CHAPTER 3

TABLE OF CONTENTS

Page

3.00 COMPREHENSIVE STORMWATER POLICIES AND PLANS

3.10 STORMWATER-MANAGEMENT POLICIES

COMPREHENSIVE POLICIES

The stormwater-management process must be a comprehensive program to manage storm water for aesthetics, flood control, pollution control and all other appropriate purposes. It involves public and intergovernmental participation. Local government should analyze the system-wide needs of the community, addressing the appropriate measures for the site, watershed, region or water body.

Water-quality Goals

The National Urban Runoff Program (NURP) (USEPA, December 1983) studied a variety of treatment systems and found that 90% removal of total suspended solids (TSS) is achievable in well-designed ponds. Significant removal of other pollutants, such as phosphorus, can also be expected.

Water Quality Volume

In Minnesota, over 90% of the daily precipitation events are under one inch (See chapter 1, Figure 1.10-6). These rainfall events also account for about 80% of the cumulative runoff and proportionately large amounts of the pollutant loading associated with these rainfalls (Pitt, 1998). The pollutant loading is more closely associated with total runoff volume than with peak runoff rates.

Large-storm events are important; but for protection of water quality and wetland preservation, small-storm hydrology is a critical component of the hydrologic investigation. The 1.25-inch rainfall event has been selected as the design event that should be used to best evaluate water-quality impacts of urban development. The use of this event as a design parameter is explained in chapter 5.

Developing Local Goals

Selection of the optimal mix of best management practices (BMPs), including stormwater ponds, depends on the goals that are established for the system and the nature of the project site and watershed.

Important factors to consider include:

- Environmental Goals
    - Pollutant-removal targets: phosphorus, total suspended solids, metals, etc.
    - Temperature changes
    - Downstream channel erosion protection
    - Wetland creation
    - Wildlife habitat

- Community Acceptance
  - Safety risks
  - Construction costs
  - Maintenance costs
  - Land-consumption costs
- Nature of the Watershed
  - Developed: retrofit options
  - Undeveloped: prediction of future development
- Selection of Proper Treatment System
  - Selection of ponds
  - Selection of associated BMPs

3.20 RESOURCE-PROTECTION POLICIES

COMPREHENSIVE PLANS

Stormwater discharges to water bodies may be a significant portion of the comprehensive stormwater and surface-water runoff-management plan developed by local units of government. Requirements of the Metropolitan Area Surface Water Management Act and other applicable planning requirements should form the basis for comprehensive review of stormwater and water bodies plans. As with all plans, the first step should be a survey of existing information, including a mapping of all the water bodies in the watershed and associated normal flow paths.

RESOURCE INVENTORY

It is recommended that the local unit of government complete the inventories of existing resources. Existing information, such as the Protected Waters Inventory (PWI/MDNR) and the National Wetland Inventory, U.S. Fish and Wildlife Service (NWI/USF&WLS) or the Watershed Heritage Program (Minnesota Department of Natural Resources) can be used as a starting point for these inventories. Any survey information must be field verified. Much of the original aerial photography was made over 10 years ago, so the surveys can be used only as a guide to field activities. Field visits will be necessary to verify NWI information. Wetlands should be identified in the inventory and classified according to their appropriate wetland sensitivity group (Eggers, 1997; Minnesota, State of, June 1997). The size should be estimated and the surface hydrologic connections should be recorded for each water body identified on the inventory.

Classification of Water Bodies

A visit should be made to a water body to determine its type. Figures 3.20-1 through 3.20-4 contain a fairly comprehensive listing of wetland types and their adjacent deep-water habitats, including a description of their sensitivity to hydraulic changes.

Assess Quality and Condition

An assessment of water-body quality and condition is probably best conducted using a methodology that evaluates the condition of the biological community. The functioning of many water-body uses is directly related to the biological integrity, since the biota will reflect the overall health of the system. Therefore, an assessment of the condition of a water body is best based on an evaluation of the relative “biotic impoverishment” (such as provided by Karr, 1993).

Two strategies are used to assess the quality and condition of a water body. The first is a quantitative-research method that is resource intensive. This method may be necessary to assess identified high-priority water bodies and continue to monitor their relative condition.

The second strategy is a rapid/practical assessment that is more qualitative and based on best professional judgment. This is an appropriate method for local government staff to conduct or to contract out for evaluation of each water-body basin or complex within the watershed. The Minnesota Routine Assessment Methodology (Minnesota Interagency Wetland Group, Board of Water and Soil Resources) is an example of a method that can work for this type of assessment.

