of open spaces into new development.

17. Create a variable width, naturally vegetated buffer system along all perennial streams that also encompasses critical environmental features such as the 100-year floodplain, steep slopes and freshwater wetlands.

18. The riparian stream buffer should be preserved or restored with native vegetation that can be maintained throughout the delineation, plan review, construction, and occupancy stages of development.

19. Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.

20. Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas to promote natural vegetation.

21. Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, stormwater credits, and by-right open space development should be encouraged to promote conservation of stream buffers, forests, meadows, and other areas of environmental value. In addition, off-site mitigation consistent with locally adopted watershed plans should be encouraged.

22. New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, sole-source aquifers, or sensitive areas.

Adapting the Principles for Your Community

The following guidance is offered to township, city, and county officials as they adapt the model development principles to achieve better development.

- It should be clearly recognized that the principles must be adapted to reflect the unique characteristics of each community. Further, not all principles will apply to every development or community. In some cases, the principles may not always fully complement each other.
- The principles are offered as a benchmark to guide better land development. Communities should consider the principles as they assess current zoning, parking, street and subdivision codes.
- The principles will not only protect natural and aquatic resources, but can also enhance the quality of life in the community.
- The principles should be used as part of a flexible, locally-adapted strategy for better site planning.

- The principles should be considered togther with the larger economic and environmental goals put forth in comprehensive growth management, resource protection, or watershed management plans.
- Where possible, infill and redevelopment should be encouraged to reduce new impervious cover in the landscape.
- These principles primarily apply to residential and commercial forms of development, but can be adapted, with some modifications, to other types of development.

CHAPTER 3

CODE AND ORDINANCE WORKSHEET

The Code and Ordinance Worksheet allows an in-depth review of the standards, ordinances, and codes (i.e., the development rules) that shape how development occurs in your community. You are guided through a systematic comparison of your local development rules against the model development principles. Institutional frameworks, regulatory structures and incentive programs are included in this review. The worksheet consists of a series of questions that correspond to each of the model development principles. Points are assigned based on how well the current development rules agree with the site planning benchmarks derived from the model development principles.

The worksheet is intended to guide you through the first two steps of a local site planning roundtable.

Step 1: Find out what the Development Rules are in your community.

Step 2: See how your rules stack up to the Model Development Principles.

The homework done in these first two steps helps to identify which development rules are potential candidates for change.

PREPARING TO COMPLETE THE CODE AND ORDINANCE WORKSHEET

Two tasks need to be performed before you begin in the worksheet. First, you must identify all the development rules that apply in your community. Second, you must identify the local, state, and federal authorities that actually administer or enforce the development rules within your community. Both tasks require a large investment of time. The development process is usually shaped by a complex labyrinth of regulations, criteria, and authorities. A team approach may be helpful. You may wish to enlist the help of a local plan reviewer, land planner, land use attorney, or civil engineer. Their real-world experience with the development process is often very useful in completing the worksheet.

Identify the Development Rules

Gather the key documents that contain the development rules in your community. A list of potential documents to look for is provided in Table 4. Keep in mind that the information you may want on a particular development rule is not always found in code or regulation, and may be hidden in supporting design manuals, review checklists, guidance document or construction specifications. In most cases, this will require an extensive search. Few communities include all of their rules in a single document. Be prepared to contact state and federal, as well as local agencies to obtain copies of the needed documents.

Table 4: Key Local Documents that will be Needed to Complete the COW

Zoning Ordinance
Subdivision Codes
Street Standards or Road Design Manual
Parking Requirements
Building and Fire Regulations/Standards
Stormwater Management or Drainage Criteria
Buffer or Floodplain Regulations
Environmental Regulations
Tree Protection or Landscaping Ordinance
Erosion and Sediment Control Ordinances
Public Fire Defense Masterplans
Grading Ordinance

Identify Development Authorities

Once the development rules are located, it is relatively easy to determine which local agencies or authorities are actually responsible for administering and enforcing the rules. Completing this step will provide you with a better understanding of the intricacies of the development review process and helps identify key members of a future local roundtable.

Table 5 provides a simple framework for identifying the agencies that influence development in your community. As you will see, space is provided not only for local agencies, but for state and federal agencies as well. In some cases, state and federal agencies may also exercise some authority over the local development process (e.g., wetlands, some road design, and stormwater).

Using the Worksheet: How Do Your Rules Stack Up to the Model Development Principles?

Completing the Worksheet

Once you have located the documents that outline your development rules and identified the authorities responsible for development in your community, you are ready for the next step. You can now use the worksheet to compare your development rules to the model development principles.

The worksheet is presented at the end of this chapter. The worksheet presents seventy-seven site planning benchmarks. The benchmarks are posed as questions. Each benchmark focuses on a specific site design practice, such as the minimum diameter of cul-de-sacs, the minimum width of streets, or the minimum parking ratio for a certain land use. You should refer to the codes, ordinances, and plans identified in the first step to determine the appropriate development rule.

The questions require either a yes or no response or a specific numeric criteria. If your development rule agrees with the site planning benchmark, you are awarded points.

Calculating Your Score

A place is provided on each page of the worksheet to keep track of your running score. In addition, the worksheet is subdivided into three categories:

- Residential Streets and Parking Lots (Principles No. 1 - 10)
- Lot Development (Principles No. 11 - 16)
- Conservation of Natural Areas (Principles No. 17 - 22).

For each category, you are asked to subtotal your score. This **"Time to Assess"** allows you to consider which development rules are most in line with the site planning benchmarks and what rules are potential candidates for change.

The total number of points possible for all of the site planning benchmarks is 100. Your overall score provides a general indication of your community's ability to support environmentally sensitive development. As a general rule, if your overall score is lower than 80, then it may be advisable to systematically reform your local development rules. A score sheet is provided at end of the Code and Ordinance Worksheet to assist you in determining where your community's score places in respect to the Model Development Principles.

Once you have completed the worksheet, go back and review your responses. Determine if there are specific areas that need improvement (e.g., development rules that govern road design) or if your development rules are generally pretty good. This review is key to implementation of better development: assessment of your current development rules and identification of impediments to innovative site design. This review also directly leads into the next step: a site planning roundtable process conducted at the local government level. The primary tasks of a local roundtable are to systematically review existing development rules and then determine if changes can or should be made. By providing a much-needed framework for overcoming barriers to better development, the site planning roundtable can serve as an important tool for local change.

Table 5: Local, State, and Federal Authorities Responsible for Development in Your Community

Development Responsibility		State/Federal	County	Town
Sets road standards	Agency:			
	Contact Name:			
	Phone No.:			
Review/approves subdivision plans	Agency:			
	Contact Name:			
	Phone No.:			
Establishes zoning ordinances	Agency:			
	Contact Name:			
	Phone No.:			
Establishes subdivision ordinances	Agency:			
	Contact Name:			
	Phone No.:			

Table 5: Local, State, and Federal Authorities Responsible for Development in Your Community (Continued)

Development Responsibility		State/Federal	County	Town
Reviews/establishes stormwater management or drainage criteria	Agency:			
	Contact Name:			
	Phone No.:			
Provides fire protection and fire protection code enforcement	Agency:			
	Contact Name:			
	Phone No.:			
Oversees buffer ordinance	Agency:			
	Contact Name:			
	Phone No.:			
Oversees wetland protection	Agency:			
	Contact Name:			
	Phone No.:			
Establishes grading requirements or oversees erosion and sediment control program	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/approves septic systems	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/approves utility plans (e.g., water and sewer)	Agency:			
	Contact Name:			
	Phone No.:			
Reviews/approves forest conservation/ tree protection plans?	Agency:			
	Contact Name:			
	Phone No.:			

1. Street Width

What is the minimum pavement width allowed for streets in low density residential developments that have less than 500 average daily trips (ADT)? ________ feet

*If your answer is between **18-22 feet**, give yourself **4** points* ☞ [ ]

At higher densities are parking lanes allowed to also serve as traffic lanes (i.e., queuing streets)? YES/NO

*If your answer is **YES**, give yourself **3** points* ☞ [ ]

2. Street Length

Do street standards promote the most efficient street layouts that reduce overall street length? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

3. Right-of-Way Width

What is the minimum right of way (ROW) width for a residential street? ________ feet

*If your answer is **less than 45 feet**, give yourself **3** points* ☞ [ ]

Does the code allow utilities to be placed under the paved section of the ROW? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

4. Cul-de-Sacs

What is the minimum radius allowed for cul-de-sacs? ________ feet

*If your answer is **less than 35 feet**, give yourself **3** points* ☞ [ ]

*If your answer is **36 feet to 45 feet**, give yourself **1** point* ☞

Can a landscaped island be created within the cul-de-sac? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are alternative turn arounds such as "hammerheads" allowed on short streets in low density residential developments? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Subtotal Page 15 [ ]

5. Vegetated Open Channels

Are curb and gutters required for most residential street sections? — YES / NO

*If your answer is **NO**, give yourself **2** points* ☞ [ ]

Are there established design criteria for swales that can provide stormwater quality treatment (i.e., dry swales, biofilters, or grass swales)? — YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

6. Parking Ratios

What is the minimum parking ratio for a professional office building (per 1000 ft^2 of gross floor area)? — ______ spaces

*If your answer is **less than 3.0 spaces**, give yourself **1** point* ☞ [ ]

What is the minimum required parking ratio for shopping centers (per 1,000 ft^2 gross floor area)?

*If your answer is **4.5 spaces or less**, give yourself **1** point* ☞ [ ]

What is the minimum required parking ratio for single family homes (per home)? — ______ spaces

*If your answer is **less than or equal to 2.0 spaces**, give yourself **1** point* ☞ [ ]

Are your parking requirements set as maximum or median (rather than minimum) requirements? — YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

7. Parking Codes

Is the use of shared parking arrangements promoted? — YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are model shared parking agreements provided? — YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are parking ratios reduced if shared parking arrangements are in place? — YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

If mass transit is provided nearby, is the parking ratio reduced? — YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Subtotal Page 16 [ ]

8. Parking Lots

What is the minimum stall width for a standard parking space? _______ feet

*If your answer is **9 feet or less**, give yourself **1** point* ☞ [ ]

What is the minimum stall length for a standard parking space? _______ feet

*If your answer is **18 feet or less**, give yourself **1** point* ☞ [ ]

Are at least 30% of the spaces at larger commercial parking lots required to have smaller dimensions for compact cars? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Can pervious materials be used for spillover parking areas? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

9. Structured Parking

Are there any incentives to developers to provide parking within garages rather than surface parking lots? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

10. Parking Lot Runoff

Is a minimum percentage of a parking lot required to be landscaped? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Is the use of bioretention islands and other stormwater practices within landscaped areas or setbacks allowed? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Time to Assess: Principles 1 - 10 focused on the codes, ordinances, and standards that determine the size, shape, and construction of parking lots, roadways, and driveways in the suburban landscape. There were a total of **40** points available for Principles 1 - 10. What was your total score?

Subtotal Page 15 _____ +Subtotal Page 16 _____ +Subtotal Page 17 _____ = [ ]

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

____

____

____

____

11. Open Space Design

Are open space or cluster development designs allowed in the community? YES / NO

*If your answer is **YES**, give yourself **3** points* ☞ [ ]

*If your answer is **NO**, skip to question No. 12*

Is land conservation or impervious cover reduction a major goal or objective of the open space design ordinance? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are the submittal or review requirements for open space design greater than those for conventional development? YES / NO

*If your answer is **NO**, give yourself **1** point* ☞ [ ]

Is open space or cluster design a by-right form of development? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are flexible site design criteria available for developers that utilize open space or cluster design options (e.g, setbacks, road widths, lot sizes) YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

12. Setbacks and Frontages

Are irregular lot shapes (e.g., pie-shaped, flag lots) allowed in the community? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

What is the minimum requirement for front setbacks for a **one half (½) acre** residential lot? ______ feet

*If your answer is **20 feet or less**, give yourself **1** point* ☞

What is the minimum requirement for rear setbacks for a **one half (½) acre** residential lot? ______ feet

*If your answer is **25 feet or less**, give yourself **1** point* ☞

What is the minimum requirement for side setbacks for a **one half (½) acre** residential lot? ______ feet

*If your answer is **8 feet or less**, give yourself **1** points* ☞

What is the minimum frontage distance for a **one half (½) acre** residential lot? ______ feet

*If your answer is **less than 80 feet**, give yourself **2** points* ☞

13. Sidewalks

What is the minimum sidewalk width allowed in the community? ______ feet

*If your answer is **4 feet or less**, give yourself **2** points* ☞

Are sidewalks always required on both sides of residential streets? YES / NO

*If your answer is **NO**, give yourself **2** points* ☞

Are sidewalks generally sloped so they drain to the front yard rather than the street? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Can alternate pedestrian networks be substituted for sidewalks (e.g., trails through common areas)? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

14. Driveways

What is the minimum driveway width specified in the community?

*If your answer is **9 feet or less (one lane) or 18 feet (two lanes)**, give yourself **2** points* ☞

Can pervious materials be used for single family home driveways (e.g., grass, gravel, porous pavers, etc)? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Can a "two track" design be used at single family driveways? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are shared driveways permitted in residential developments? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

15. Open Space Management

Skip to question 16 if open space, cluster, or conservation developments are not allowed in your community.

Does the community have enforceable requirements to establish associations that can effectively manage open space? YES/NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Are open space areas required to be consolidated into larger units? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Does a minimum percentage of open space have to be managed in a natural condition? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Are allowable and unallowable uses for open space in residential developments defined? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Can open space be managed by a third party using land trusts or conservation easements? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

16. Rooftop Runoff

Can rooftop runoff be discharged to yard areas? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Do current grading or drainage requirements allow for temporary ponding of stormwater on front yards or rooftops? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Subtotal Page 20 [ ]

Time to Assess: Principles 11 through 16 focused on the regulations which determine lot size, lot shape, housing density, and the overall design and appearance of our neighborhoods. There were a total of **36** points available for Principles 11 - 16. What was your total score?

Subtotal Page 18 _____ +Subtotal Page 19 _____ +Subtotal Page 20 ______ = [ ]

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

____

____

____

____

____

17. Buffer Systems

Is there a stream buffer ordinance in the community? YES / NO

*If your answer is **YES**, give yourself **2** point* ☞ [ ]

If so, what is the minimum buffer width? ________ feet

*If your answer is **75 feet or more**, give yourself **1** point* ☞ [ ]

Is expansion of the buffer to include freshwater wetlands, steep slopes or the 100-year floodplain required? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

18. Buffer Maintenance

If you do not have stream buffer requirements in your community, skip to question No. 19

Does the stream buffer ordinance specify that at least part of the stream buffer be maintained with native vegetation? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Does the stream buffer ordinance outline allowable uses? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

Does the ordinance specify enforcement and education mechanisms? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

19. Clearing and Grading

Is there any ordinance that requires or encourages the preservation of natural vegetation at residential development sites? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

Do reserve septic field areas need to be cleared of trees at the time of development? YES / NO

*If your answer is **NO**, give yourself **1** point* ☞

20. Tree Conservation

If forests or specimen trees are present at residential development sites, does some of the stand have to be preserved? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

Are the limits of disturbance shown on construction plans adequate for preventing clearing of natural vegetative cover during construction? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞

21. Land Conservation Incentives

Are there any incentives to developers or landowners to conserve non-regulated land (open space design, density bonuses, stormwater credits or lower property tax rates)? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

Is flexibility to meet regulatory or conservation restrictions (density compensation, buffer averaging, transferable development rights, off-site mitigation) offered to developers? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

22. Stormwater Outfalls

Is stormwater required to be treated for quality before it is discharged? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞

Subtotal Page 22

Are there effective design criteria for stormwater best management practices (BMPs)? YES / NO

*If your answer is **YES**, give yourself **1** point* ☞ [ ]

Can stormwater be directly discharged into a jurisdictional wetland without pretreatment? YES / NO

*If your answer is **NO**, give yourself **1** point* ☞ [ ]

Does a floodplain management ordinance that restricts or prohibits development within the 100 year floodplain exist? YES / NO

*If your answer is **YES**, give yourself **2** points* ☞ [ ]

Time to Assess: Principles 17 through 22 addressed the codes and ordinances that promote (or impede) protection of existing natural areas and incorporation of open spaces into new development. There were a total of **24** points available for Principles 17 - 22. What was your total score?

Subtotal Page 21 ______ +Subtotal Page 22 _____ +Subtotal Page 23______ = [ ]

Where were your codes and ordinances most in line with the principles? What codes and ordinances are potential impediments to better development?

____

____

____

____

To determine final score, add up subtotal from each **Time to Assess**

Principles 1 - 10 (Page 18) ______

Principles 11 - 16 (Page 21) ______

Principles 17 - 22 (Page 23) ______

TOTAL [ ]

SCORING (A total of **100** points are available):

See Page 10 to determine where your community's score places in respect to the site planning roundtable Model Development Principles:

Your Community's Score		
90- 100	☞	Congratulations! Your community is a real leader in protecting streams, lakes, and estuaries. Keep up the good work.
80 - 89	☞	Your local development rules are pretty good, but could use some tweaking in some areas.
79 - 70	☞	Significant opportunities exist to improve your development rules. Consider creating a site planning roundtable.
60 - 69	☞	Development rules are inadequate to protect your local aquatic resources. A site planning roundtable would be very useful.
less than 60	☞	Your development rules definitely are not environmentally friendly. Serious reform of the development rules is needed.

CHAPTER 4

TECHNICAL SUPPORT FOR THE MODEL DEVELOPMENT PRINCIPLES

Changing local development codes and regulations is not easy. Advocates of change are going to be asked hard questions. The hard questions will come from many diverse members of the community and government, including fire chiefs, traffic engineers, developers, homeowners, and elected officials, and tend to focus on economic, public safety, and convenience issues. For example, will the proposed changes:

- make it more difficult to park?
- increase the cost of development?
- increase our exposure to lawsuits?
- increase the cost of maintenance for local governments or individual homeowners?
- make it more difficult to sell new housing developments?
- reduce property values?
- lower the response time for fire trucks and emergency vehicles?
- increase the risk that our children will be struck by cars?
- decrease quality of life for homeowners?

Therefore, it is essential to have good answers to these and other questions during the roundtable process. Real change to the rules can only happen when these questions are thoroughly addressed and community concerns are satisfied.