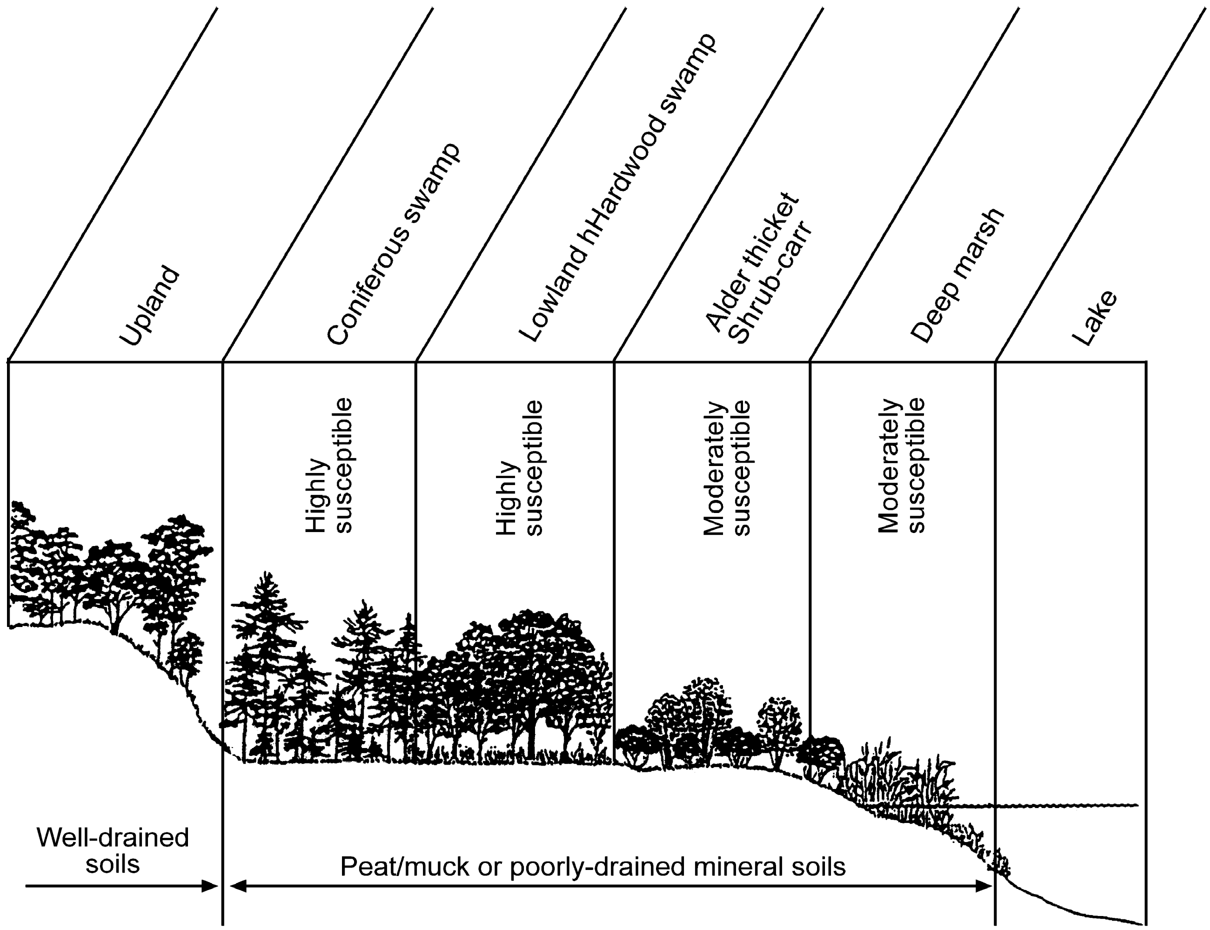


Figure 3.20-1 Susceptibility of wetlands to stormwater input: plant communities in a lake basin

These two assessment methods vary greatly in the precision of the data collected. To reduce assessor bias, both methods should include least-disturbed reference water bodies. Once identified, these least-disturbed water bodies should be used as standards in making judgments about the condition of the assessed water bodies. It is recommended that three reference water bodies be identified for each of the various hydrogeomorphic water body classes found within the watershed -- for example, depressional water bodies, riparian wetlands, lake-fringe wetlands, and peatlands (Brinson, 1993).

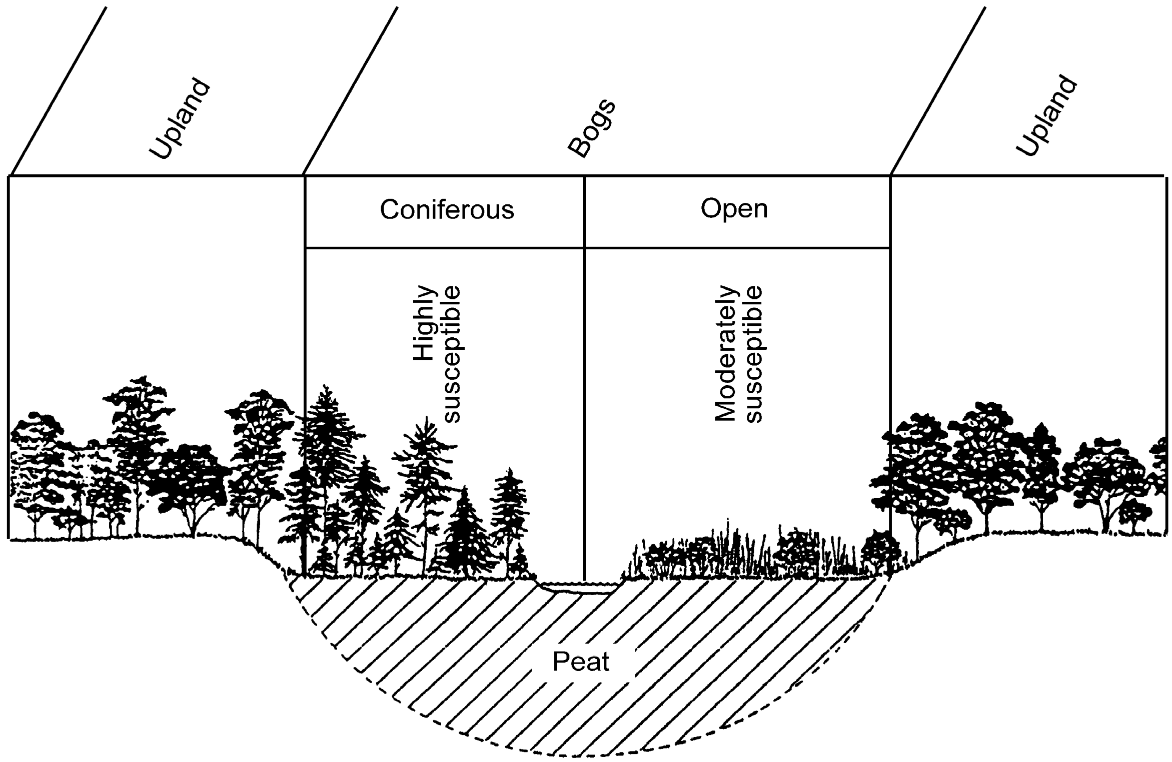


Figure 3.20-2 Susceptibility of wetlands to stormwater input: generalized cross section of a bog

Water-body quality can be assessed as excellent, moderate or highly impacted, depending on the extent to which human activities have affected the water body. Water bodies should be evaluated using the following criteria:

Excellent-quality water bodies. These water bodies remain in a least-impacted condition and, as such, typically possess very diverse vegetative assemblages. Strata are well developed and composed of native species. Non-native species, if present, are infrequent and do not comprise significant relative cover percentiles. Water bodies that support rare, threatened or endangered species are likely to be included as high-quality water bodies.

Moderate-quality water bodies. Areas that have been subjected to varying degrees of human disturbance, but still provide important ecological water body functions and values, are considered to be of moderate quality. An example would be a partially drained wetland complex composed of 60% cover of reed canarygrass and 40% cover of native species, such as sedges. These wetlands often provide important wildlife habitat and water-quality benefits.

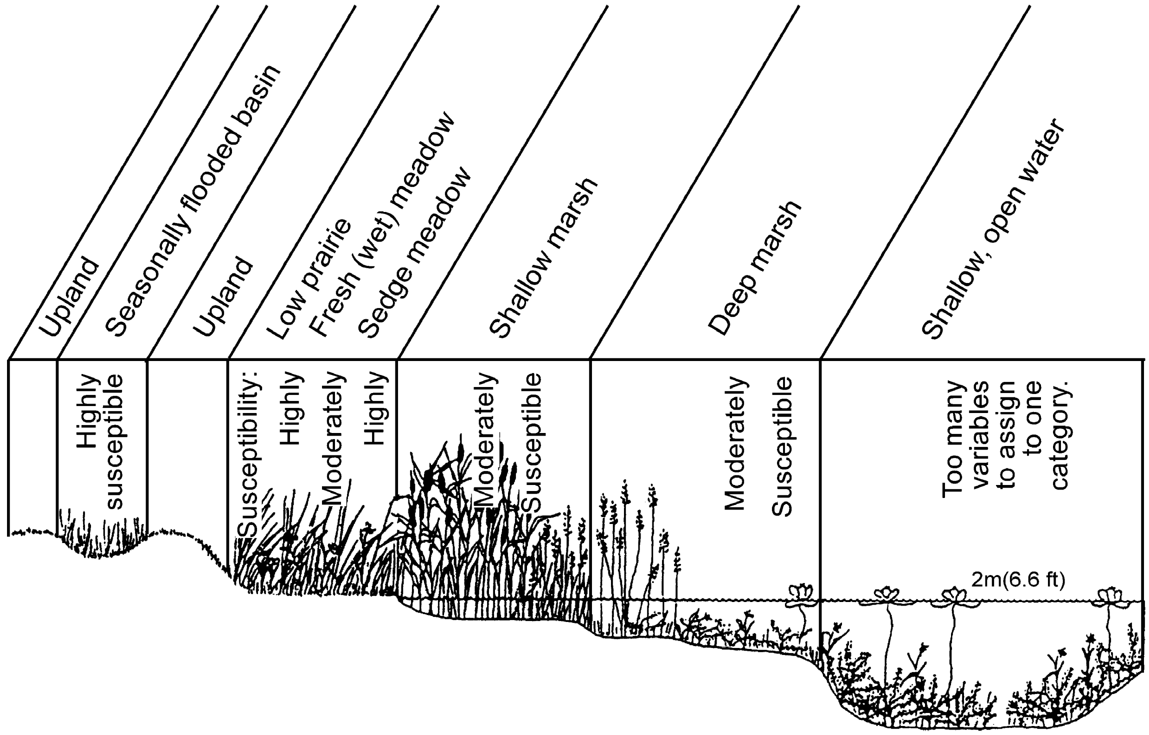


Figure 3.20-3 Susceptibility of wetlands to stormwater input: meadow-marsh-open-water complex