The answers to some of the hard questions is generally either a resounding no, or at least a somewhat qualified no. In other cases, the answers are more ambiguous, suggesting that implementation of the model development principles will require a careful balancing of several competing community objectives–a trade-off perhaps between a smaller parking lot and the possibility of parking congestion a few days a year, or between a narrower road and the inconvenience of having to pull over to let a driver in the opposite direction pass by. Another important trade-off involves balancing a small but real safety risk against the environmental and economic benefit of a particular model development principle.

This balancing is best resolved through a local site planning roundtable, where a community can come together through a consensus process to make better choices about the design of new development.

To get this process started, we have compiled summary sheets for the 22 Model Development Principles. Each summary sheet consists of five key sections:

- **Current Practice.** This section describes the typical development practice in many communities across the country and explains why it leads to increased impervious cover and greater stormwater runoff.

- **Recommended Practice.** This section shows how the existing development rules could be changed to reduce impervious cover, conserve natural areas or better manage stormwater. While the recommended practices are often very specific, we have not endorsed any single, numerical design criteria. Many of the current problems in subdivision codes stem from the "cookbook" mentality, where communities adopted national subdivision "recipes" without modifying them to fit their individual needs. It is not intended that the recommended practice replace current cookbooks with a national one.

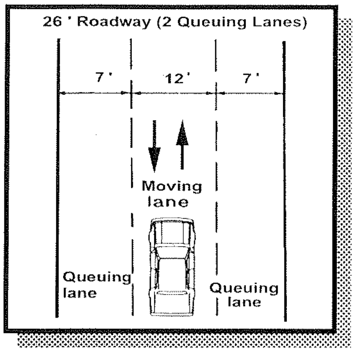
- **Perceptions and Realities.** In this section, the most common negative perceptions about the site planning topic are raised, followed by an objective assessment of the data. The data is drawn from a host of economic studies, public surveys, market studies, and environmental research. In some cases, the data is thin or contradictory, and this is so noted.

- **Case Studies.** This section presents case studies from across the country where communities have successfully applied the ideas presented in the model development principles.

- **Where to Get Started.** This last section of each summary sheet provides more detailed references and resources to consult as you begin the process of changing your local development rules.

On the following page is an index that will guide you directly to the summary sheet for the site planning topic that you are interested in.

INDEX TO SUMMARY SHEETS



PRINCIPLE NO. 1

Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.

CURRENT PRACTICE

Many communities require that residential streets be 36 feet wide or more, even when they serve developments that produce small volumes of traffic. These wide streets result from blanket application of high volume and high speed highway design criteria, as well as a perceived need to supply both on-street parking and unobstructed access for fire trucks. However, residential streets are often unnecessarily wide and the excessive widths contribute to making them the largest single component of impervious cover in a subdivision. Narrowing residential street widths can help reduce the amount of impervious cover created by excessive street widths requirements.

RECOMMENDED PRACTICE

Several national engineering organizations have recommended that residential streets can be as narrow as 22 feet in width (AASHTO, 1994; ASCE, 1990) if they serve neighborhoods that produce low traffic volumes (less than 500 daily trips, or 50 homes) In addition, several communities such as Buck's County, Pennsylvania and Boulder, Colorado have implemented narrower streets with success (see Table 1.1).

Table 1.1: Examples of Narrow Residential Street Widths

Organization, Source	Residential Street Pavement Width	Maximum Average Daily Traffic (trips/day)
State of New Jersey	20' (no parking)	0-3,500
	28' (parking on one side)	0-3,500
Boulder, Colorado	20'	150
	20' (no parking)	350-1,000
	22' (one side)	350
	26' (both sides)	350
	26'(one side)	500-1,000
Bucks County, PA	12' (alley)	--
	16-18' (no parking)	200
	20'-22'(none)	200-1,000
	26' (one side)	200
	28' (one side)	200-1,000

Note: Street options are influenced by housing density and the need for on-street parking

Streets do need to be wider when they serve higher density developments. It is still possible, however, to design a relatively narrow street even when housing densities begin to require more on-street parking. A common solution is the use of queuing streets. In the queuing street design, only one traffic lane is used and parking lanes serve as queuing lanes where oncoming vehicles pull over to allow another vehicle to pass by (Bray and Rhodes, 1997; ASCE, 1990; and Figure 1.2 for an illustration).

Communities have a significant opportunity to reduce impervious cover by revising their street standards, so that streets are the minimum width to carry traffic and meet residential parking demand.

Perceptions and Realities about Street Width

Any effort to narrow residential streets will need to satisfy community concerns about parking, safety, fire truck access, congestion and other factors. Much of the available research profiled in Table 1.2, however, suggests that careful design of narrow streets can address these concerns.

On-Street Parking Demand

The need for on-street parking is often used to justify wider residential streets. Most communities require that 2 or 2.5 parking spaces be provided for each home. Depending on its dimensions, 2 spaces can usually be provided by the driveway which leaves at most one space that must be provided on the street. These on-street parking spaces need to be about 20 feet long and seven feet wide. Providing a continuous parking lane on both sides of the street, however, is a very inefficient and expensive way to satisfy this relatively minor parking need. Each on-street parking lane increases a street's impervious cover by 25% (Sykes, 1989) while creating unutilized parking capacity. If one or both of the on-street parking lanes also serve as a traffic lane (i.e, a queuing street), both traffic movement and parking needs can be met by a narrower street.

Street Width and Safety

The potential for increased vehicle-pedestrian accidents is often cited for not allowing narrower streets. Many studies, however, indicate that narrow residential streets may be safer than wider streets. The Federal Highway Administration (1997) noted that narrow street widths tend to reduce the speed at which drivers travel. This finding has also been noted by the ITE (1997) and ULI (1992). Slower vehicle speeds provide drivers with more time to react and prevent potential accidents. Slower speeds also reduce the severity of injuries sustained in accidents.

Fire Safety

Another common impediment is the perception that narrow streets do not provide adequate access for emergency vehicles, particularly fire vehicles. The conventional wisdom is that very wide streets are needed to ensure access. However, a number of local fire codes permit roadway widths as narrow as eighteen feet (Table 1.3).

Table 1.2: Perceived Impediments to Narrow Streets

Perception	Facts, Case Studies, and Challenges	
1. Narrow streets interfere with the ability to clear and stockpile snow.	FACT:	"Narrow" snowplows are available. Snowplows with 8' width, mounted on a pick-up truck are common. Some companies manufacture alternative plows on small "Bobcat" type machines (Frink America, 1997).
	FACT:	Snow stockpiles on narrow streets can be accommodated if parking is restricted to one side of the street (ITE, 1997).
2. Narrow streets will cause traffic congestion.	FACT:	Narrow streets are generally appropriate only in residential areas that experience less than 500 trips per day. Street width is largely a function of traffic volume. Design criteria based on volume generally provide safe and efficient access in residential areas (ITE, 1993).
3. Narrow streets do not provide enough room for on-street parking.	FACT:	Parking can be accommodated through the use of "queuing streets" with only one travel lane (Bray and Rhodes, 1997; ASCE, 1990).
	FACT:	Most communities require some off-street parking accommodation in residential subdivisions. Olympia, Washington requires two parking spaces per dwelling unit. On-street parking is used for visitor parking or parkable vehicles, such as boats (Wells, 1995).
4. Narrow streets can cause pedestrian/ vehicle accidents.	FACT:	In a study of over five thousand pedestrian and bicycle crashes, a narrow roadway was a factor in only two cases (FHA, 1996). Unsafe driving speed, on the other hand, contributed to 225 accidents.
	FACT:	Narrower street widths reduce the speed at which vehicles can drive (FHA, 1996).
5. Narrow streets do not provide access for maintenance and service vehicles.	FACT:	Trash trucks require only a 10.5' travel lane (Waste Management, 1997), with a standard truck width of approximately 9' (BFI, 1997). In residential neighborhoods, trash collection often occurs simultaneously on both sides of the street; cars must wait for trash trucks to pass regardless of street width.
	FACT:	Half ton mail trucks, smaller than many privately owned vehicles, are generally used in residential neighborhoods. Hand delivery of mail is also an option (US Post Office, 1997).
	CASE STUDY:	School buses are typically eight feet wide (nine feet from mirror to mirror). Both Prince Georges County and Montgomery County, Maryland require only a 12' driving lane for bus access. Furthermore, school buses usually do not drive down every street, but instead meet children at bus stops on larger roads.

Table 1.3: Street Width Requirements for Fire Vehicles

Width	Source
18'-20'[1]	US Fire Administration (Cochran, 1997)
24' (on-street parking) 16' (no on-street parking)	Baltimore County Fire Department
18' minimum	Virginia State Fire Marshal
24' (no parking) 30' (parking on one side) 36' (parking on both sides) 20' (for fire truck access)	Prince Georges County Department of Environmental Resources
18' (parking on one side)[2] 26' (parking on both sides)	Portland Office of Transportation

[1]Represents typical "fire lane" width, which is the width necessary to accommodate a fire vehicle.

[2]Applicable to grid pattern streets or short cul-de-sacs.

ECONOMIC BENEFITS

Significant construction cost savings can be achieved by building narrower streets. Construction costs for paving are approximately $15 per square yard. For example, a local jurisdiction currently requires all residential streets with one parking lane to be a minimum of 28 feet wide. The jurisdiction adopts a new standard: 18 feet wide queuing streets. This new standard would reduce the overall imperviousness associated with a 300 foot road by 35% and construction costs by $5,000. Additional economic benefits include reduced clearing and grading, infrastructure, and stormwater management costs. Long-term pavement maintenance costs would also be reduced.

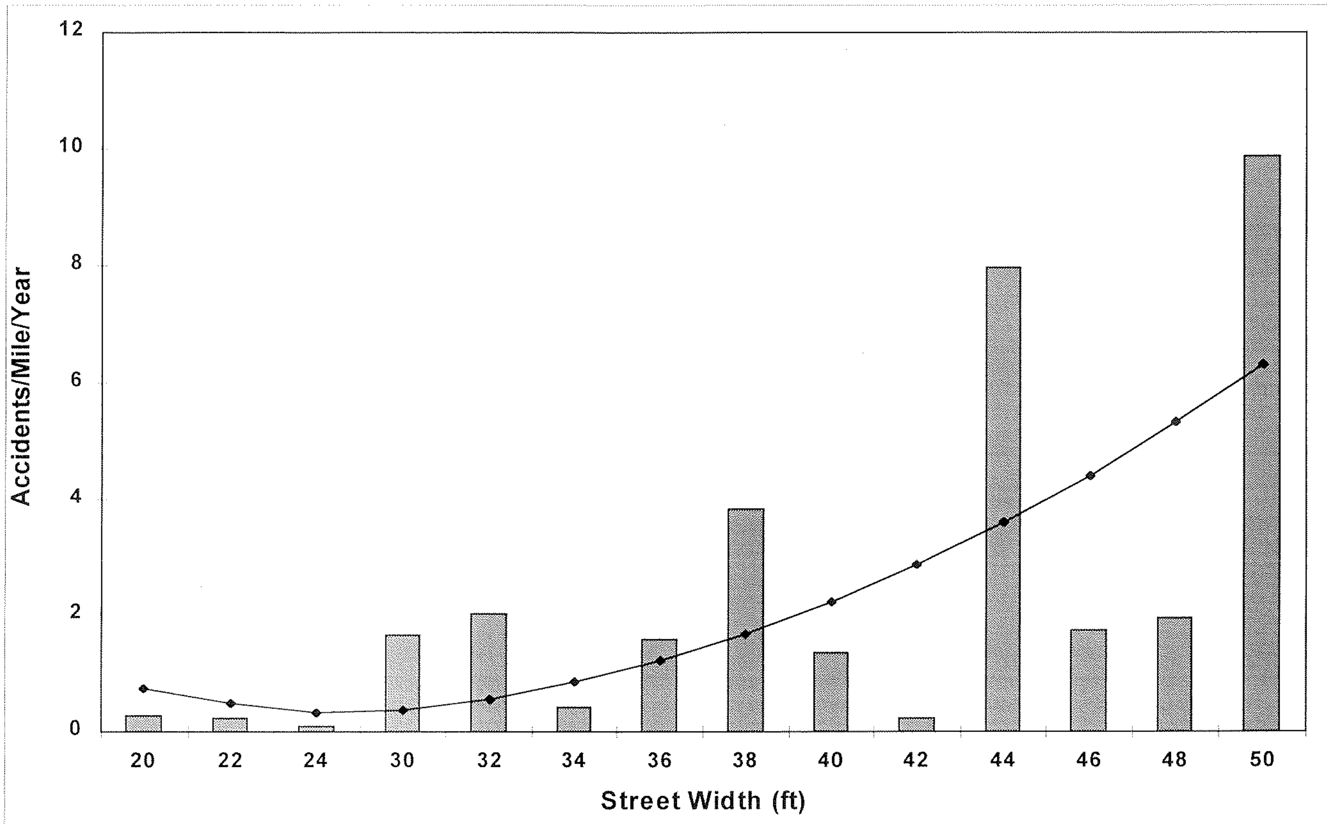
CASE STUDY: LONGMONT, COLORADO

(Source: Swift, et al, 1998)

The City of Longmont, Colorado is experiencing rapid growth. The quality and type of new development has become an important issue as more development and non-conventional site designs are proposed. Part of this discussion is acceptable residential street design.

Over 20,000 police reports were examined to determine the relationship between street design and safety. The study focused specifically on residential streets with maximum ADTs of 2,500. Accidents attributable to poor road conditions or substance abuse were excluded from the study. As shown in Figure 1.1, the study results suggested that narrow residential streets are safer than wide streets. Specifically, streets between 22 to 30 feet in width were found to be the safest. The study further indicated that curvilinear streets were safer than straight streets. In general, the Longmont study suggests that narrow, curved streets can safely be used in residential developments.

Figure 1.1: Relationship Between Street Width and Accidents in Longmont, Colorado based on Swift, et al., (1998)



The curve illustrates the increase in the number of accidents as street width increases.

CASE STUDY: PORTLAND, OREGON

(Source: Portland Office of Transportation, 1994)

The City of Portland investigated the use of queuing streets as described by ASCE (1990) to reduce street widths. The ASCE design assumes that cars will wait between parked cars, or "queue", while the approaching traffic passes (see Figure 1.2). The new design reduces existing street widths by up to eight feet. Prior to implementing the revised standard, the Portland Department of Transportation studied existing narrow streets to determine if reduced street widths would endanger pedestrians and residents. The findings of this study were:

- A bicycle and a car can fit down a 24 foot wide street with parking on both sides.
- A dump truck can fit down a 24 foot wide street with parking on both sides.
- Fire trucks can easily drive down 26 foot wide streets with parking on both sides.
- A fire truck can make the turn from an 18 foot wide to a 20 foot wide road at slow speeds.
- Traffic engineers could point to no accident history relating to narrow street widths.

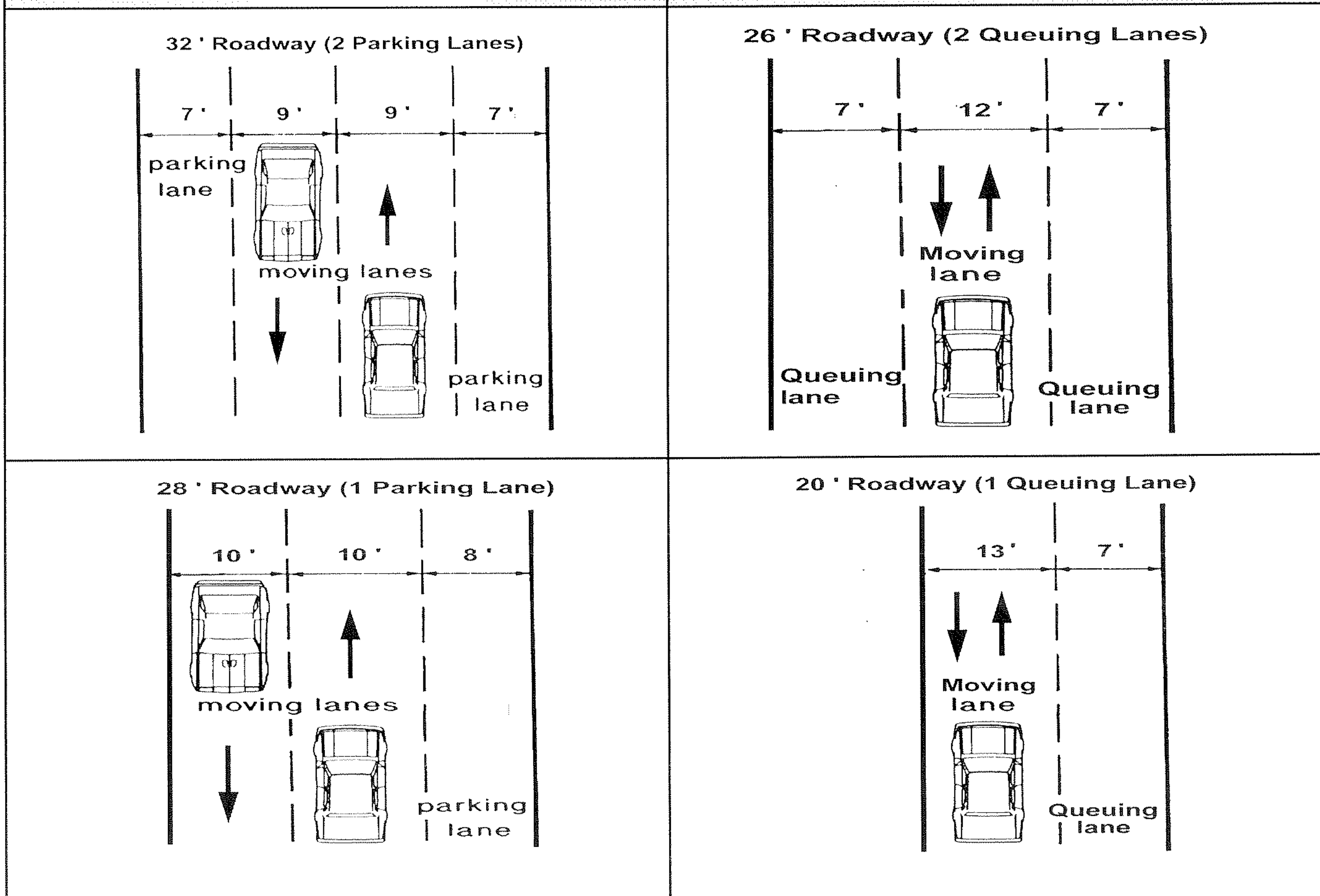
- The Portland fire chief was amenable to streets as narrow as 18 feet with parking on one side in grid pattern streets or on short cul-de-sacs.
- No citizen has charged that fire rescue time was impeded by skinny streets since the inception of this program in 1991 (Bray, 1997)

One exception was noted with respect to long roads leading to cul-de-sacs (e.g., 1500 feet); these streets require two travel lanes for adequate fire vehicle access. The fire bureau therefore retained the right to veto narrow streets on long cul-de-sacs.