Highly impacted water bodies. Areas that have been so severely degraded that they have little vegetation, or the vegetation is dominated by non-native species or by monotypic stands of species, such as cattails, are considered highly impacted. Hydrologic and/or biological processes have been greatly altered and inputs of urban storm water will have minimal impacts. Examples of highly impacted water bodies are abandoned gravel pits, nutrient-loaded water bodies, stormwater-detention basins, and dredged areas within water bodies that result in extreme hydrologic modifications.

Significant Resources

Water bodies that have been designated by local, state or federal action as providing unique qualities, such as recreational, scientific, educational or aesthetic uses, would be considered significant resources. Other significant water bodies would include those that have been restored for specific purposes, such as water-quality improvement or wildlife, industrial or agricultural uses. Water bodies known to be important to local recreation activities, such as hunting, fishing or bird watching, and water bodies occurring within parks, shoreland areas and conservation corridors would also be considered to be significant resources. Forested areas may also be considered significant resources and should be designated for protection from destruction by removal, inundation and flooding.

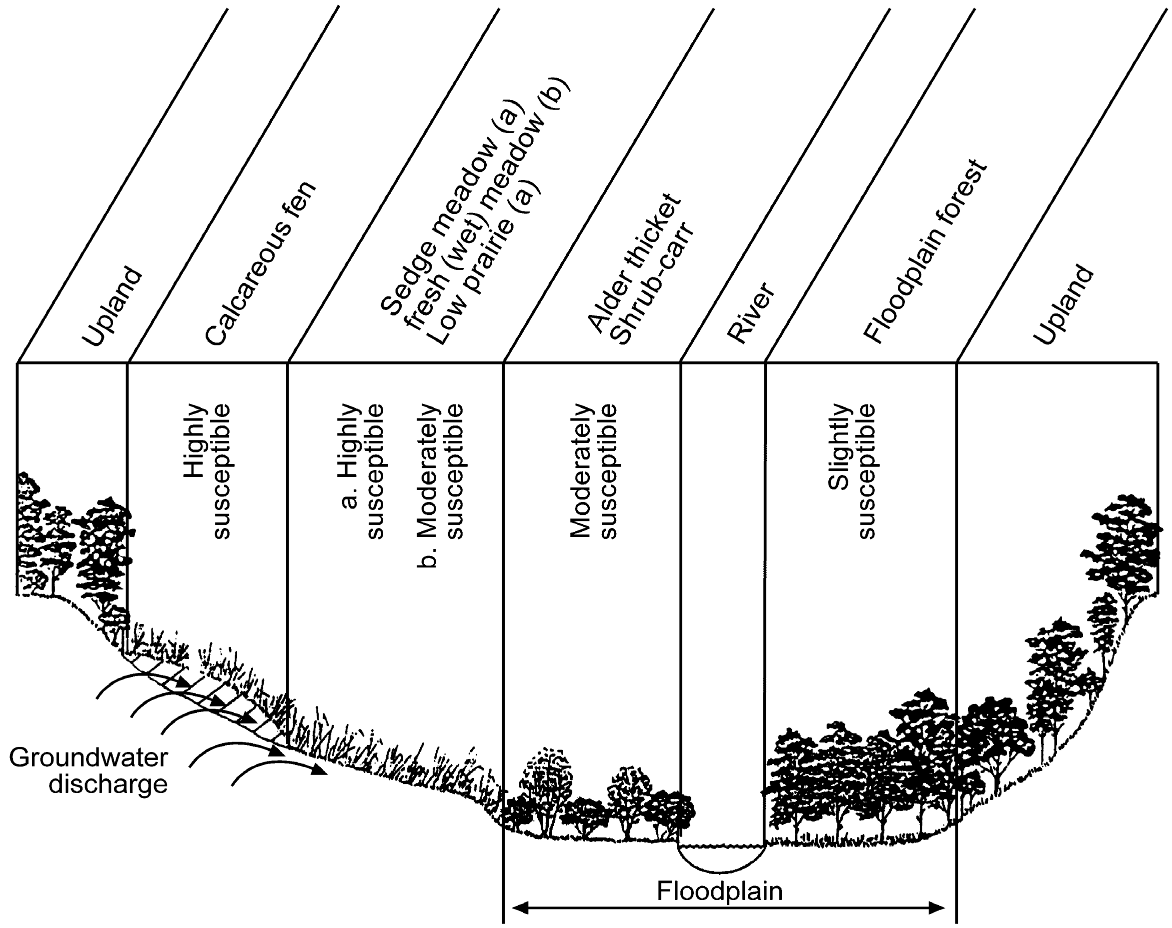
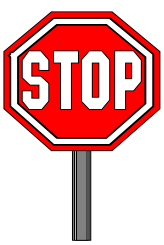


Figure 3.20-4 Susceptibility of wetlands to stormwater input: plant communities in a river valley



Resource-significant "red flags" warn of recognized special uses or unique features such that a water body's integrity should be preserved. Examples of such red flags include if the water body:

- is on the Minnesota Department of Natural Resources protected waters inventory (MS 1036.245).
- has a direct hydrologic association with a designated trout stream.
- borders the Mississippi or Minnesota rivers or Lake Superior.
- borders a state or federal wild and scenic river.
- has been restored or created for mitigation purposes.
- is within an environmentally sensitive area or environmental corridor identified in a local water-management plan, special area-management plan, special water-body inventory or an advanced identification study.
- is recognized as an Outstanding Resource Value Water (Minn. R. ch. 7050).

- is within a local, state or federal park, forest, trail or recreation area.
- is within a state or federal fish and wildlife management refuge or area.
- is part of an archeological or historic site designated by the State Historic Preservation Office.
- is part of a sole-source aquifer-recharge area.
- provides endangered species habitat.
- has biological communities or specie listed in the Natural Heritage inventory database.
- is recognized as an important local recreation resource.

The red flags listed above indicate that there are concerns that are local, regional or statewide that must be addressed in the evaluation.

Water bodies that involve red flags are of special concern beyond the local boundaries.

Excellent-quality water bodies of all types are very rare and becoming more rare as time and development goes on. Therefore, they are given red flags.

Highly sensitive water bodies, even of moderate quality, are red-flagged because of the care that must be taken to preserve them. Also, providing off-site compensation does not easily mitigate these types of water bodies. They often cannot be reproduced through artificial means.

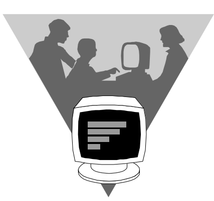
Most moderately and slightly sensitive water bodies should be protected; but importantly, they can more easily be mitigated, preferably through restoration but also through creation.

Maintaining public uses and values is a very important component of maintaining the entire function of a watershed. Piecemeal destruction of minor water bodies or changes in the hydraulic regime can significantly damage the entire system through changes in erosion, nutrients or other pollutant loading on the system.

Stormwater System Inventory

Certain water bodies, because of their position in the watershed, morphology, surface-flow connections or other physical attributes, are especially well suited to be part of a stormwater-management system. Identification of such basins does not necessarily mean they will be targeted only for receipt of storm water, though they should be highlighted in the inventory when this function is believed to be most important.

DECISION TOOLS



Information layers on water-body trends, sensitivity and condition, as well as resource significance and management needs, can be incorporated into a geographic information system (GIS) to provide easy updating and viewing. Viewing these information items as overlays will help the decision-making process.

After the data have been compiled, a process for making decisions should be developed. This should be coordinated with respective local, state and federal permitting and regulatory agencies to ensure that ecologically and socially acceptable decisions are the result. Public participation should be an integral part of the process, and it should be included early and throughout the planning.

Once local water-body-management decisions are made, the local unit of government should make a commitment to initiate a water-body-monitoring and -maintenance effort. Local citizens or schools may be recruited to carry the monitoring effort. If the local government is unable to commit to sponsoring a citizen monitoring effort, then at a minimum it should support monitoring of water bodies afforded long-term preservation. As much as possible, these monitoring efforts should include a review of individual and landscape water body functions.

Water bodies that are less sensitive to stormwater discharge, or are impaired, present opportunities for improving water-body integrity. These water bodies may be good candidates for applying guidelines for control of "storm bounce" and pollutant loading, or to modify the water body basin for improved storm treatment. In a planning context, this is not an easy decision to make, and there are no prescriptive means of further defining how these water bodies should be viewed. However, where possible, the following should be considered in making these decisions:

- relative rarity of habitat types remaining in the water bodies in comparison with historical ratios of water body types. Even if they are impaired, a diversity of water body types is preferred.
- the amount of fragmentation and isolation of a water body that would result.
- the possibility of avoiding, through zoning or other means, development or other pressures that would influence the integrity of the water body basin.
- the ability to minimize the impact of stormwater flows on the water body through consideration of alternatives.
- the relative position of the water body within the watershed in relation to other surface waters.
- greater recognition of seasonal features of water body importance, such as ephemeral wetlands, which have important forage value to migrating aquatic birds. Often these are the first waters to open up in the spring and this triggers complex cycles of certain freshwater crustaceans, such as various species of fairy shrimp.

MITIGATION OF FUNCTIONS AND VALUES

If a significant resource must be used, mitigation should be considered, especially in cases where a wetland is targeted for expanded hydrologic utilization that will not comply with the guidelines presented in this manual. If utilization will change the character of the water body and these conversions will result in changes in the uses that a water body can provide, compensation must be provided. Ideally, this compensation must replace the affected water body's uses and function. At a minimum, compensation is intended to maintain the no-net-loss water bodies policy enacted at the local, state and federal levels of government. One of the prime questions in replacement is whether water body values can be replaced on site in the watershed or at remote locations. We highly recommend replacement within the watershed if possible. Mitigation for all lost functions and values should be provided, even if less strict regulatory and management options are allowed.