In the City of Portland, the cost savings realized from narrow streets allowed the city to improve less-developed portions of the roadway which, in turn, encouraged infill development. Infill development refers to development or enhancement within existing urban areas as an alternative to developing surrounding rural areas.

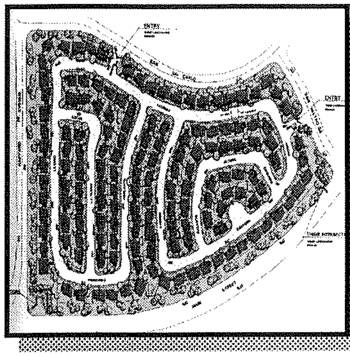
Figure 1.2: A Comparison of Queuing Streets vs. Traditional Streets [Source: Portland (OR) Office of Transportation, 1994]

Original Standards (Separate travel lanes and parking lanes)	Revised Standards (Parking lanes serve as Queuing lanes)



WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
A Policy on Geometric Design of Highways and Streets (1994) by American Association of State Highway and Transportation Officials (AASHTO) Provides guidance on highway design including shared use of transportation corridors and cost-effective highway design that reflects the needs of non-users and the environment.	AASHTO Publications 444 North Capitol Street, NW Washington, DC 20001 888-227-4860
Report on New Standards for Residential Streets in Portland, Oregon (1994) by Portland Office of Transportation Summarizes new residential street standards that encourage less costly street improvement with minimal impact on water quality and urban forests.	City of Portland Office of Transportation 1120 S.W. Fifth Avenue Room 802 Portland, OR 97204-1971 503-823-7004
Performance Streets: A Concept and Model Standards for Residential Streets (1980) by Bucks County Planning Commission. Presents model standards focusing on pedestrian as well as vehicular traffic and reducing overdesigned street networks.	Bucks County Planning Commission Route 611 and Almshouse Road Neshaminy Manor Center Doylestown, PA 18901 215-345-3400
Residential Streets (2nd Edition) Includes discussion of design considerations for pedestrian walks and paths.	Urban Land Institute 1025 Thomas Jefferson Street, NW Washington, DC 20007 800-321-5011 Also available from the American Society of Civil Engineers and the National Association of Home Builders



Source: ULI 1992

PRINCIPLE NO. 2

Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.

CURRENT PRACTICE

Most communities do not explicitly require site designers or traffic engineers to use the shortest street network needed to serve individual lots on residential streets. It is generally assumed that the cost of constructing roads is sufficient incentive to assure short street networks. However, in many cases, the overriding consideration for traffic engineers is that streets operate at a certain service level (Ewing 1996). Streets are designed to accommodate rapid, smooth traffic flow and, consequently, total street length is rarely the most important design consideration. Traffic movement tends to be given even more weight as the size of the development increases.

The most common types of street networks used are grid and curvilinear (see Figure 2.1). The grid pattern is a traditional urban street network. The curvilinear pattern is a more contemporary subdivision network. Grid patterns typically require 20 to 25 percent more total street length than curvilinear patterns. When narrower pavement widths are used, however, the reduced street widths can offset the greater street length associated with the grid pattern (Bookout, 1992).

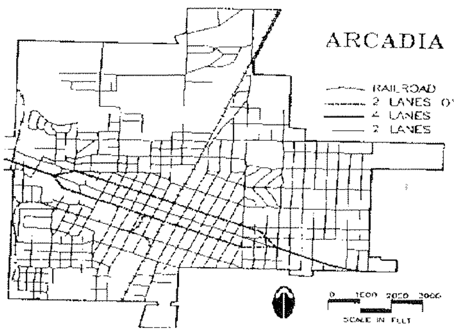
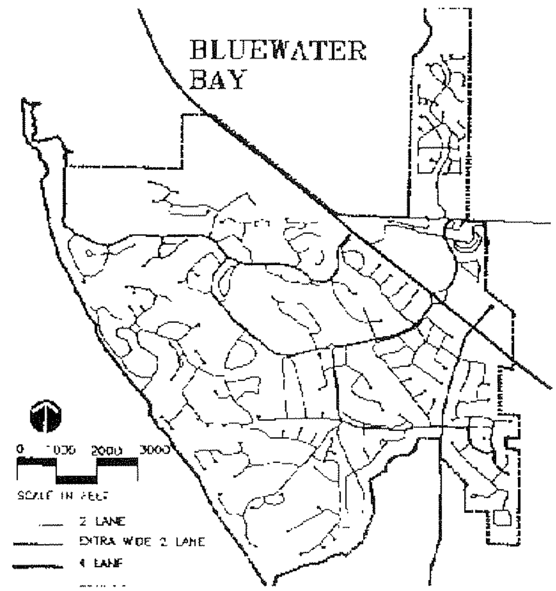
Another street network used is the hybrid street network. This design combines both grid and curvilinear patterns to create a bending grid of roads in a wheel and spoke design. Cul-de-sacs, loops, and short straight streets feed off the basic grid to provide residential access (Ewing, 1996). This road layout design accommodates the contours and natural features of a site while still providing interconnectivity (Figure 2.2).

RECOMMENDED PRACTICE

Total street length is a function of the distance between house lots and site layout. There is no one street layout that is guaranteed to minimize total street length in residential developments. Instead, site designers are encouraged to actively look for opportunities to reduce street length. Generally, a more compact street network can be achieved by reducing frontage distances and side yard setbacks and allowing narrower lots (Principle No. 12). Smaller lots clustered together (Principle No. 11) can also reduce the total street length. Site designers should also reduce the number of non-frontage roads. In other words, as many homes as possible should be directly accessible from the main streets. Long streets serving only one or two homes should be discouraged.

Site designs that lend themselves to reduced street length include the "traditional neighborhood development" and "open space development."

Figure 2.1: Grid and Curvilinear Road Patterns (Based on Ewing, 1996)

	
Grid (Traditional Urban Pattern)	**Curvilinear (Contemporary Suburban Pattern)**
Characteristics	**Characteristics**
Short block lengths	Cul-de sacs
Straight streets	Long block lengths
Systematic layout	Branching street networks
Advantages	**Advantages**
Greater dispersal of traffic	Uses natural topography to reduce excavation
Greater direct access	Eases avoidance of natural areas
More pedestrian friendly	Reduces cut-thru traffic
Transit oriented	Reduces vehicle speeds due to curving nature
Maximizes number of homes fronting a street	
Typically provides water main system with greater pressure	

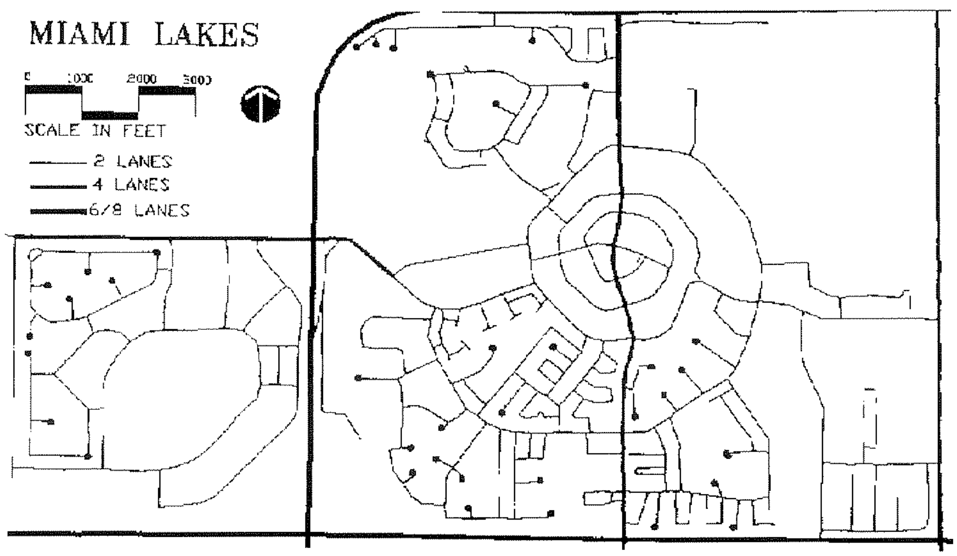
Traditional Neighborhood Development (TND)

Also called neo-traditional development, this development pattern is designed to emulate the characteristic of small, older communities of the 18th through the early 20th centuries. A central feature of traditional neighborhood development (TND) is to shift the focus of the infrastructure from serving the automobile to serving pedestrians. To do so, designers must carefully consider the connectedness of the street and alley network while lowering auto speeds and providing reasonable safety for pedestrians. ITE (1997) has produced detailed guidelines on how to design more efficient street systems within TNDs.

In the TND design, streets tend to be laid out in a grid pattern, more community open space is provided, and a variety of housing types are employed with smaller front yards. TNDs often employ a variety of land use activities in a single project. One goal of TNDs is to provide communities where residents can walk from home to jobs and commercial establishments.

TND can minimize the environmental impacts associated with extensive roadways. The idea is to provide a critical mass of residents, in close proximity to jobs, shopping, and mass transit to help reduce reliance on the automobile for transportation.

Figure 2.2: Hybrid Street Networks (Ewing, 1996)



Open Space Development

Open space development is a compact form of development that concentrates density on one portion of the site in exchange for reduced density elsewhere. Minimum lot sizes, setbacks and frontage distances are relaxed to provide common open space. The distance between homes is shortened, allowing shorter streets.

Most open space developments use either a curvilinear or hybrid street pattern. The curvilinear pattern is a flexible option that allows the site designer to follow the topography of the site and avoid sensitive environmental areas. Clearing and grading requirements are minimized and more protection is provided for forests, wetlands, and trees.

Arendt (1996) recommends that open space site designers make street layout their ***third*** priority. Identification of conservation areas and location of house lots are the first two priorities. This ensures minimal disturbance to natural areas. Because narrow, small lots are an integral part of open space design, the resulting street network will most likely be smaller than that achieved using a conventional design. Additional street length reduction can be achieved by reducing the length of the access roads (i.e., placing homes closer to the subdivision entrance).

Table 2.2: Perceived Impediments to Shorter Street Networks

Perception	Fact, Case Studies, and Challenges	
1. Shorter street lengths reduce on-street parking.	FACT:	The average number of vehicles in a household is 1.66 which can usually be accommodated between the driveway, garage, and on-street parking (Pisarski, 1996).
	FACT:	Many open space and TND designs include garages and/or driveways. Further, many of today's subdivision ordinances shift on-street parking to off-street locations such as driveways, garages, and parking lots (Ewing, 1996). This trend is echoed in the joint ASCE, NAHB and ULI document Residential Streets (ULI, 1990). Specifically, "All residential occupant parking should be off-street parking, accommodated by driveways, carports, and garages, or, in higher-density developments, parking lots. Only visitor parking should overflow onto the street."
	CHALLENGE:	Designers must consider the trends in vehicle ownership. The percentage of households with 3 or more vehicles decreased by 1% from 1980 - 1990. However, this decrease is significant in light of the extraordinary increase in such households (10-fold) between 1960 and 1980 (Pisarski, 1996).
2. As housing density increases, traffic will become more congested.	FACT:	Shorter block lengths typically encourage greater street connectivity. This greater connectivity usually increases the amount of traffic local streets can accommodate. Additionally, more route options are available for traffic dispersal, leading to a reduction in congestion (ITE, 1994b).
3. Shorter roads increase the likelihood of accidents and the liability of planners.	FACT:	Shorter street lengths reduce traffic speeds (ITE, 1997). At reduced speeds (20 mph or less) there is a 95% chance a pedestrian will survive an accident (Ewing, 1996).
	FACT:	Knoblauch, et al (1988) found that local streets where parking was permitted on both sides of the road were more hazardous relative to those with parking restrictions.
	FACT:	Shorter streets allow for more travel options for emergency vehicles to reach an accident scene (Fontana, 1998).

Perceptions and Realities about Street Length

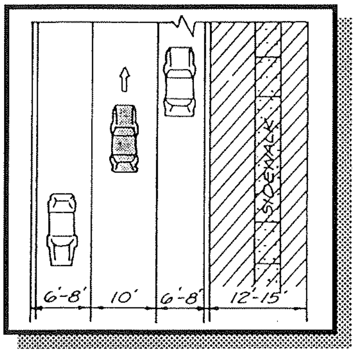
The purpose of considering alternative road layout patterns is to minimize the overall street length. There are some concerns that shorter street lengths will significantly reduce the amount of available on-street parking. Other potential impediments to shorter street networks include concerns regarding traffic congestion and safety (Table 2.1). There is also a perception that public officials, transportation planners, and plan reviewers will be held liable for these potential safety impacts. Courts, however, tend to support the design decisions of planning agencies as long as significant professional errors were not made and decisions are consistent with a level of ordinary care. Ordinary care means that design decisions are based on the level of care and knowledge that can be expected of a reasonably experienced and prudent professional (NHI, 1996).

ECONOMIC BENEFITS

A savings of approximately $150 per linear foot can be achieved by shortening roads (CBP, 1993). This includes savings achieved through reduced pavement, curb and gutter, and the storm sewer construction. Using this figure, a 100 foot reduction in road length will result in a savings of about $15,000. In addition, the costs for providing other utilities such as gas, water, and electricity will be reduced because less cable and pipe will be required. Additional long-term savings will be realized due to reduced roadway maintenance.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Traditional Neighborhood Development Street Design Guidelines (1997) by Institute of Traffic Engineers. Presents design guidelines that include street use by non-automobile traffic and the street's relationships to adjacent and future land use.	Institute of Transportation Engineers 525 School Street, SW Suite 410 Washington, DC 20024-2797 202-554-8050
Best Development Practices: Doing the Right Thing and Making Money at the Same Time (1996) by Reid Ewing Presents practices for developers and local governments regarding land use, transportation, the environment, and housing.	American Planning Association Planners Book Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344



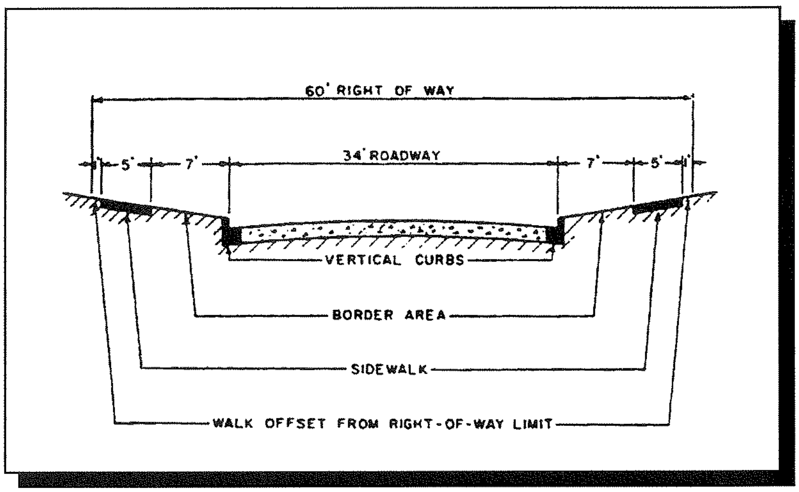
PRINCIPLE NO. 3

Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.

CURRENT PRACTICE

A street right-of-way (ROW) is a public easement that creates a corridor to move traffic, pedestrians, utilities, and stormwater through a development. In many communities, a single right-of-way width of 50 or 60 feet is applied to all residential street categories. Some examples of ROW for residential streets are presented in Table 3.1, and a typical cross-section of a wide right-of-way is shown in Figure 3.1. A wide ROW is only needed when utilities and sidewalks are located some distance from the paved section of the roadway.

Figure 3.1: Cross Section of Currently Used ROW (Source: ITE, 1993)



While a wide right-of-way does not necessarily create more impervious cover, it can work against better site design for several reasons. First, it subjects a greater area to clearing during road construction, which may result in needless loss of existing trees. Second, and more importantly, a wide right-of-way consumes land that may be better used for housing lots, making it more difficult to achieve a more compact site design.

Table 3.1: Examples of Conventional Right-of-Way (ROW) Requirements (Includes Pavement)

Right-of-Way Width	Source	Comment
50 - 60 feet	ITE (1993)	ITE is currently considering reduced ROW recommendations
50 - 60 feet	Frederick County, Maryland	Minimum for all residential streets 20' to 32' feet wide
60 feet	El Paso (1981)	
50-60 feet	Bucks County Planning Commission (1980)	Minimum for all residential streets

Recommended Practice

A narrower right-of-way can generally be accommodated on many residential streets without unduly compromising safety or utility access. Some communities have recently narrowed ROWs for residential streets to 35 to 45 feet (see Table 3.2). This is done by redesigning each of the main components of the right-of-way. First, the pavement width is reduced on some streets (see Principle No. 1). Second, sidewalks are either narrowed or restricted to one side of the street (see Principle No. 13). Third, the border width, which separates the street from the sidewalk, can be slightly relaxed. Lastly, utilities are installed underneath street pavement at the time of construction. When these design techniques are combined together, the width of most residential ROWs can be reduced by 10 to 25 feet.

Table 3.2: Examples of Narrower ROW Widths

Source	ROW Width	Pavement Width and Purpose
Portland, Oregon	35'	20' residential street
	40	26' residential street
Montgomery County, Maryland	20'	16'; residential alley
	44'	20'; residential street
	46'-60'	26'; residential streets
ASCE, 1990 (Recommendation)	24-26'	22'-24 residential alley
	42'-46'	26' residential street

It should be noted that a narrow right of way may not always be desirable if stormwater is conveyed by swales along the road (see Principle No. 5). Swale designs that provide the best stormwater treatment and prevent standing water may require 10 to 12 feet along one or both sides of the road. Several options for narrower rights-of-way are provided in Figure 3.2.