3.30 COMMUNITY PLANNING POLICIES

IMPERVIOUSNESS

While population density is important for many planning and zoning regulations, imperviousness and the way impervious surfaces drain should be considered the primary environmental planning tool, not density of units.

Impervious surface area is the portion of the land where water cannot infiltrate to the subsurface. Instead, water is conducted by gravity on the surface as overland flow. Impervious systems generally consist of roads, parking lots, sidewalks, rooftops and other impermeable surfaces of the urban landscape. While imperviousness is fairly easy to define, it may be hard to identify in practice. While asphalt and concrete are generally considered impervious, they have been found to allow significant infiltration under some conditions. Gravel surfaces can be pervious, but if they contain a high percentage of fines, they may become impervious. Lawns are considered pervious, but disturbed urban soils may allow only minimal infiltration (Pitt, 1994).

Criteria

Imperviousness is still a very useful indicator by which to measure the impacts of land development on aquatic systems. Research conducted in many geographic areas and employing many different methods of analysis has led to surprisingly similar conclusions regarding the nature of impervious surfaces and stream degradation: Stream degradation occurs at levels of imperviousness from approximately 10 to 20% of the watershed. (Schueler, Fall 1994)

One classification for urban stream quality indicates that streams, particularly in watersheds where no BMP strategies are in place, can be stressed from 1 to 10% of impervious cover, impacted by 11 to 25% impervious cover, and degraded by 26 to 100% impervious cover (Schueler, 1994b).

Imperviousness is a good indicator of the impacts of land development on a watershed. It is composed of two primary components, the buildings and the transport system. “Buildings” include homes, shopping centers and industries. The “transport system” consists of roads, driveways, parking lots, and walkways that people use to get from one place to another. The transport component often exceeds the rooftop component in terms of total impact and total impervious area created.

The impacts of impervious surfaces are many. Bacteria in urban runoff or failing septic systems influence the closing of swimming areas in local streams and lakes. Other pollutants from the atmosphere directly deposit and accumulate on impervious surfaces. This allows the quick washoff and rapid delivery of pollutants to aquatic systems. Impervious surfaces also absorb heat, strongly influencing water temperature. Macroinvertebrate diversity drops sharply with impacts caused by increased impervious surface, as do the abundance and diversity of fish.

In addition, impervious surface increases the volume and peak flow of stormwater runoff, contributing to greater annual water-level fluctuations, resulting in stream bank and bed erosion and inundation of wetlands. When the annual water-level fluctuation in wetlands exceeds about 8 inches, the richness of both wetland plant and amphibian communities can drop sharply.

Traditional zoning methods

Municipalities have addressed the problem of impervious surface by setting the maximum density for an area based on building units. The transport component is generally not addressed. However, transport-related imperviousness often exerts a greater hydrological impact than building-related imperviousness. Runoff from rooftops can be spread over pervious areas, such as yards and grassed waterways, whereas roads and parking lots are usually directly connected to the storm-drain system.

Not only are roads generally connected to the drainage system, they also have the secondary effect of producing development with a multiplying effect on the impacts to the watershed system. Because impervious surfaces place greatly increased total flow and loadings on waterways and on aquatic systems, it is very difficult to mitigate the impacts of the impervious surfaces by BMPs. BMPs that provide stable channels, reduce pollutant loading and reduce impacts to benthic biota raise the allowable imperviousness from 35 to 60%.

Therefore, even when effective practices are widely applied, the threshold of imperviousness is eventually crossed, which results in a degraded condition.

Many policies and BMPs can be adopted to reduce the impact of impervious surfaces on the watershed. These include running the roof and roadway runoff over vegetated areas and into soils instead of storm sewers. Use of ponds and other treatment measures can also help reduce pollutant loadings and peak flows from impervious areas to some extent. However, imperviousness increases the total runoff loading of pollutants and may bring new flows, which had not been a contributing part of the watershed, into the watershed.

The relationship between imperviousness and runoff is becoming better understood, but the impact of the changes in runoff to aquatic systems is neither fully understood nor appreciated. The impact of increased runoff from the development of new impervious surfaces must be understood in terms of peak flow and total flows to fully understand the impacts on stream bank erosion, pollutant loadings and inundation effects on the biotic community.

The effectiveness of BMPs to increase the threshold of effect from impervious surfaces should be studied more carefully. The threshold beyond which predevelopment water quality cannot be maintained is not well understood and should be carefully analyzed for each situation. In addition, politically and legally acceptable regulatory programs that reflect our understanding of how impervious surface can affect the aquatic community must be developed. New methods and new ways of looking at these issues must be tried.

RESIDENTIAL DEVELOPMENT

In the past, the concept of low-density development has been used as a planning tool to protect resources. It would seem logical to limit the development to no more than 10% of the impervious cover. Of course, this could not be sustained over a large number of watersheds or a large geographic area due to the long-term physical and social infrastructure costs of this development pattern.