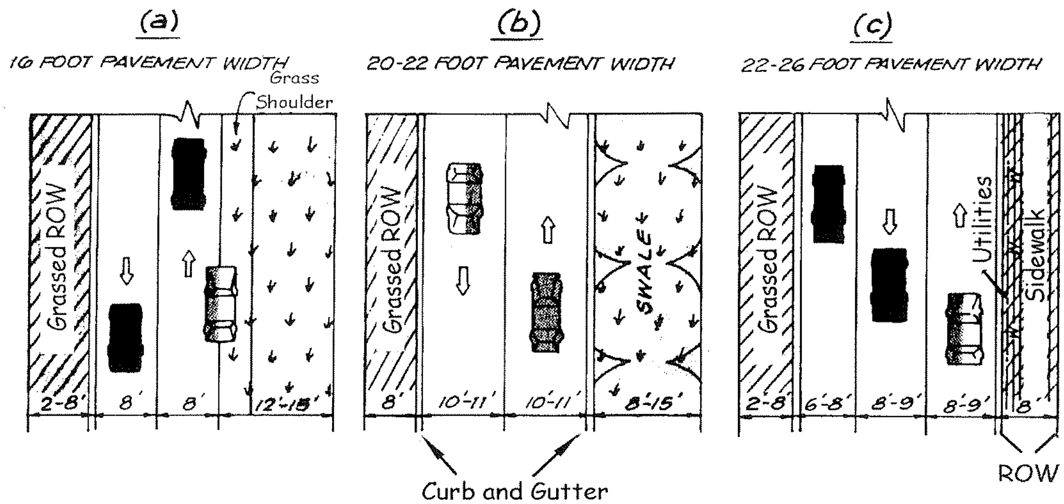
Perceptions and Realities about Narrower Right-of-Ways

Two common concerns about narrowing rights-of-way include pedestrian safety and utility maintenance, which are reviewed below. Other potential barriers to narrower street ROWs are reviewed in Table 3.4.

Pedestrian Safety

A wide separation between street and sidewalk is one approach to protect pedestrians from traffic. An equally effective approach involves designing narrower roads that reduce traffic speed (Principle No. 1), designing narrower sidewalks for pedestrian movement (Principle No. 13) and ensuring adequate sight distance. Sight distance refers to the distance that allows a driver to see a pedestrian in time to stop or avoid an accident. In most cases, a narrow ROW does not greatly impair sight distance. In general, narrower ROW widths correspond to low traffic volume streets. As discussed in Principle No. 1, cars tend to travel slower through narrower streets, reducing the likelihood and severity of accidents.

Figure 3.2: Potential Design Options for Narrower ROW on Residential Streets (Schueler, 1995)



Utility Maintenance

It is common practice for communities require water and sewer lines be installed underneath the pavement section at the time of construction (see example design standards in Table 3.3). Any utility that is installed below the paved section, however, will eventually need to be accessed for repair or replacement. Traffic flow may be temporarily impeded during these operations, and utility companies will incur the additional cost of repaving the road where they need to work. The amount of pavement turned up during these operations can be reduced through better diagnostic tests and trenchless technologies for utility construction and repair (see Table 3.4). A narrower right-of-way can still be created, even if local agencies cannot require placement of utilities under the street by narrowing pavement sections, modifying sidewalk requirements, and reducing grass border areas.

Table 3.3: Example Water and Sewer Design Guidelines

Jurisdiction	Guidelines
Frederick County, Maryland	• Water mains and sewer lines shall be placed seven feet from the street center line in developments with curb and gutter, or five feet from the street center line in streets without curb and gutter, on opposite sides of the street.
Washington Suburban Sanitary Commission	• Water lines should be designed seven feet from the street center line. • Water lines should be separated from sewer lines by at least ten feet.

Table 3.4: Perceived Cost Impediments to Narrower ROW Widths

Perception	Fact, Case Studies, and Challenges	
1. Placing utilities under the roadway increases construction and maintenance costs for water and sewer lines.	FACT:	Many communities currently place water and sewer pipes under the pavement (see Table 3.3 for example Water and Sewer Guidelines).
2. Costs of installing and maintaining cable or electric utilities will be higher.	FACT:	During construction, utilities can be put in place prior to pavement construction.
	FACT:	Many "trenchless" technologies are available to minimize impacts to pavement (ISTT, 1997). In these techniques, pipes are tunneled into the surface. Although consistent cost data are not available on the application of these methods, they may provide a viable alternative in some situations.
	CHALLENGE:	Cost impacts for excavating new lines and repairing them are unknown, but many public works officials are concerned that private utility companies will damage public roads.
3. Narrow ROW widths do not allow future road widening.	FACT:	The traffic volume of most residential streets is constant over time; thus, few streets ever need to be widened.
4. A larger ROW may be needed for open channel development.	CHALLENGE:	If a community encourages open channel development, it may need to keep a larger ROW.

Where to Get Started

Suggested Resources	How to Get a Copy
Report on New Standards for Residential Streets In Portland, Oregon (1994) by Portland Office of Transportation Summarizes new residential street standards that encourage less costly street improvement with minimal impact on water quality and urban forests.	City of Portland Office of Transportation 1120 S.W. Fifth Avenue Room 802 Portland, OR 97204-1971 503-823-7004
Design Standards (1996) by Montgomery County Maryland Department of Public Works and Transportation Standards for design of highways, streets, shoulders, driveways, drainage, and landscaping.	Montgomery County Department of Public Works and Transportation Design Section 101 Monroe Street Rockville, MD 20850 301-217-2121

Suggested Resources	How to Get a Copy
Residential Streets (2nd Edition) Includes discussion of design considerations for pedestrian walks and paths.	Urban Land Institute 1025 Thomas Jefferson Street, NW Washington, DC 20007 800-321-5011 Also available from the American Society of Civil Engineers and the National Association of Home Builders
Site Planning for Urban Stream Protection (1995) by Thomas R. Schueler Chapter 6 discusses right-of-way criteria and cites various ROW design standards currently in use.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323

Principle No. 4

Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.

Current Practice

A cul-de-sac is a local street open at only one end. A large "bulb" is located at the closed-end to enable emergency and service vehicles to turnaround without having to back up. Cul-de-sacs are a prominent feature in many contemporary residential developments. Many communities require that the bulb be 50 to 60 feet or more in radius, which creates a large circle of impervious cover that is never fully utilized for turning movements.

Recommended Practice

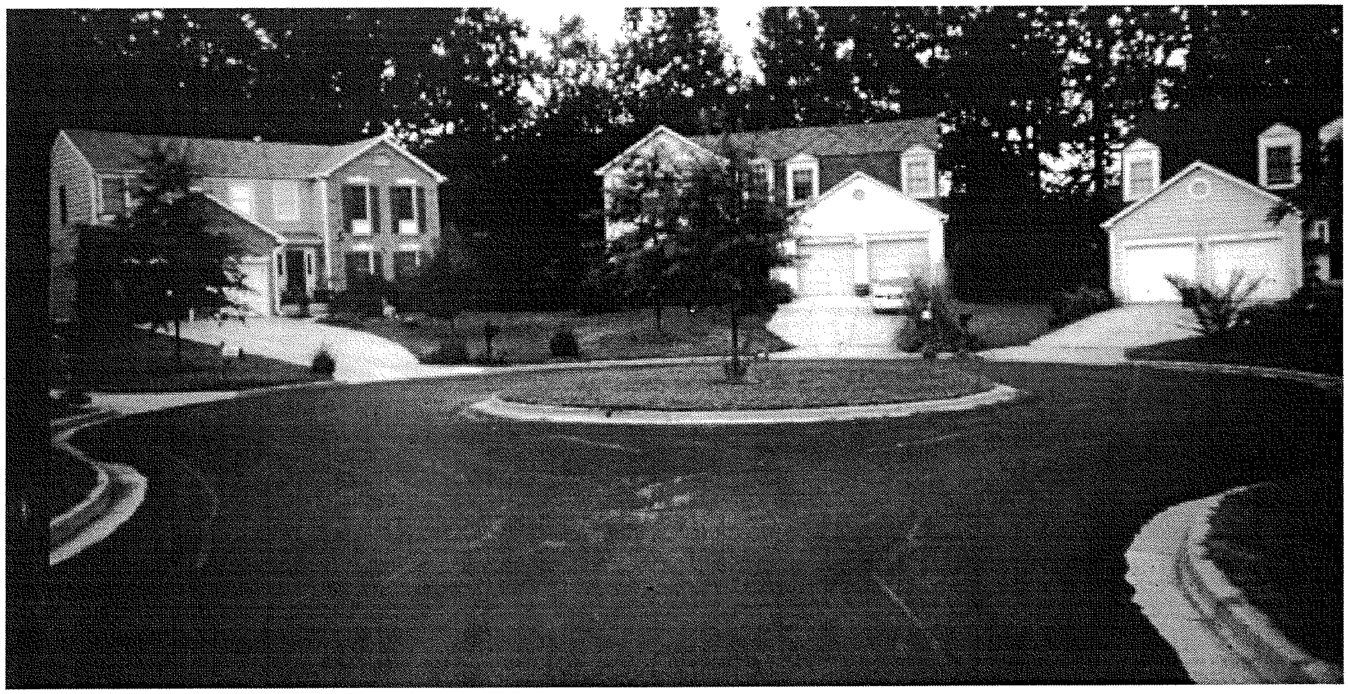
One option to reduce the impervious cover associated with cul-de-sacs is to reduce the radius of the turnaround bulb. A number of communities are now allowing smaller radii, ranging from 33 to 45 feet (see Table 4.1). Reducing the radius by even a few feet can sharply reduce the impervious cover created by a cul-de-sac (Schueler, 1995). See Figure 4.2 for an illustration of the varying amounts of impervious cover generated by various turnaround types.

A second option for designing cul-de-sacs involves the placement of a pervious island in the center of the turn. Vehicles only travel along the outside of a cul-de-sac when turning, leaving an unused "island" of pavement in the center (see Figure 4.1). These cul-de-sac islands can be attractively landscaped and also designed to store and treat stormwater runoff (see Principle No. 20) Concerns regarding sight impairment can be addressed by using slow-growing shrubs or ground cover.

Table 4.1: Recommended Cul-de-Sac Turnaround Radii

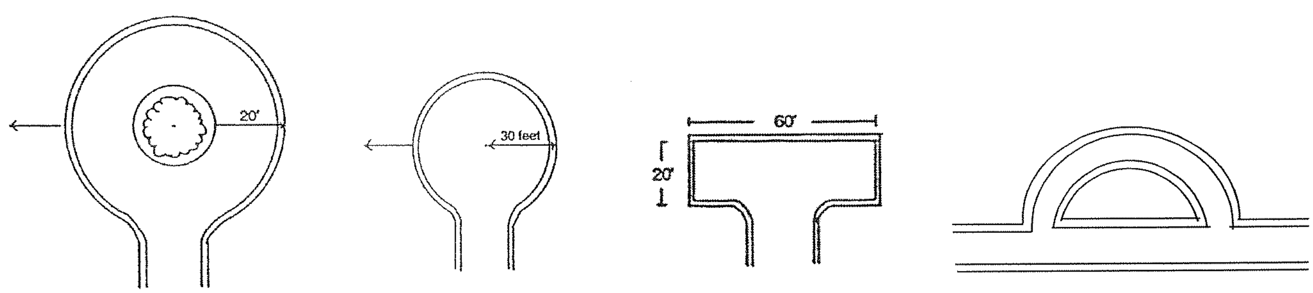
Turning radius	Source
35 feet (with approval of fire dept.)	Portland (OR) Office of Transportation
38 feet outside turning radius	Bucks County (PA) Planning Commission
45 feet	Fairfax Co (VA) Fire and Rescue Department
35 feet	Baltimore County (MD) Fire Department
45 feet	Montgomery County (MD) Fire Department
43 feet	Prince Georges County (MD) Fire Department

Figure 4.1: Cul-de-sac With Small Landscaped Island



Cul-de-sacs are not the only turnaround option. Other designs can be used to create less impervious cover. A T-shaped turnaround (also known as a "hammerhead") generates approximately 75% less impervious cover than a 40 foot radius circular turnaround. T-shaped turnarounds are only generally applied to cul-de-sacs when streets are short (less than 200 feet) or when lot sizes are very large. The minimum dimensions for a T-shaped turnaround are 60 feet by 20 feet (ULI, 1990; NAHB, 1990). Figure 4.1 illustrates various turn around options.

Figure 4.1: Four Turnaround Options for Residential Streets



(a) 40 ft cul-de-sac with landscaped island

(b) 30 ft radius cul-de-sac

(c) 60 by 20 ft T-shaped turnaround

(d) Loop road

Another alternative to circular cul-de-sacs is the loop road. A loop road is a curved road that joins with another road at each end, providing two points of entry and exit. Loop roads provide multiple access points for emergency vehicles and reduce the need for backing-up of vehicles. Further, trips for residents may be shortened since each house has access to an exit on either end of the loop. Finally, loop roads are generally allowed to carry double the traffic volume of cul-de-sacs since there are two ways out. In Performance Streets it was noted that "residential access loop streets may serve twice as many units as a cul-de-sac, since it is assumed that the traffic volume will be equally divided between both halves of the loop"(Bucks County, 1980).

PERCEPTIONS AND REALITIES ABOUT CUL-DE-SACS

It is widely perceived that large cul-de-sac radii (upwards of 60 feet) allow fire trucks, emergency vehicles and service trucks to turnaround. An analysis of the actual turning radii for most vehicles suggests that most cul-de-sacs are wider than they really need to be (see Table 4.2).

Table 4.2: Perceived Impediments to Smaller Cul-de-sacs

Perception	Facts and Case Studies	
1. The need for adequate turning radii for school buses and maintenance and emergency vehicles requires large cul-de-sacs.	FACT:	Fire trucks with 30 - 40 foot turning radii are available (ULI, 1990).
	FACT:	Many newer large service vehicles are being made with tri-axles which allow for sharper turns. (Waste Management Inc, 1997)
	FACT:	Smaller minimum turnaround radius of 30 feet has been suggested by several organizations (ULI, 1990; NAHB, 1990).
	FACT:	School buses do not typically enter cul-de-sacs.
2. Homeowners like the "end of the road" appeal of cul-de-sacs.	FACT:	Loop roads can also provide end of road appeal while reducing impervious cover.
	FACT:	"End of the road" appeal can be accommodated in an open space development, particularly for lots that back onto open space areas.

Developers often add cul-de-sacs to their site designs because they feel that they provide premium lots. Some home buyers clearly do prefer lots on cul-de-sacs, attracted by the lower traffic and the end-of-the road appeal. However, home buyers exhibit an even greater preference for natural and open space and parks (see Table 4.3). Many of these premium development features can be easily incorporated into open space or cluster design.

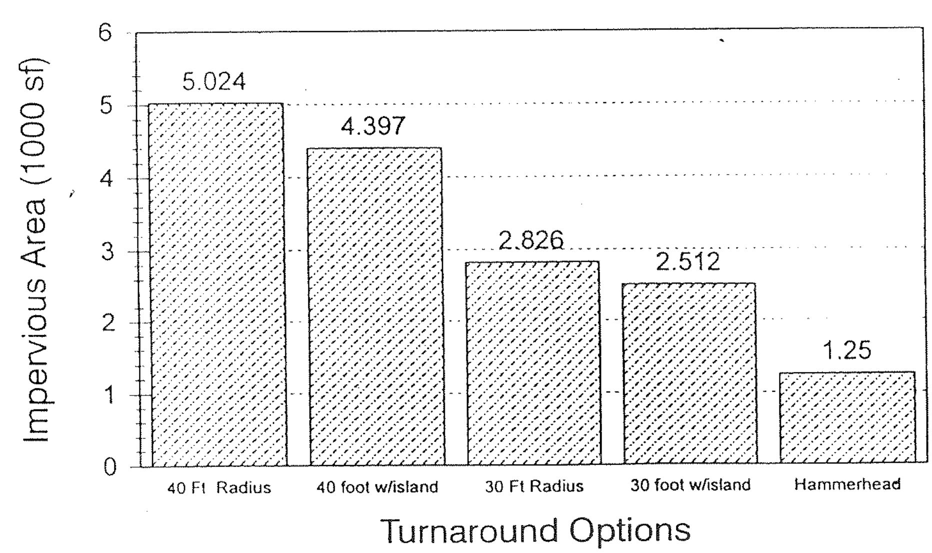
Table 4.3: Home Owner Preference for Proximity to Open Space Features (Source: Emmerling-DiNovo, 1995)

Open Space Feature	Mean Score
Adjacent to wet pond	4.44
Adjacent to natural area	4.27
On a cul-de-sac	3.83
Adjacent to golf course	3.67
Adjacent to public park	3.10
Adjacent to dry pond	2.05

CASE STUDIES

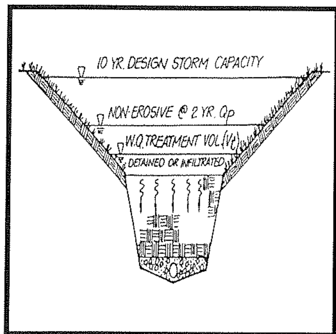
Several areas of the country have experimented with reducing the size and/or number of cul-de-sacs. As previously mentioned, the City of Portland (Oregon) has implemented smaller radii cul-de-sac turnarounds. Bucks County, Pennsylvania, has also reduced the size of residential cul-de-sacs. In North Carolina, the town of Carrboro recently passed an ordinance proposing that all roads should be interconnected when possible, and that cul-de-sacs should not be used unless the topography of the land makes a connecting road impractical (Raleigh News and Observer, 1997). In Middletown, Delaware, a "mobility-friendly" design initiative created by the Wilmington Area Planning Council (WILMAPCO) is being incorporated into a study of new standards that may lead to the region's first pedestrian-oriented planning model. One of the recommendations is to use short interconnected streets with direct routes and loops as opposed to cul-de-sacs (Taft, 1997).