Many planners have proposed that the best way to minimize the impact of impervious area on a watershed is to concentrate it in highly developed clusters. It would be virtually impossible to maintain predevelopment stream quality in the watershed affected by these clusters. Many people find it troubling that it may be necessary to degrade one water body or reach in order to protect another. However, given the low level at which impervious surface can impact a water body, there is no doubt that the present systems of zoning development are already having significant impacts.

On the other hand, cluster development may offer many advantages to the municipality, developer and prospective homeowner.

“Cluster development” is defined as the grouping of all residential structures of a development on a portion of the available land, reserving a significant amount of the site as protected open space. Many communities in Minnesota and across the United States are updating their comprehensive plans and establishing ordinances to guide the development and construction of cluster developments. New ordinances are requiring design standards, and identifying open space and density standards. These key changes have prompted some communities to opt for more descriptive terminology, such as “open-space development” or “conservation subdivision design,” instead of the more traditional “cluster development.” While this use of different terminology has created some confusion, each still maintains the three basic goals of cluster development: (1) preserving open space, (2) protecting critical ecological habitat and (3) preserving agricultural land.

The useable open space created by a cluster development can serve to meet a number of community goals, such as the protection of critical ecological resources, protection of wooded areas or the preservation of farmland. Obviously, these goals overlap and have the potential to conflict with one another. For example, the protection of wildlife habitat may be incompatible with the preservation of agricultural land. However, the key benefit is the quality of life preserved by the availability of open space made possible through the clustering of units. The ultimate use of the open space is left for the landowner and community to decide.

Gross Density and Lot Size

Current zoning practices establish gross population densities based on minimum lot sizes, setbacks and widths that need to be met by developers as they design subdivisions. This leads to a development that maximizes the number of lots based on the total acreage of the parcel. For instance, if the code requires a minimum lot size of 0.5 acre and the developer has a six-acre parcel, barring major site limitations, the site will be developed with 12 residential units (see Figure 3.30-1). The gross density of this parcel is then 12 units per six acres.

Cluster development can achieve the protection of open space by establishing a gross density requirement for the parcel independent of lot size. This density requirement, rather than minimum lot size, determines the number of allowed units. For example, a parcel of six acres that has a gross density requirement of one unit per 0.5 acre will allow a maximum of 12 units to be developed on the site. If the lot size requirement is less than 0.25 acre or variable sizes, some clustering of units will be possible. The developer is still limited to 12 total units, but has the flexibility to place these units in a manner that is more responsive to the physical characteristics of the site, such as the preservation of 2 to 3 acres of commonly owned land (see Figure 3.30-1).

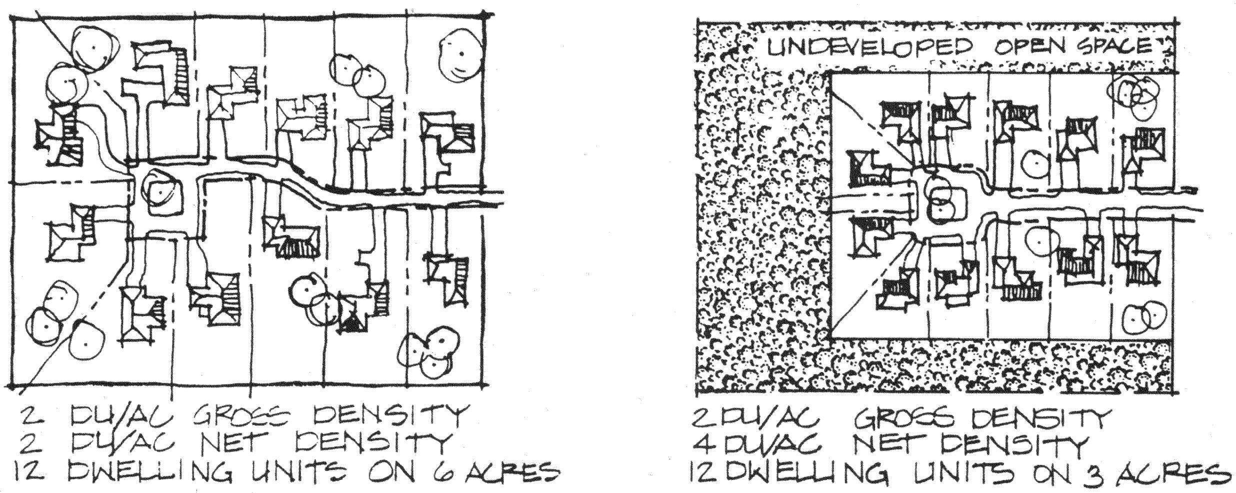


Figure 3.30-1 Cluster development using the PUD approach can result in narrower lot frontages, shorter street and utility rows plus the preservation of significant blocks of undeveloped open space.

Options for Use of Open Space

The open space created by cluster developments can be used in three ways:

1. exclusive use by residents (*e.g.*, private trails, passive recreational areas);
2. preservation of land use, such as agricultural land or wooded areas; and
3. protection of wildlife habitat.