Figure 4.2: Impervious Cover Created by Various Turnaround Options (Source: Schueler, 1995)



Where to Get Started

Suggested Resources	How to Get a Copy
Performance Streets: A Concept and Model Standards for Residential Streets (1980) by Bucks County Planning Commission. Presents model standards focusing on pedestrian as well as vehicular traffic and reducing overdesigned street networks.	Bucks County Planning Commission Route 611 and Almshouse Road Neshaminy Manor Center Doylestown, PA 18901 215-345-3400
Residential Streets (2nd Edition) Chapter 2 discusses design considerations and vehicle turning requirements for cul-de-sacs.	Urban Land Institute 1025 Thomas Jefferson Street, NW Washington, DC 20007 800-321-5011 Also available from the American society of Civil Engineers and the National Association of Home Builders
Rural by Design (1994) by Randall Arendt Chapter 11 discusses design alternative cul-de-sac design.	American Planning Association Planners Book Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344



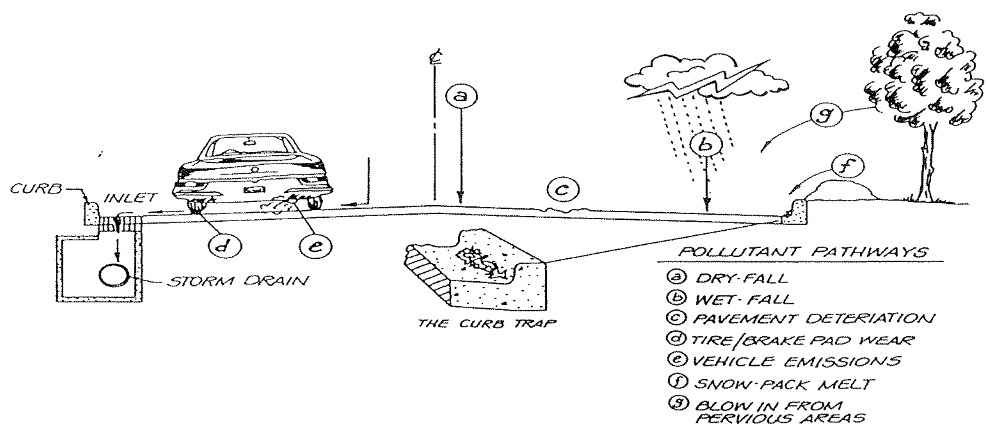
PRINCIPLE NO. 5

Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.

CURRENT PRACTICE

Streets contribute higher loads of pollutants to urban stormwater than any other source area in residential developments (Bannerman, et al., 1993 and Steuer, et al., 1997). The sources of pollutants to streets are numerous. Some examples are atmospheric deposition, vehicle emission, pavement deterioration, tire and brake pad wear, pet waste, lawn runoff, and blow in from adjacent pervious areas (Figure 5.1). Research in Michigan and Wisconsin has indicated that residential streets contribute a majority of the sediment, phosphorous, copper, zinc, and fecal coliform bacteria found in urban stormwater runoff (see Figure 5.2).

Figure 5.1: Stormwater Pollutant Pathways (Schueler, 1995)

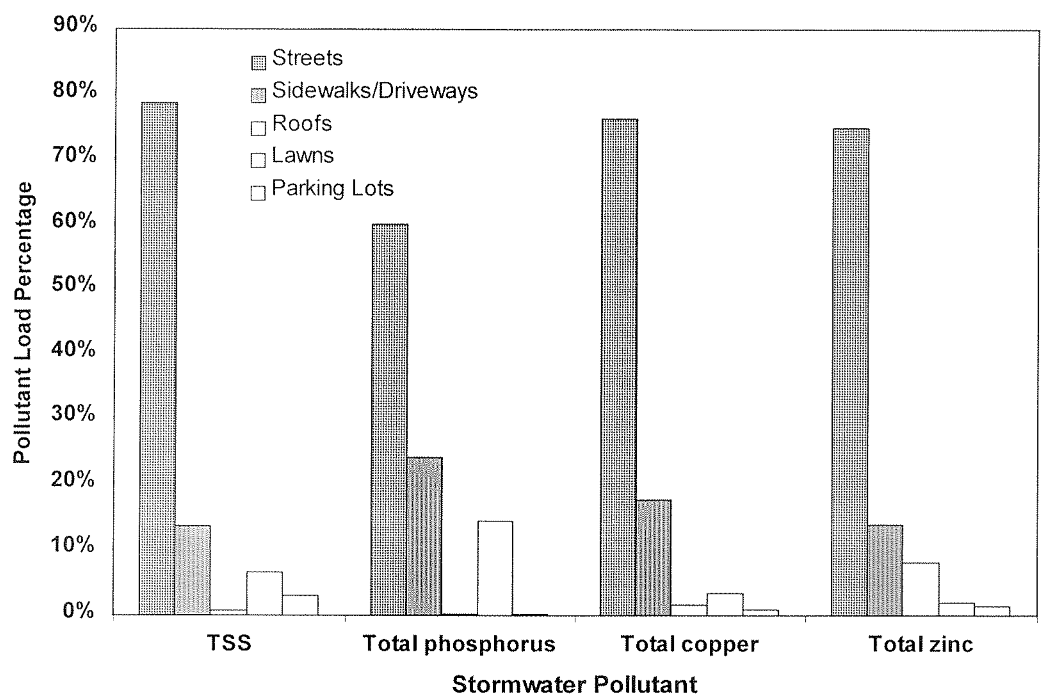


Streets provide several pathways for stormwater pollutants. Atmospheric pollutants settle or are washed onto the street during rain events (a, b). Pavement fragments also contribute to stormwater pollution (c). Vehicles contribute emissions and tire and brake pad particles (d, e). Snow collected at the street edge melts and contributes salts (f). Leaves and pollen from trees are blown into the street (g). Curb and gutter systems channel polluted stormwater directly into streams.

Most jurisdictions require that curb-and-gutter systems be installed along residential streets to convey stormwater runoff. Curb-and-gutter systems, however, provide no stormwater treatment and quickly discharge stormwater directly into streams. By contrast, open vegetated channels that could provide better treatment are usually discouraged or prohibited in many subdivision codes.

Public works agencies often favor curb and gutter over swales because they are easy to maintain, and eliminate many of the perceived problems associated with roadside ditches such as erosion, standing water, mosquitos, and break up of the road edge.

Figure 5.2: Key Pollutant Sources in Residential Areas (based on Bannerman and Dodd, 1992)



RECOMMENDED PRACTICE

The use of engineered swales should be encouraged in residential streets where soils, slope and housing density permit. These engineered swales are a far cry from the roadside ditches that have plagued public works officials in the past.

Unlike curb-and-gutter systems, which move stormwater with virtually no treatment, open vegetated channels remove pollutants by allowing infiltration and filtering to occur. Open channels also encourage groundwater recharge, and can reduce the volume of stormwater runoff generated from a site.

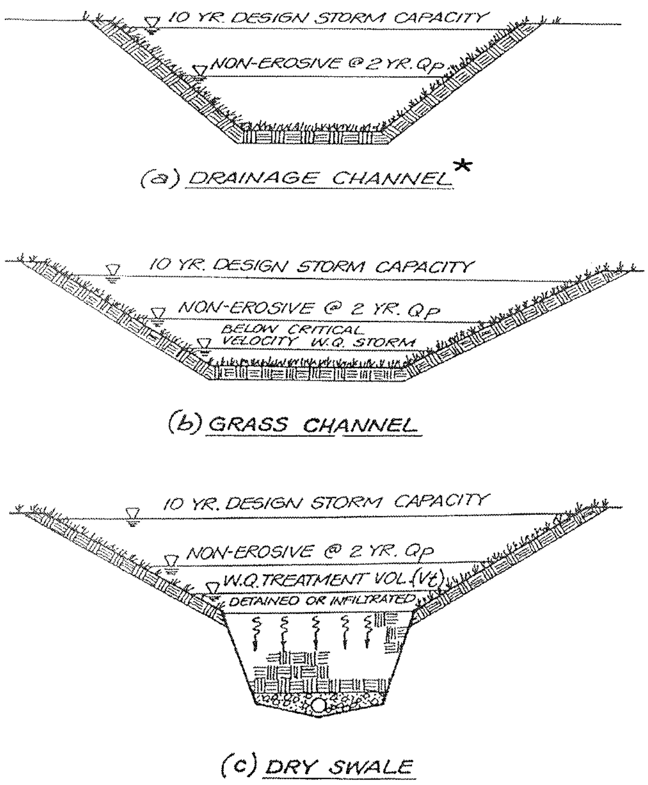
Types of Engineered Channels

There are two types of engineered channels that can be used for residential developments: grass channels and dry swales (see Figure 5.3). These channel designs differ primarily in bottom width, longitudinal and side slopes, and the underlying soil bed beneath the channel. The pollutant removal effectiveness of these channeling options is summarized in Table 5.1.

Grass Channels or Biofilters

Compared to roadside ditches, grass channels have a wider bottom, gentler slopes, and denser vegetation. They are designed to detain stormwater flows for ten to twenty minutes to allow sediments and heavy particles to filter out. Grass channels are relatively easy to construct and maintain. If applied under the right site conditions, and installed properly, grass channels experience few of the nuisance problems associated with roadside ditches.

Figure 5.3: Open Channel Options (Schueler, 1995)



*refers to roadside ditches

Dry Swales

Dry swales are essentially "engineered" grass channels that provide full treatment of stormwater pollutants. The dry swale design includes a layer of prepared sandy loam soil topped by dense turf. Runoff flows into the swale, depositing some of its sediment load as it flows through the dense vegetation. Water quality treatment is provided as the runoff infiltrates through the sandy loam layer. The treated runoff is collected in an underdrain pipe system and discharged into the downstream receiving waters or into a stormwater BMP for further treatment or attenuation. Because the swale is designed to dewater within a few hours after a storm, standing water and its other associated nuisance problems are generally not a concern.

Dry swales are a relatively new design and have only been applied in a few communities. Recent experience with dry swales in Carroll County, Maryland is very promising. Grass channels, on the other hand, have been in use for many years.

It should be noted that the feasibility of using engineered swales at a development site is determined by a number of factors, including drainage area, slope, length, housing density, and street type. In general, open channel systems are most appropriate for smaller drainage areas, mildly sloping topography, and housing density less than 4 dwelling units per acre.

Table 5.1: Pollutant Removal Capability of Open Channels (based on Brown and Schueler, 1997)

BMP	Pollutant Removal				
	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Metals	
Roadside ditch	30%	10%	- 0 -		
Grass channel	65%	25%	15%	hydrocarbons: metals: bacteria:	65% 20 - 50% negative
Dry swale	90%	65%	50%	metals:	80 - 90%

PERCEPTIONS AND REALITIES ABOUT OPEN CHANNELS

Most of the concerns regarding open channels (Table 5.2) focus on potential maintenance problems, impacts to pavement stability, and potential nuisance problems. These concerns, for the most part, can be addressed through the careful design and integration of open channels along residential streets.

Table 5.2: Perceived Impediments to Open Channels

Perception	Facts, Case Studies, and Challenges	
1. Increased maintenance of the shoulder and the open channel may be required.	FACT:	Maintenance requirements for grass channels are generally not excessive in comparison to maintenance requirements for curb-and-gutter systems. The major requirements are mowing of turf, removal of sediment build-up and debris, and periodic inspections.
	FACT:	Maintenance requirements for dry swales are similar to those for grass channels. The most significant additional requirements are replacement of filter beds and periodic replacement of the top layer. These maintenance requirements may be offset by savings associated with reduced curb-and-gutter construction, replacement, and maintenance costs.
2. Lack of curbing may increase the potential for failure of the road surface at the pavement/grass interface.	FACT:	Based on an informal survey of local public works officials, the potential for failure at the pavement/grass interface can be alleviated by "hardening" the pavement grass interface. For example, grass pavers or geo-synthetics can be placed beneath the grass immediately adjacent to the pavement to provide additional protection from structural failure. Other options include placement of a low rising concrete strip along the pavement edge.
3. Snow removal may be more difficult.	CHALLENGE:	Plow blades may scrape the edge of the pavement, making removal more challenging. On the plus slide, roadside swales increase snow storage at the road edge. Smaller snowplows are available.
4. Cars may be more likely to hit pedestrians due to the lack of curbing.	FACT:	In a study of over 3,826 pedestrian and car crashes, only 0.2% of the crashes were associated with low soft shoulders. Even when loose material shoulders are factored in, these crashes still represent less than 1% of all crashes (FHA, 1996).
	FACT:	Alternative road designs place the sidewalk on the far side of the swale, furthest from the road, thereby providing a barrier between pedestrians and cars.
5. Open channel BMPs may harbor pests and standing water may interfere with homeowners' ability to mow their front yards.	FACT:	The potential for snakes and other vermin can be minimized by more frequent mowing.
	FACT:	Grass channels are not designed to detain water for any appreciable length of time. Properly designed dry swales will drain within 24 hours, minimizing the potential for mosquitoes and interference with mowing.

Economic Benefits

Engineered swales are very attractive to developers because they are a much less expensive option for conveying stormwater than the curb and gutter/storm drain inlet and storm drain pipe system that they replace. The cost of a curb and gutter/storm drain pipe system typically ranges from $40 to $50 per running foot (SMBIA, 1990) which is about 2 to 3 times more expensive than an engineered swale.

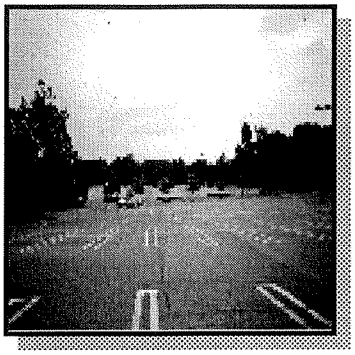
CASE STUDY: SARASOTA, FLORIDA

(Source: Ewing, 1996)

Environmentally sensitive site design techniques were used extensively in Palmer Ranch, a large (more than 10,000 acre) development southeast of Sarasota, Florida. Forty percent of the acreage in this development is preserved in a natural state. A key component of the site design was creation of an integrated stormwater conveyance and treatment system. This system incorporates open channel drainage and existing drainageways. This integrated approach included a vegetated swale as well as a restored creek that had been confined in a manmade channel. The swales were provided throughout the community wherever soils, water table elevation, and density permitted. This integrated approach has been cited as the chief reason that post-development nutrient and sediment loads are significantly less than pre-development loads.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Design of Stormwater Filtering Systems (1996) by Richard A. Claytor and Thomas R. Schueler Presents detailed engineering guidance on ten different stormwater filtering systems.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323
Biofiltration Swale Performance: Recommendations and Design Considerations (1992) by Washington Department of Ecology	Washington State Department of Ecology Olympia, WA 98507
Start at the Source (1997) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
Best Development Practices: Doing the Right Thing and Making Money at the Same Time (1996) by Reid Ewing Chapter 5 discusses open vegetated channels and other stormwater management options. Developments that use these options are highlighted.	American Planning Association Planners Book Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344



PRINCIPLE NO. 6

The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible.

CURRENT PRACTICE

A parking ratio is set by local communities and expresses the number of parking spaces that must be provided for a particular land use. It is typically stated as the number of spaces per square foot of building space, number of dwelling units (d.u.'s), persons, or seats. Parking ratios usually represent the minimum number of spaces needed to accommodate the highest hourly parking at the site (Wells, 1995). Parking demand refers to the number of spaces actually used for a particular land use (ITE 1987). Table 6.1 gives examples of conventional parking requirements and compares them to average parking demand.

Table 6.1: Conventional Minimum Parking Ratios (Source: ITE, 1987; Smith, 1984; Wells, 1994)

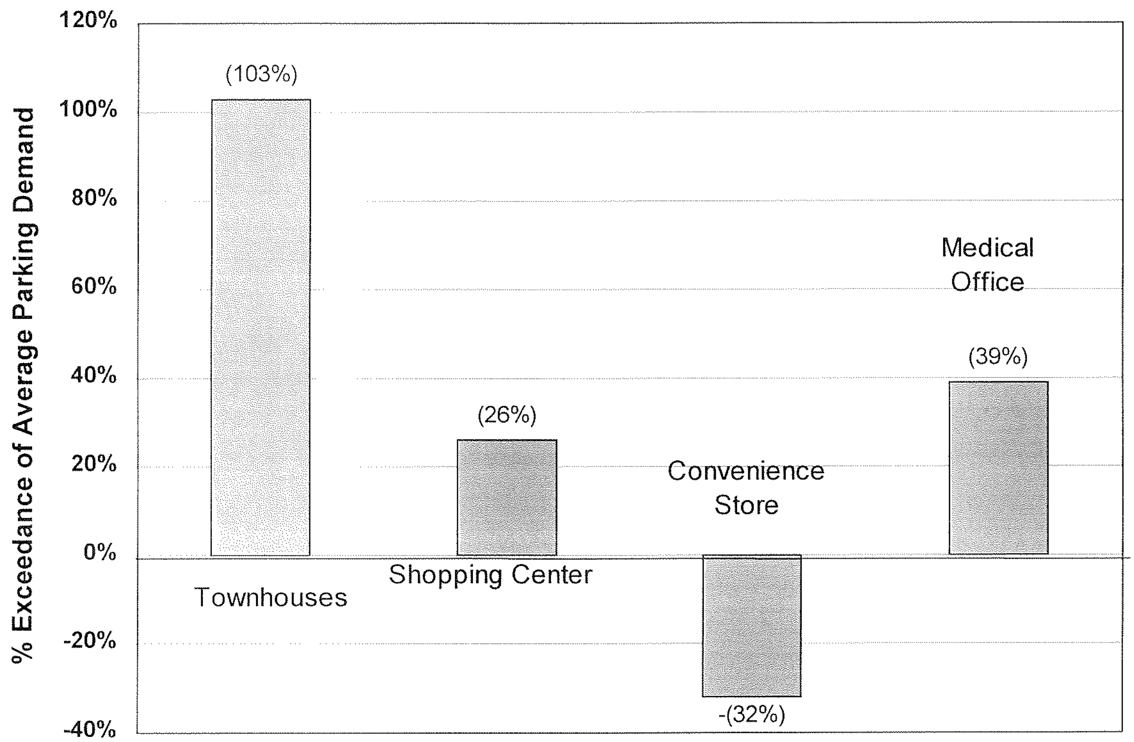
Land Use	Parking Requirement		Actual Average Parking Demand
	Parking Ratio	Typical Range	
Single family homes	2 spaces per dwelling unit (d.u.)	1.5 - 2.5	1.11 spaces per d.u.
Shopping center	5 spaces per 1000 ft^2 GFA[1]	4.0 - 6.5	3.97 per 1000 ft^2 GFA
Convenience store	3.3 spaces per 1000 ft^2 GFA	2.0 - 10.0	--
Industrial	1 space per 1000 ft^2 GFA	0.5 - 2.0	1.48 per 1000 ft^2 GFA
Medical/dental office	5.7 spaces per 1000 ft^2 GFA	4.5 - 10.0	4.11 per 1000 ft^2 GFA

[1]Abbreviated GFA and refers to the gross floor area of a building, without storage and utility spaces

Communities often determine minimum parking ratios by either adopting and modifying the requirements of neighboring communities or by using the Institute of Transportation Engineers informational publication. In many cases, these parking ratios result in far more spaces than are actually required. This occurs because ratios are typically set as minimums and not maximums. Therefore, builders and developers are free to provide excess parking. The excess parking is provided to prevent complaints from residents, employees, and customers regarding inadequate parking. Commercial landowners are particularly sensitive to this issue, reluctant to risk losing customers due to lack of parking. Further, loans for commercial development often require more parking spaces than are established by the local minimum parking ratio.

As a result, parking lots are often fully utilized only for a few hours each year. During off-peak periods, a significant portion of most parking spaces will be empty. Figure 6.1 illustrates the percentages of excess parking for different land uses.

Figure 6.1: Excess Parking Under Conventional Parking Requirements (Source: ITE, 1987; Morris, 1989; Smith, 1984)



RECOMMENDED PRACTICE

Communities should re-evaluate the parking demand ratios that they currently have in the books to make sure they are in line with national or regional averages. In addition, local surveys of actual parking lot utilization rates for a mix of common land uses or activities may be desirable as well. When combined with local experience, the data can often be used to modify, and hopefully lower, the parking demand ratios on the books.

Communities should also check their parking codes to make sure they clearly state that the parking ratios should be interpreted as the maximum possible number of spaces that can be built at a project, unless compelling data justify more parking spaces are actually needed (i.e., actual parking demand studies). In reevaluating their parking demand ratios, communities can benefit from conducting a local study or referring to national averages.

PERCEPTIONS AND REALITIES ABOUT PARKING

The major impediment to reduced parking ratios is the perception that more stringent parking ratios will lead to inadequate parking (Table 6.2). This in turn may lead to increased complaints from residents, employees, and customers. Research has indicated, however, that many parking ratios can be revised downward without significant impacts to parking availability.

Table 6.2 : Perceived Impediments to Reduced Parking Ratios

Perception	Facts, Case Studies, and Challenges	
1. Large retailers desire excess parking.	CHALLENGE:	Retailers do desire excess parking and many lending institutions also require excess parking.
2. Retailers fear loss of customers to competitors with more parking.	CHALLENGE:	The potential loss of customers due to reduced parking ratios is unknown.
3. There is a lack of research on parking demands for various land uses and activities.	FACT:	Parking demand for various land uses has been well documented. Many cities have conducted parking demand studies to determine the appropriate minimum, median, or maximum parking ratio requirements. The publication Parking Generation (ITE, 1987) documents actual parking demand for various land uses.
4. A lack of adequate parking may occur at peak parking demand times.	FACT:	Several studies have documented excess parking during peak periods. The City of Olympia recently surveyed 31 sites representing 15 land uses. Of these, 18 had less than 75% occupancy rates during their peak period (Wells, 1995).
5. Parking may spillover into residential or commercial areas when parking lots are full.	CHALLENGE:	Spillover parking into residential areas is a problem faced by many communities. Many have taken actions to reduce or prevent this problem, including preferential parking for residents, and enforcement of meter feeding and time limit codes.

ECONOMIC BENEFITS

To avoid the effects and costs of excess parking, ratios should be reexamined to reflect actual parking demand. Excess parking increases impervious cover and leads to greater construction and maintenance costs. Stormwater runoff also increases which leads to higher stormwater management costs. The costs associated with parking lot construction can be quite high. Costs per space range from $1,200 to $1,500 (Markowitz, 1995). For example, if a 50,000 ft^2 shopping mall is being considered and the maximum parking ratio is 5 spaces per 1000 ft^2 GFA, the total cost of constructing the parking lot could be as high as $337,500 (at $1,350 per space). When a more reasonable ratio of 3.97 spaces per 1000 ft^2 GFA is used, construction costs would be $268,650. This represents a savings of $68,850.

Case Study: Scarborough, Ontario

(Source: Smith, 1984)

A parking study was conducted at 14 office sites in Scarborough, Ontario to determine an appropriate parking ratio. A parking ratio of 3.5 spaces per 1000 square feet GFA was recommended. This ratio allowed adequate employee and visitor parking in sites that were not affected by parking demand factors (e.g., mass transit availability, large indoor storage areas, recreational facilities, and executive offices). The borough did not accept the recommendation and adopted their own lower standard of 3.0 spaces for 1000 square feet GFA. Experience with this standard has not resulted in any parking problems. In fact, to foster an even greater use of mass transit, Scarborough has since implemented an even lower requirement.

Where to Get Started

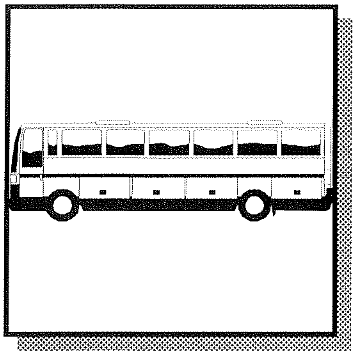
Suggested Resources	How to Get a Copy
Impervious Surface Reduction Study: Final Report (1995) by Cedar Wells Presents recommendations for pervious materials and shared parking. Based on results of study to identify strategies for reducing impervious surface in Olympia, Washington.	City of Olympia Public Works Department P.O. Box 1967 Olympia, WA 98507 360-753-8454
Parking Generation (1987) by Institute of Transportation Engineers Provides parking data for 64 land uses and discusses three methods for determining average parking occupancy of a land use or building.	Institute of Transportation Engineers 525 School Street, SW Suite 410 Washington, DC 20024-2797 202-554-8050
Flexible Parking Requirements (1984) by Thomas P. Smith Discusses local parking policies, flexible parking requirements, and case studies of parking demand for four land uses.	American Planning Association Planning Advisory Service 122 S. Michigan Avenue Suite 1600 Chicago, IL 60603 312-786-6344 Report No. 377

Suggested Resources

Site Planning for Urban Stream Protection (1995)
by Thomas R. Schueler
Chapter 7 discusses downsizing parking areas, impervious cover associated with various parking ratios, and local experience with parking codes.

How to Get a Copy

Center for Watershed Protection
8391 Main Street
Ellicott City, MD 21043
410-461-8323



PRINCIPLE NO. 7

Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.

CURRENT PRACTICE

Parking demand represents the actual number of parking spaces required to accommodate the parking needs of a particular land use. It is typically based on average parking requirements. Depending on site conditions (i.e., proximity to mass transit or mix of land uses), it may be possible to reduce the number of parking spaces needed. When site conditions are appropriate, communities could actively encourage developers to reduce the number of parking spaces constructed.

Mass transit can lower parking demand directly by reducing the number of vehicles driven, and, therefore, vehicles parked. Further, mass transit is a key strategy for reducing traffic congestion and air pollution. Encouraging car users to switch to mass transit has not been easy, as seen in the decline of the market share (i.e., share as a percent of all ridership) in transit ridership from 3% of all trips to only 2% from 1980 to 1992 (Schulz, 1994). Still, there are some communities where mass transit ridership is strong, and the amount of parking provided could be reduced. Only a handful of communities, however, require or even encourage developers to reduce the number of parking spaces built when mass transit is readily available.

Shared parking is a strategy that reduces the number of parking spaces needed by allowing adjacent land uses to share parking lots. This arrangement is possible when peak parking demands occur at different times during the day or week. Only a few communities, however, have actively encouraged shared parking arrangements, and individual businesses are often hesitant to employ it as an option.

RECOMMENDED PRACTICE

Mass Transit Credits

Mass transit can lower parking demand by reducing the number of cars entering (and parking in) commercial and business districts. To alleviate the increasing demand for parking spaces, local governments should reduce parking ratios to account for mass transit present at a site.

Some communities have successfully encouraged mass transit use. In Bellevue, Washington, there has been an increase in transit ridership from 4% in 1980 to 11% in 1992. This increase corresponded with the implementation of a maximum parking ratio for office use; an increase in transit service, the development of a transit center, the addition of urban HOV lanes, and an increase in parking prices (Federal Transit Administration, 1997). In Seattle, Washington the transit share downtown is 45%. Transit share is defined as the percentage of trips using a particular mode of travel. Seattle has instituted a maximum requirement of 1 parking space per 1,000 square feet, imposed requirements on developers to encourage transit, and improved transit service in the downtown area (Federal Transit Administration, 1997).

Shared Parking Credits

Shared parking arrangements can significantly reduce the area needed for parking, but this option is not widely used in most communities. Although shared parking arrangements can be difficult to implement, they have been successfully used in many cities across the country. For shared parking to operate successfully, the participating facilities should be in close proximity to each other and should have different peak operating times on a daily, weekly, monthly, or seasonal basis. Examples of facilities with different daily peak hours are presented in Table 7.1. Required parking in shared facilities is typically based on the land use with the highest parking demand.

When shared parking is implemented with an accompanying reduction in required parking, developers can

Table 7.1: Land Uses with Different Peak Daily Operating Hours

Land Uses with Daytime Peak Hours	Land Uses with Evening Peak Hours
Banks	Bowling Alleys
Business Offices	Hotels (without conference facilities)
Professional Offices	Theaters
Medical Clinics	Restaurants
Service Stores	Bars
Retail Stores	Night clubs
Manufacturer/Wholesale	Auditoriums
Grade Schools/High Schools	Meeting Halls

recognize a substantial cost savings by building fewer parking spaces. Other potential benefits and drawbacks associated with shared parking are presented in Table 7.2.

Communities need to actively promote shared parking, make it easy to implement, and offer real reductions in parking ratios. Surprisingly, some communities that use shared parking do not require a corresponding reduction in parking spaces. Instead, the number of required parking spaces in the shared lot is calculated as the sum of the parking needed during the peak demand time for each individual land use, which translates to no net reduction in parking lot area and no reduction in total impervious cover.

Table 7.2: Pros and Cons of Shared Parking

Pros of Shared Parking	Cons of Shared Parking
Reduced impervious cover Reduced construction and maintenance costs for parking lots Increased land available for tax revenue-generating purposes Increased attractiveness of city-scape Increased ability for developers to complete projects that otherwise would have been denied due to insufficient parking	Possible shortage of parking if land ownership and/or land uses change Parking cannot be reserved for 24 hours for a particular use Potential difficulty in dealing with multiple developers Developers' perceptions that large parking lots are a necessity

Perceptions and Realities about Transit Use and Shared Parking

There are significant challenges to increasing mass transit usage and implementing shared parking arrangements (Table 7.3). However, as congestion becomes more of a problem, many communities, including Charlotte, North Carolina; Washington, DC; and Los Angeles, California; are beginning to re-examine mass transit options. Shared parking arrangements are currently being examined by the Institute of Traffic Engineers and have been used with some success in several communities including Niles, Illinois; Rockville, Maryland; and Pasadena, California (ITE, 1995). A model shared parking agreement can be found Appendix B.

Table 7.3: Perceived Impediments to Mass Transit and Shared Parking

Perception	Facts, Case Studies, Challenges	
1. There is a lack of widespread acceptance and use of mass transit in many areas.	CHALLENGES:	In many areas of the country the transit system is geared towards the car, and mass transit is not commonly used or available.
	CASE STUDIES:	Incentive programs can be used to encourage use of mass transit. Montgomery County, Maryland subsidizes monthly transit passes on the MARC rail and Metro public transit systems for its employees.
2. Shared parking arrangements are difficult to implement.	CHALLENGES:	Shared parking arrangements can be difficult to implement, but may yield potentially significant environmental benefits, construction cost savings, and aesthetic improvements (see Table 7.2).

Case Studies

Many communities allow a reduction in required parking in conjunction with mass transit. Examples are presented in Table 7.4. Model shared parking ordinance provisions can be found in Appendix A.

Table 7.4: Sample of Communities that Reduce Required Parking in Conjunction with Mass Transit

Community	Description of Program
Olympia, WA	Allows reduction in required parking in concert with public transportation
Loudoun County, VA	Allows a reduction of up to 20% of the required parking for any use, building or complex within 1,000 feet of any regularly scheduled bus stop
Chicago, IL	Offers reduction in required parking for buildings connected to underground transit stations[1]
Hartford, CT	Reduces minimum required parking in return for developer carpool and transit encouragements)[1]
Montgomery County, MD	Reduces minimum parking requirements in proximity to rail stations [1]
Phoenix, AZ	Allows relaxations in proximity to bus transit [1]
Orlando, FL	Allows payments which support a transportation management program in-lieu of on-site parking [1]

[1]Source: Federal Transit Administration, 1997

The City of Olympia, Washington requires applicants to provide proof that shared parking is infeasible when adjacent land uses have different hours of operation. Mixed use and shopping center developments with similar operating hours may also be required to submit a parking demand study to determine if parking can be combined. Additional shared parking case studies are presented in the document "Shared Parking Planning Guidelines," an informational report of the Institute of Transportation Engineers. The studies presented include the following:

Location	Land Use
414 Hungerford Drive, Rockville, MD	Office/retail/restaurant in suburban commercial center
Brown's Wharf Parking Study, Baltimore, MD	Retail/restaurant/office/marina in a highly urbanized, tourist-oriented environment
Pasadena Towers, Pasadena, CA	Retail/office/bank
Concourse Project, Skokie, IL	Hotel/restaurant/office
Downtown Mountain View, CA	Primarily restaurant/retail in a low-to-moderate density suburban commercial business district (CBD)
Yorkdale Shopping Center Expansion/Rail Station Parking, Toronto Metropolitan Area (North York), Ontario	Regional retail center expansion and rapid transit station
Simpsons Galleria (Bay-Adelaide Centre), Toronto CBD, Ontario	Retail/office

Case Study: Downtown Oakland, California

(Source: ITE, 1995)

The shared parking concept is essential for a city like Oakland because it furnishes much of the parking for its commercial areas. Providing adequate, convenient parking in these areas is very important in reducing parking problems in residential areas. Zoning regulations specifically incorporate heavier mass transit use and walk-in clientele.

A thorough study of short- and long-term parking demand was performed that included an inventory of existing land uses, a parking inventory, and an occupancy study. Parking rates were redesigned to reflect such variables as, vacancy factors, mass transit access, low auto ownership per household, and operations of special use facilities like the convention center. The study concluded that the parking rate for office space could be reduced from 3 spaces to 1.44 spaces per 1000 GSF.

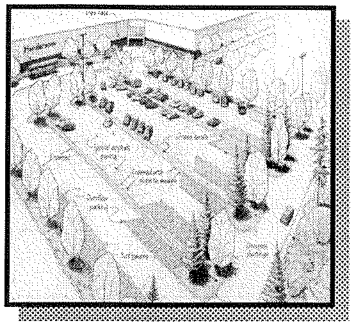
Oakland's experience provided several worthwhile lessons. Shared parking can work very well in urban areas because parking needs often vary over the course of a day. The costs of constructing additional parking facilities can make shared parking a very attractive alternative. Also, the financial burdens of shared facilities can be distributed through assessments among more businesses over a longer time frame. Shared parking should be applied on a block-by-block basis and should include on-street spaces. This is because overflow from a shared parking facility can effect parking availability on adjacent streets. While the overflow could be problematic, it is useful in determining an appropriate size and location for a shared use facility.

The study also concluded that a shared parking facility located within 1000 feet of a subway station in the heavily urbanized downtown Oakland area could reduce parking generation by up to 40% for offices, 75% for retail, 58% for residential, and 72% for hotel.

Where to Get Started

Suggested Resources	How to Get a Copy
Shared Parking Planning Guidelines (1995) by Institute of Transportation Engineers Discusses shared parking issues and guidelines, including detailed case studies and results of local government survey.	Institute of Transportation Engineers 525 School Street, S.W., Suite 410 Washington, DC 20024-2797 202-554-8050
Parking Supply Management (1997) by Federal Transit Administration Discusses mass transit use and its relationship to reduction in required parking through case studies of several communities.	Web address: http://www.fta.dot.gov/fta/library/planning/tdmstatus/FTARPKSP.HTM.

Suggested Resources	How to Get a Copy
Impervious Surface Reduction Study: Final Report (1995) by Cedar Wells Presents recommendations for pervious materials and shared parking. Based on results of study to identify strategies for reducing impervious surface in Olympia, Washington.	City of Olympia Public Works Department P.O. Box 1967 Olympia, WA 98507 360-753-8454



Source: *Wells 1995*

PRINCIPLE NO. 8

Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas.

CURRENT PRACTICE

The size of a parking lot is driven by stall geometry, lot layout, and, as discussed in Principle No. 6, parking ratios. A parking space is composed of five impervious components, of which the stall is only one part. The five components include:

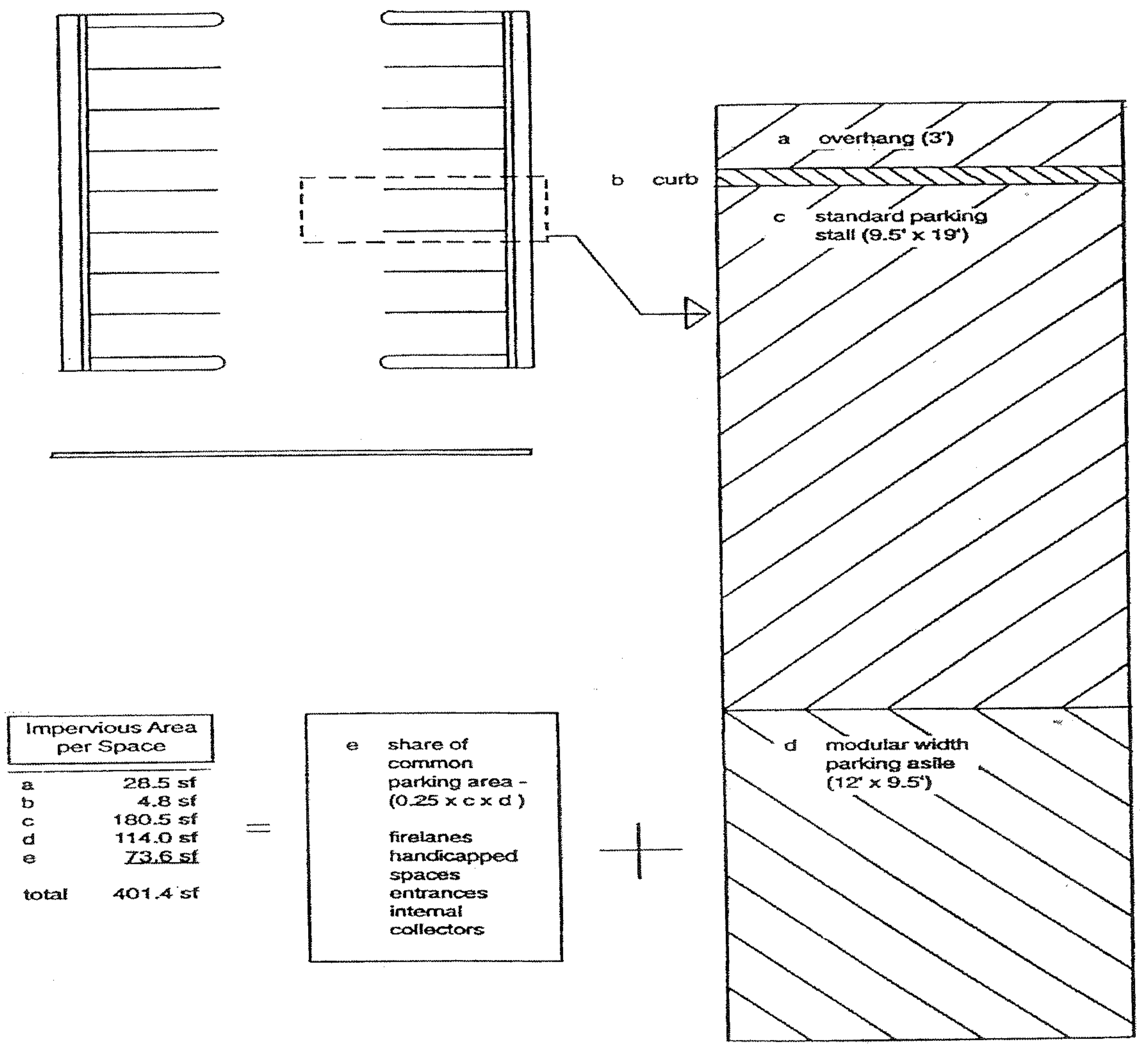
- the overhang at the edge of the stall (beyond the car)
- a narrow curb (or curb stop);
- the parking stall;
- the parking aisle that allows access to the stall; and
- a share of the common impervious area (e.g., fire lanes, entrances, and traffic lanes).

The impervious area associated with each parking space is more than double the area of an individual stall (see Figure 8.1). In most local parking codes, stall size can range from 162 to 185 square feet–often 10 feet wide and 19 feet long.

Another component of lot layout is the internal geometry or traffic pattern. Two-way traffic aisles require greater widths than one-way aisles. One-way aisles used in conjunction with angled parking stalls can significantly reduce the overall size of the parking lot.

Parking lots are the largest component of impervious cover in most commercial and industrial zones, but conventional design practices do little to reduce the paved area in parking lots. For example, many parking codes require a standard parking stall dimension that is geared to larger vehicles. Communities seldom allow smaller parking spaces that can handle compact cars, despite the fact that these smaller cars comprise 40 to 50% of all cars on the road (ITE, 1994a). In addition, local construction specifications for parking lots specify an impermeable asphalt or concrete surface. Use of more permeable surfaces, such as grass pavers and porous concrete, is usually frowned upon by reviewing authorities. Most parking codes also do not distinguish between regular parking areas that are used most of the time and spillover parking, which is used for a few days per year. Spillover parking areas are often the best locations to use more permeable paving options.

Figure 8.1: The total impervious area needed to support a single parking stall.



A parking stall is supported by a larger parking space that includes the (a) overhang, (b) curb, (c) stall, (d) parking aisle needed to get into the stall, and (e) the stall's share of common parking area, such as entrances, internal collectors, fire lanes and handicapped parking spaces. When these extra features are added in, the approximately 180 ft^2 needed for each parking stall increases to over 400 square feet.

Recommended Practice

The amount of impervious cover created by parking lots can be reduced in three basic ways. Communities should first evaluate whether their standard parking stall dimensions are too spacious, and if so, consider shaving six inches or a foot off of their length and width. Second, communities may wish to amend their parking codes to require that a fixed percentage of all parking stalls (e.g., 15 to 35%) be dedicated for compact cars; with correspondingly smaller stall dimensions. Compact parking stalls create up to 30% less impervious cover than stalls for larger cars. Increasing the percentage of compact car parking stalls can lead to smaller parking lots, less impervious cover, and reduced construction and maintenance costs.

Third, communities may want to require designation of spillover parking areas for larger parking lots and promote the use of alternative paving materials in these areas. Pervious materials such as permeable pavement, grass pavers, grass and gravel, are usually less durable than traditional paving materials, and are appropriate for less traveled spillover parking areas. Pervious paving materials can infiltrate stormwater runoff while simultaneously providing a stable travel pathway.

Perceptions and Realities about Parking Lots

There are impediments to changing the way parking lots are constructed. First, there is a perception that today's cars and trucks won't fit into smaller parking stalls. Second, there is a reluctance to use pervious materials due to expense, potential conflicts with the Americans With Disabilities Act, uncertainties about long-term performance and durability. These impediments are summarized in Table 8.1 and are further addressed in the following discussion.

Are Larger Stalls Needed for Sport Utility Vehicles?

One argument against making parking stalls smaller is that today's consumers are buying larger vehicles – in particular, sport utility vehicles (SUVs), mini-vans, and 4 x 4 trucks. Since 1970, SUV sales have climbed by 47% in the U.S., and presently account for about 25% of the sales of the big-three auto makers (AAMA, 1997). It is important to keep in mind that most SUV's are less than 7 feet wide and can comfortably fit into a standard space. With a few exceptions, most of the size of SUV is vertical – they stand taller than sedans, but are often not much wider or longer than a full-size car. In fact, many SUV models are actually smaller than a typical car (e.g., Jeep Wranglers).

Alternative Paving Issues

Alternative paving materials can make sense in many parking lot designs, but accessibility, site conditions, and long-term performance need to be carefully considered.

Accessibility

In general, conventional paving material should be used in handicapped parking areas and on public pathways such as sidewalks to ensure a smooth surface for travel. Note that the City of

Olympia has found that UNI Eco-Stone, an alternative pavement option, does comply with the ADA (Wells, 1997), providing a uniform travel surface.

Table 8.1: Perceived Impediments To Reduced Parking Lot Imperviousness

Perception	Facts, Case Studies, and Challenges	
1. Existing stall sizes are already too small for the largest cars.	CHALLENGE:	There is an increasing trend towards larger sport utility vehicles (SUVs).
	FACT:	Many SUVs are actually small cars (e.g., Jeep Wranglers, Suzuki Sidekick, Toyota Rav4).
	FACT:	Stall width requirements in most local parking codes are much larger than the widest SUVs.[1]
2. Alternative paving is expensive.	FACT:	Yes, but long term costs savings may be achieved. Less imperviousness may reduce the need for stormwater management or eliminate the need for curb and gutter.
3. Alternative paving may not comply with ADA.	FACT:	Alternative paving materials that do not conflict with the ADA are available.
	FACT:	Alternative paving is recommended for spillover parking only. ADA compliant parking spaces typically will be placed near the building in the permanent parking area paved with traditional materials.
4. Alternative paving performance is uncertain.	CHALLENGE:	The performance of alternative pavements (other than porous pavement) is not well documented.

[1]One of the largest SUVs, the Ford Expedition, is 6'7" wide; most local codes set parking stall width as high as 9.5'

Site Conditions

The most successful installations of alternative pavements are found in coastal areas where slopes are flat, sandy soils are present, and winter sanding and salting are minimal (BASMAA, 1997). However, in coastal areas with very coarse sands, infiltration through the pavement may be too rapid to allow adequate water quality treatment. In these cases, the pavement may need to be augmented with a peat liner to enhance water quality treatment (Cahill, 1994). On the other hand, pervious pavement will not work if existing soil conditions do not allow for minimum necessary rates of infiltration (0.5 inches per hour or more).

Pervious pavement has been successfully applied in cold climates but is only recommended for spillover parking. In addition, sand causes clogging and should be completely eliminated as a method for handling snow or ice.

Performance

The performance of alternative paving materials is dependent upon proper installation and maintenance. For example, tests by the Florida Concrete and Products Association show the permeability of new pervious concrete surfaces as high as 56"/hr with proper installation. With improper installation, permeability is reduced to 12"/hr (BASMAA, 1997).

Some common causes of pavement failure include:

- Lack of erosion and sediment control during construction;
- Compaction of the subsoils during construction;
- Clogging due to sand used to deice in the winter;

- Fine silt particles pass through the pavement and settle in the underlying bed, reducing infiltration capability over time;
- Damage by snow plows (plow blades may catch the edge of individual blocks);
- Placement of alternative pavement on impermeable layer; and
- Poor geotechnical testing or engineering design (improper soils/ infiltration rate).

Issues related to cost and the relative effectiveness in meeting water quality goals are summarized in the Table 8.2.

Table 8.2: Summary of Issues Related to Various Types of Alternative Pavements, based on BASMAA (1997)

Material	Initial Cost	Maintenance Cost	Water Quality Effectiveness*
Conventional Asphalt / Concrete	Medium	Low	Low
Pervious Concrete	High	High	High
Porous Asphalt	High	High	High
Turf Block	Medium	High	High
Brick	High	Medium	Medium
Natural Stone	High	Medium	Medium
Concrete Unit Pavers	Medium	Medium	Medium
Gravel	Low	Medium	High
Wood Mulch	Low	Medium	High
Cobbles	Low	Medium	Medium

* Relative effectiveness in meeting stormwater quality goals

Economic Benefits

Construction costs for pervious pavements are generally greater than those for conventional pavements (see Table 8.3). Construction cost savings due to reduced curb and gutter and reduced stormwater management requirements may offset this initial cost difference. Similarly, reduced storm sewer and stormwater management facility maintenance requirements may offset the generally greater maintenance requirements associated with pervious pavement. For example, the City of Olympia "paved" an overflow parking lot at Olympia High School with Geoweb (a geotextile usually planted with grass). The Geoweb cost $60.50/yd^2$; conventional paving would have cost approximately $48/yd^2$. The Geoweb cost, however, included the cost of constructing an infiltration trench, in lieu of a retention pond (Runoff Report, 1997).

Table 8.3: Costs of Various Types of Permeable Pavements

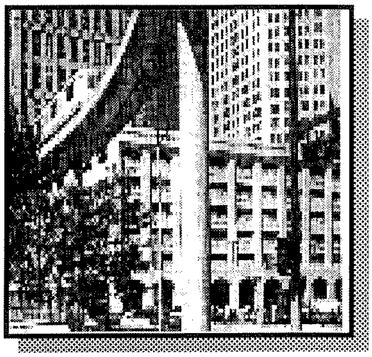
Product	Manufacturer	Cost per square foot*
Asphalt	Various	$0.50 - $1
Geoweb	Presto Products, Inc.	$1 - $2
Grasspave^{2}™, Gravelpave^{2}™	Invisible Structures, Inc.	$1 - $2
GRASSY™ PAVERS	RK Manufacturing	$1 - $2
Geoblock	Presto Products	$2 - $3
Checkerblock	Hastings Pavement Co.	$3 - $4
Grasscrete	Bomanite Corp.	$3 - $4
Turfstone	Westcon Pavers	$2 - $3
UNI Eco-Stone	Concrete Paving Stones	$2 - $3

This table was adopted from the table "Summary Characteristics of Widely Available Permeable Pavement Systems" in Booth et. al., 1997.

* Includes material cost, typical shipping and installation on a fully prepared base course. Does not include cost of gravel or soil and grass fill, or labor. These costs add approximately $0.10 to $0.25 per square foot.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Start at the Source (1997) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
The University of Washington Permeable Pavement Demonstration Project (1997) by Derek B. Booth, Jennifer Leavitt, Kim Peterson Reviews and provides information on types and characteristics of permeable pavements.	**Parking Supply Management** (1997) by Federal Transit Administration Discusses mass transit use and its relationship to reduction in required parking through case studies of several communities.



Source: *ULI 1997*

Principle No. 9

Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.

Current Practice

Most communities do not specify the type of parking structure to be built (e.g., surface lot or parking garage). The type of parking facility constructed in a given area is a reflection of the cost of land and construction expenses. In suburban and rural areas where land is relatively inexpensive, surface parking costs much less than a parking garage. However, in highly urban areas, garages may be more economical to build than purchasing additional land.

ITE (1994a) discussed the influence of land cost on parking facility development. Where land is abundant and inexpensive, surface lots are usually built. In areas with higher land costs, multi-deck garages may be more economical per car space than open lots. For sites limited by size or extremely high land prices such as downtown business districts, combination facilities with vertically mixed land uses may be the most feasible.

Recommended Practice

Vertical parking structures can significantly reduce impervious cover by reducing acreage converted for parking. Given the economics of parking lots, however, it is not likely that developers will be willing to build a parking garage when a surface parking lot would be cheaper. Local governments should consider using incentives to encourage the building of multi-level, underground, and under-the-building parking garages. Incentives for defraying some of the costs of parking structures could come in the form of tax credits; stormwater waivers; or density, floor area, or height bonuses.

One way that developers can eliminate land expenses is by incorporating parking into a multipurpose building. The parking is located above or below a ground floor level of retail establishments, with additional floors containing offices, hotels, or apartments. This reduces the land cost chargeable to parking (ITE ,1994a). Lastly, communities should practice what they preach and use garages where feasible in the many parking areas they administer.

Perceptions and Realities about Structured Parking

The strongest impediment to structured parking is the high cost associated with construction of parking garages. The construction costs of vertical parking structures are significantly higher than of surface lots. ITE (1994a) pointed out that for a typical site, construction of an above-ground garage may be four times the cost per space in a surface lot. Construction costs for a parking garage can range from $7,500 to

$20,000 per parking space, whereas a surface lot averages $1,200 to $1,500 per space (Markowitz, 1995; IPI, 1997). Underground facilities are even more expensive, with an average cost of $35,000 per space (Markowitz, 1995). ITE (1994a) calculated that an underground parking facility is an additional 1.5 to 2 times per space cost compared to an above-ground structure. Table 9.1 discusses the impediments to structured parking.

Table 9.1 Perceived Impediments to Parking Structures

Perception	Reality	
1. Garages cost more to construct than surface lots.	FACT:	Traditional parking garages do cost more to construct (see above). Alternatives for establishing parking facilities could include eliminating land costs by building in air rights above or below another use or by incorporating parking into multipurpose buildings (ITE, 1994a)[1].
	FACT:	Recent investigation into innovative parking structures built with pre-fabricated steel components has shown that the construction and maintenance costs could be competitive with the cost of surface lots (Hardigg, 1998).
2. Garages are more crime ridden than surface lots.	FACT:	There is no unbiased data at this time to deny or support this perception.

[1] Air rights refer to the area above a structure where development may take place.

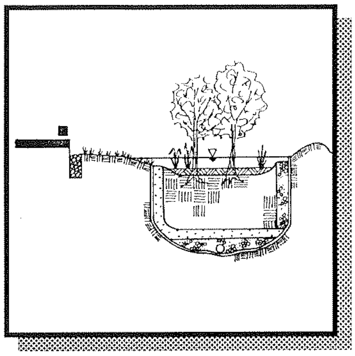
Case Study: Olympia, Washington

(Source: Wells, 1995)

The City of Olympia has proposed a comprehensive plan that supports the redevelopment of surface parking lots in commercial districts. According to the draft requirements, surface parking lots will be slated for more intensive use and allowable building heights will be increased if parking is incorporated into the structure. In one commercial zone, for example, one story may be added if at least 50% of the parking is under the building. This is a unique way to simultaneously reduce imperviousness while providing convenient parking areas.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Guidelines for Parking Facility Location and Design (1994) by Institute of Transportation Engineers. Detailed discussion of surface, structured, and handicapped parking design, including discussion of driveways.	Institute of Transportation Engineers 525 School Street, SW Suite 410 Washington, DC 20024-2797 202-554-8050
Impervious Surface Reduction Study: Final Report (1995) by Cedar Wells Presents recommendations for pervious materials and shared parking. Based on results of study to identify strategies for reducing impervious surface in Olympia, Washington.	City of Olympia Public Works Department P.O. Box 1967 Olympia, WA 98507 360-753-8454
Shared Parking Planning Guidelines (1995) by Institute of Transportation Engineers Discusses shared parking issues and guidelines, including detailed case studies and results of local government survey.	Institute of Transportation Engineers 525 School Street, S.W., Suite 410 Washington, DC 20024-2797 202-554-8050



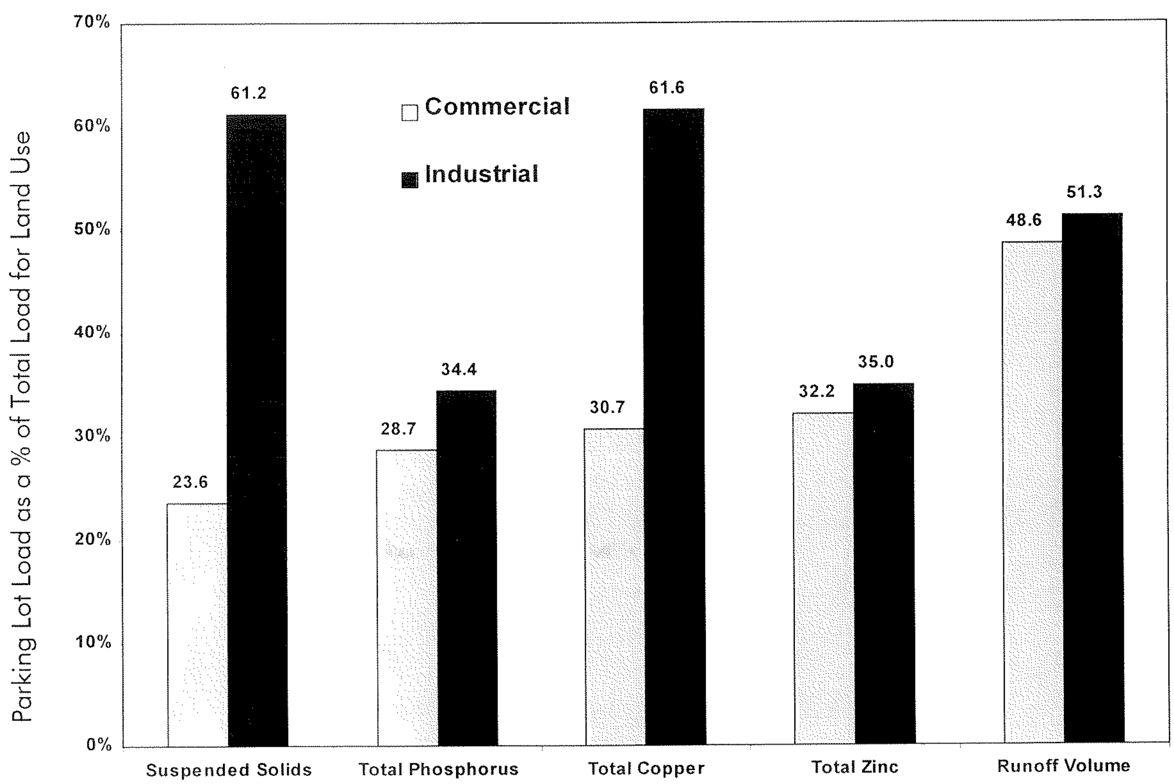
PRINCIPLE NO. 10

Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

CURRENT PRACTICE

Parking lots are a significant source of stormwater pollutants in the suburban landscape, particularly lots in commercial areas. These large impervious areas also generate a significant volume of runoff. Vehicle wear and tear, emissions and leakage, and atmospheric deposition are the key pollutant sources. Parking lots are almost completely impervious, so much of the pollutants deposited on the lot surface will be washed off by stormwater runoff.

Figure 10.1: Percent of Stormwater Pollutant Load and Stormwater Runoff Volume Attributable to Parking Lots by Land Use for Various Stormwater Pollutants (Based on Bannerman et al. 1992)



Bannerman (1992) documented the significance of parking lot runoff. His study showed that for commercial and particularly industrial land uses, parking lots are a critical source of stormwater pollution (Figure 10.1). In fact, parking lot runoff accounted for approximately one-fourth to two-thirds of the suspended solids, total phosphorus, total copper, and total zinc loads in the commercial and industrial areas studied.

Although parking lots are a significant source of stormwater pollution, many communities do not require developers to provide stormwater quality control. In addition, opportunities to minimize the amount of stormwater runoff generated or to manage runoff are often overlooked.

Recommended Practice

There are several techniques that communities can use to reduce the volume of stormwater generated at parking lots. These include:

- reducing minimum parking requirements to allow smaller lots to be built (see Principle No. 6);
- allowing developers to use pervious materials for spillover parking (see Principle No. 8); and
- promoting the use of parking garages which expose less impervious cover to rainfall (see Principle No. 9).

Another option is to require onsite stormwater management. Existing landscape areas in parking lots can be used to provide some stormwater management. Many communities already require developers to landscape parking lot islands. Typically, the landscaping is used to enhance the appearance of a parking lot or to visually separate land uses or development. These areas often account for 10 - 15% of the total parking lot surface area (see Table 10.1).

Table 10.1: Parking Lot Landscape Requirements for Various Communities

Jurisdiction	Requirements
Portland, Oregon	• Landscaping required in building and street setbacks (typically 5 - 10 feet in width) • Landscaping primarily consists of ground cover plants and a mixture of trees, high shrubs, and low shrubs
St. Tammany Parish, Louisiana	• Two trees must be provided for every eight (8) parking spaces (excluding commercial parking garages and multi-level parking)
James City County, Virginia	• Landscaping required for off-street parking areas containing ten or more parking spaces. • Existing trees must be preserved (as feasible) • Landscaped areas must account for at least 10% of the parking lot surface area • At least one tree and two shrubs must be provided for every five parking spaces
Colleton County, South Carolina	• Landscaping required for lots containing 20 or more parking spaces • Ten percent of the lot must be landscaped • Natural vegetation must be preserved

These landscaped areas can be used for stormwater management. There are several options, including:

- bioretention facilities
- dry swales
- perimeter sand filters
- filter strips

Bioretention Facilities

This technique uses planting strips to provide stormwater management (Figure 10.2). Runoff is directed into a shallow, landscaped area and temporarily detained. The runoff then filters down through the bed of the facility and is either infiltrated into the subsurface or collected in an underdrain pipe for discharge into another stormwater management facility or into a stream. Bioretention facilities can be attractively integrated into landscaped areas and can be maintained by commercial landscaping firms. The vegetation recommended for use in bioretention facilities is generally hardier than the species typically used in parking lot landscapes. This is a particular advantage in urban areas where plants often fare poorly due to poor soils and air pollution.

Figure 10.2: Bioretention Area (Prince Georges County, Maryland)

Bioretention encourages treatment of stormwater runoff at the source, before the runoff enters the stream system. Other advantages include:

- Can be used for snow storage during the winter season.
- Requires relatively little engineering design in comparison to other stormwater management facilities (e.g., sand filters);

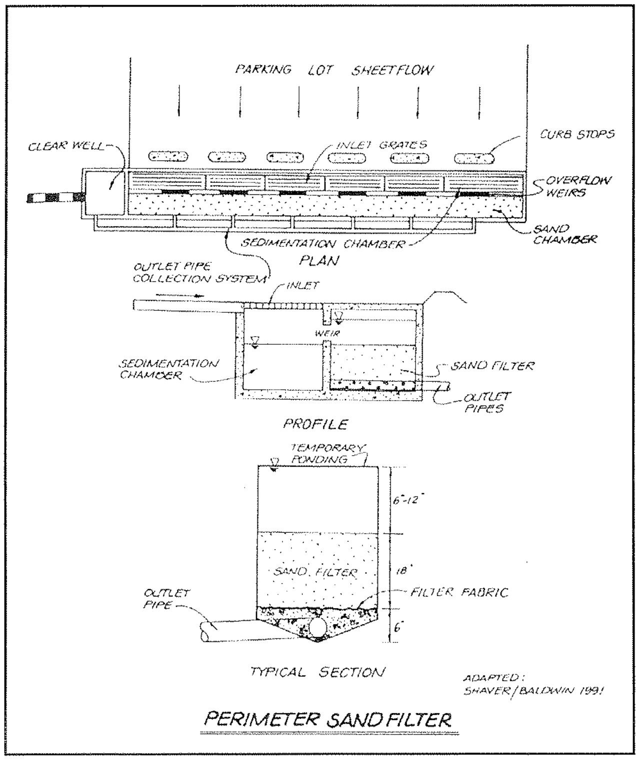
- Provides groundwater recharge when the runoff is allowed to infiltrate into the subsurface; and
- Enhances the appearance of parking lots.

Dry Swales

Dry swales are essentially "engineered" grass channels that provide full treatment of stormwater pollutants (see Principle No. 5 for additional information). The dry swale design includes a layer of prepared sandy loam soil topped by dense turf. Runoff flows into the swale, depositing some of its sediment load as it flows through the dense vegetation. Water quality treatment is provided as the runoff infiltrates through the sandy loam layer. The treated runoff is collected in an underdrain pipe system and discharged into the downstream receiving waters or into a stormwater BMP for further treatment or attenuation. Because the swale is designed to dewater within a few hours after a storm, standing water and its attendant nuisance problems are generally not a concern.

The feasibility of dry swales at parking lots is determined by a number of factors, including drainage area, slope, and length. The amount of stormwater runoff generated at parking lots could overwhelm a dry swale system. In general, dry swales are most appropriate for smaller parking lots (or drainage areas) or larger parking lots subdivided into smaller subdrainage areas and mildly sloping topography.

Figure 10.3: Perimeter Sand Filter (Claytor and Schueler, 1996)



Wet swales can also be used in parking lots, under some conditions. Wet swales are similar to dry swales, but do not have an underlying filter bed. The wet swale occurs when the water table is located very close to the surface. As a result, the swale is often fully saturated or filled with standing water during the greater part of the year. Concerns regarding the standing water may limit the usefulness of wet swales.

Perimeter Sand Filters

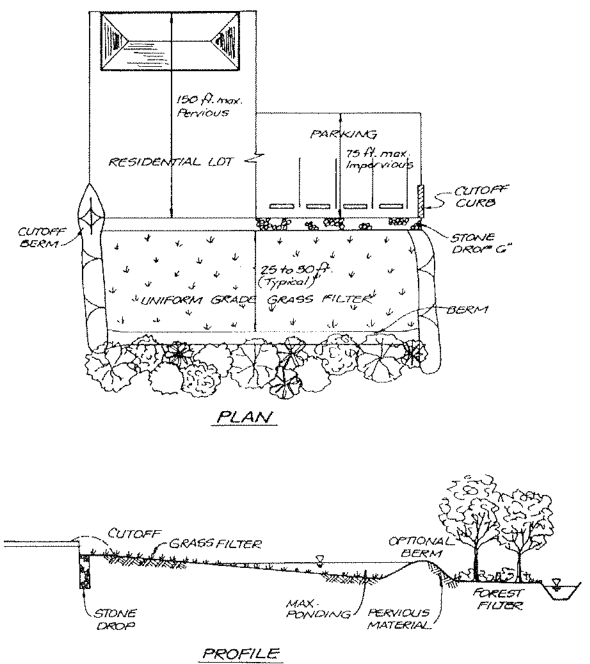
Perimeter sand filters (Figure 10.3) are a more engineered approach to treating parking lot runoff at the source. These devices are usually placed along the downstream edge of parking lots. Perimeter sand filters are particularly suited for parking lots because they are placed underground and consume little usable land.

Runoff flows over the surface of the lot into a grated sedimentation chamber where coarse sediments are trapped. The runoff is then spread over a filter bed and pollutants are captured as the runoff flows downward through the filter. The treated runoff is collected at the bottom and returned to the storm sewer or discharged to a receiving stream. Other types of sand filters include surface, underground, and organic sand filters.

Filter Strips

Filter strips rely on vegetation to slow runoff velocities and filter out sediments and other pollutants from stormwater runoff (Figure 10.4). To be effective, the runoff must flow as sheetflow across the filter strip. Once flow concentrates to form a channel, it effectively "short-circuits" the filter strip. Further, a significant amount of land is required (equivalent to 100% of the impervious drainage area). For these reasons, filter strips are only recommended for very small parking lots or parts of larger parking lots. The parking lot should be adjacent to stream buffers or open space.

Figure 10.4: Filter Strips (Claytor and Schueler, 1996)



Additional stormwater management options include porous pavements (see Principle No. 8) and infiltration trenches. Porous pavement is a pervious asphalt or concrete that allows rainfall to infiltrate into the subsurface. Infiltration trenches are stone-filled reservoirs. Pollutants are removed from the stormwater as the runoff flows downward through the soils beneath the reservoir. Infiltration trenches are typically located along the outer edges of parking lots. In comparison to bioretention facilities, infiltration trenches may require greater care in design, maintenance, and operation (Horner et al., 1994) unless the bioretention is used as a recharge BMP.

PERCEPTIONS AND REALITIES ABOUT PARKING LOT STORMWATER MANAGEMENT ON SITE

Communities may be reluctant to require stormwater management at parking lots (Table 10.2). Although there is data on some BMPs, others are relatively new and their effectiveness has not been extensively documented. Unless BMPs are explicitly required, developers may be reluctant to provide stormwater management due to the cost. Maintenance requirements are a consideration for landowners.

It should be noted that bioretention facilities, open channels, sand filters, and filter strips provide little quantity control. (Quantity controls such as detention ponds are used to minimize the chance of onsite flooding.) These techniques, however, can often reduce the volume and velocity of runoff from parking lots. The amount of quantity control needed is therefore reduced. Thus, overall stormwater management requirements are minimized and smaller quantity controls can be used.

Table 10.2: Perceived Impediments to Parking Lot Stormwater Management

Perception	Facts, Case Studies, and Challenges	
1. Many of the stormwater management techniques are relatively new and their long term performance uncertain.	CHALLENGE:	A recent study by Brown and Schueler (1997) found only 3 performance studies for perimeter sand filters and 4 for dry swales. However, preliminary monitoring and results from the limited number of monitoring studies suggest that these BMPs can significantly reduce stormwater pollutants (See Table 10.3). If not properly maintained, infiltration trenches can have failure rates as high as 50% (Galli, 1993). Bioretention facilities are relatively untested. Brown and Schueler (1997) identified only one performance study for bioretention facilities, but also found some studies on biofilters and surface sand filters, which have pollutant removal capabilities similar to on-site BMPs.
2. The cost to provide onsite stormwater management may be more expensive than providing offsite management at one regional facility.	FACT:	The use of bioretention facilities and other on-site stormwater management facilities can significantly reduce the need for storm sewers, thus reducing stormwater infrastructure costs.
	FACT:	Filter strips, bioretention facilities, and dry swales may be placed in dead space areas such as setbacks and traffic islands, minimizing impacts to usable (i.e., buildable) land.
	CHALLENGE:	Sand filters are expensive, generally on the order of $10,000 - $50,000 per impervious acre. This cost may be offset by the costs for land acquisition, construction of the storm drain conveyance, and construction for a large offsite facility.
3. Maintenance requirements may be burdensome for lot owners.	FACT:	Bioretention areas can easily be maintained by commercial landscapers, but will require regular maintenance.
	CHALLENGE:	Maintenance and physical plant workers may require special training to ensure that open channels, sand filters, and filter strips are properly maintained.
4. The modifications to curbing around bioretention facilities, open channels, sand filters, and filter strips may cause the pavement to fail.	FACT:	Potential failure at the interface may be avoided through the use of a low-rising concrete lip.
	FACT:	Curbing can be used as long as curb cuts or some similar device are provided to allow parking lot runoff to enter bioretention areas or sand filters.
	CHALLENGE:	Care should be taken to ensure that runoff is conveyed away from the pavement. Standing water and water beneath the pavement may cause the pavement to fail. Steps that can be taken to avoid pavement failure include providing a gravel subgrade and requiring geotechnical testing.

Table 10.2: Perceived Impediments to Parking Lot Stormwater Management (Continued)

Perception	Facts, Case Studies, and Challenges	
5. Snow removal may be more difficult.	FACT:	Bioretention areas, filter strips and surface sand filters can be used for snow storage in the winter months (Caraco and Claytor, 1997).
6. Quantity control is difficult to achieve with bioretention areas, sand filters, filter strips, and open channels.	FACT:	Some jurisdictions do allow temporary ponding of stormwater in parking (lot) bays when detention and space limitations are a primary consideration (Bell, 1998).
	FACT:	By providing stormwater management at the source, these facilities can reduce downstream stormwater management requirements.
	CHALLENGE:	Bioretention areas, sand filters, filter strip, and open channels. are not specifically designed to provide quantity control.

Effectiveness

Because most of the stormwater management technology for parking lots is relatively new, only a limited amount of effectiveness data is available to evaluate the long-term performance. However, preliminary monitoring results suggest that these practices can significantly reduce sediment, nutrient, hydrocarbon, and metal loads (PGDER, 1997; Brown and Schueler, 1997).

Table 10.3: Pollutant Removal Effectiveness of Stormwater Management Practices for Parking Lots

Stormwater Management Practices	Pollutant Removal Effectiveness				
	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Metals	
Bioretention facilities [1]	Assumed comparable to the dry swale.				
Dry swales[2]	91 %	67 %	92 %	metals:	80 - 90%
Sand filters[1,2]	85%	55 %	35 %	lead	60 %
				zinc	68 %
Filter strips[1]	70 %	10 %	30 %	metals	40 - 50 %

[1] Claytor and Schueler, 1996; [2] Brown and Schueler, 1997

Expense

The major expenses for parking lot stormwater management are land acquisition, construction, and maintenance. Land acquisition is particularly a concern because many parking lots are associated with commercial development. Commercial land is typically more costly than other land uses. Limiting stormwater management facilities to already required landscaped areas and setbacks could significantly reduce land acquisition costs.

The real challenge is that onsite stormwater management is often more costly than offsite management. However, construction costs for onsite stormwater management may be partially offset by reduced storm drain construction and avoidance of large offsite facilities. Also, even simple grading of the landscaped areas to accept runoff can provide some stormwater management.

Maintenance

Maintenance requirements, as well as relative expense, are summarized in Table 10.4.

Table 10.4: Comparison of Maintenance and Cost Requirements for Several Stormwater Management Facilities (Claytor and Schueler, 1996)

Stormwater Management Facilities	Maintenance Requirements	Relative Cost
Surface sand filter	• trash removal every 6 months and after major storms • mow to maintain grass at 18" • check and clean perforated standpipe and/or low flow orifice • remove deposited silt when > ½ inch in depth over filter bed	moderate
Underground sand filter	• monitor water level in filter chamber (4 times a year for first year, 2 times a year thereafter • pump out sediment chamber when sediment depth > 12 inches • remove deposited silt when > ½ inch in depth over filter bed	high
Perimeter sand filter	• inspect 2 times a year and after major storms • remove trash and debris • remove deposited silt when > ½ inch in depth over filter bed	high
Organic filter	• replace compost every 3 - 4 years • annual removal or roto-till of top layer • remove deposited silt when > ½ inch in depth over filter bed	high
Bioretention facility	• maintain landscape vegetation • annual inspection of plants • mulching 2 times a year • annual testing of soil bed for pH	low
Porous pavement*	• sweeping or vacuuming • replaced when clogged	moderate
Filter strip	• mowing • edge scrapping	low

* *Porous pavement alone is approximately the same cost as conventional asphalt or concrete. However, when the cost for the underground storage reservoir is factored in, porous pavement is more expensive than conventional pavement.*

CASE STUDY: PRINCE GEORGE'S COUNTY, MARYLAND

(Source: PGDER, 1997)

Prince George's County MD promotes the use of bioretention facilities at commercial, industrial and residential sites. This is an integral part of the County's strategy for development. The County is encouraging low impact (i.e., low imperviousness) development even in commercial and residential areas. The integration of bioretention facilities in landscape areas is a key part of this approach.

A mall developer in Prince George's County was required to construct a bioretention facility to treat runoff from a new parking lot. The developer graded the lot to drain to the bioretention facility and planted it with a variety of attractive and hardy plants (see Figure 10.2). The bioretention facility has worked successfully for several years. Customer response to the attractiveness of the bioretention facility was so great, that the developer constructed a "dummy" facility (i.e., it receives no stormwater runoff) in an upland portion of the parking lot.

Prince George's County hopes to encourage other developers to use bioretention facilities by offering a variety of incentives, including reduced stormwater management requirements and mitigation credit for environmental impacts. In addition, the County is collecting data to document reduced costs for site grading and infrastructure construction.

WHERE TO GET STARTED

Suggested Resources	How to Get a Copy
Start at the Source (1997) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
Design of Stormwater Filtering Systems (1996) by Richard A. Claytor and Thomas R. Schueler Presents detailed engineering guidance on ten different stormwater filtering systems.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323
Design Manual for Use of Bioretention in Stormwater Management (1993) Presents guidance for designing bioretention facilities.	Prince George's County Watershed Protection Branch 9400 Peppercorn Place, Suite 600 Landover, MD 20785

Suggested Resources	How to Get a Copy
Operation, Maintenance and Management of Stormwater Management (1997) Provides a thorough look at stormwater practices including, planning and design considerations, programmatic and regulatory aspects, maintenance considerations, and costs.	Watershed management Institute, Inc. 410 White Oak Drive Crawfordville, FL 32327 850-926-5310