Traditionally, open space has been reserved for recreational use by residents. The local government can encourage other options (preservation of agricultural land, wooded land and critical wildlife habitat) through comprehensive land-use planning and subdivision ordinances. Initially, the municipality needs to identify the areas that are important to the community and develop goals for them These goals can be realized through the establishment of physical design standards, density requirements and the employment of transfer of development rights or other incentive programs.

Ensuring Full Potential of Development

The intent of cluster ordinances is to develop less total land area while allowing the same number of housing units that would be allowed under traditional subdivision ordinances. Since cluster development allows the same number of housing units, it does not penalize landowners or developers financially. In fact, many governmental units allow additional units to be added to encourage this option.

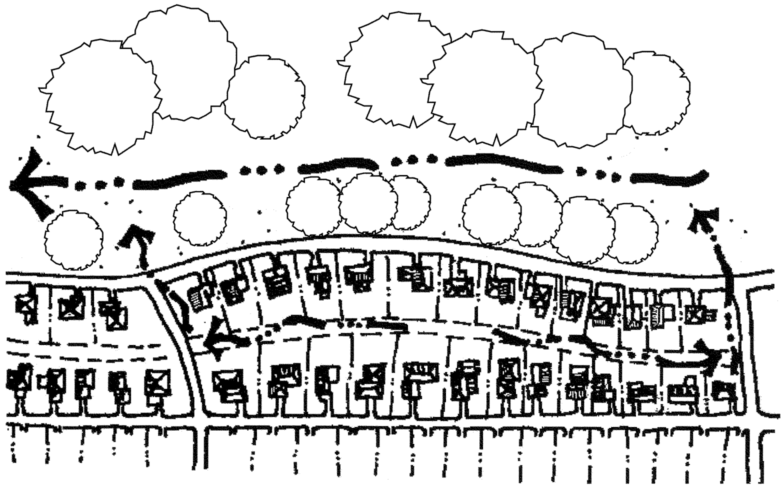


Figure 3.30-2 Example of a development that preserves a natural drainage area

Stormwater Management

Cluster developments can help create undeveloped open space for the neighborhood. The design of stormwater-management systems within cluster developments should maximize overland flow and combine the use of plants and landforms or use grass swales along drainage easements to convey water to natural drainage areas. This will help to infiltrate, slow, hold and treat runoff from new development (see Figure 3.30-2).

The use of rural technologies for stormwater management can avoid the expensive curb, gutter and storm sewer approach. Instead, the development can have a stormwater-management system that is more in keeping with the environmental constraints of the land.

Management of Common Resources

Cluster strategies leave the majority of the new development as open, shared space. Inherent in this design is the mutual ownership and management of the property. Management responsibilities within a cluster development include controlling, directing and handling all resources held in common by the homeowners. This includes, but is not limited to, open space, wastewater-treatment systems and stormwater-management facilities.

Many cluster-development ordinances mandate the establishment of a homeowners association to manage the common open space. The homeowners association is set up by the developer, who may remain a member of the association until all or a specified number of units are sold. The association is then responsible for all management and capital improvements.

In developments with many common resources, the developer may want to explore an alternative homeowners association to manage the resources.

Wastewater Management

Clustering can help limit impacts of development in areas with important natural resources or buffer zones for waters or wildlife. Minimum lot size for cluster development need not be limited by requirements for siting sewage-treatment systems. Options are available to treat sewage off site by collecting the sewage from a cluster of homes, with treatment by community treatment systems (*e.g.*,

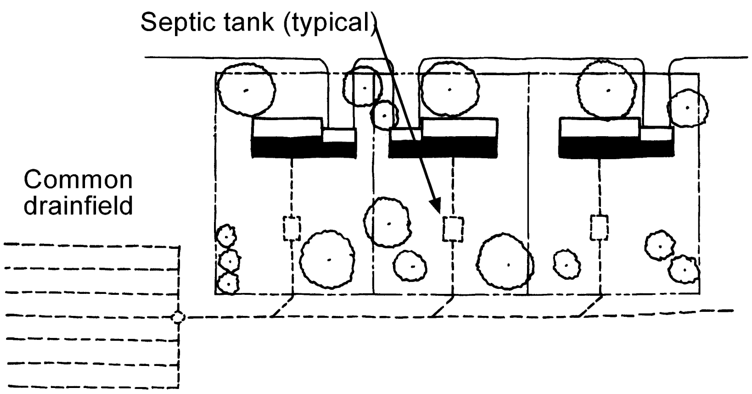


Figure 3.30-3 Typical on-site septic layout for a cluster

drainfields, package plants). These options can reduce infrastructure investment and allow placement of the systems in a way that will minimize adverse environmental impact. Figure 3.30-3 illustrates the use of a community septic drainfield as an alternative to individual systems.

Alternative systems may have additional technical and administrative requirements. Some of the issues that may need to be addressed include:

- location determinations based on site and ground-water conditions,
- design applications to maximize sewage treatment, and
- potential permit requirements.

The Minnesota Pollution Control Agency (MPCA) should be contacted for information about treatment systems related to cluster development.

Mixed Use and Nonresidential Development

Just as creating a storm-water-friendly residential clustered development requires a new way to set standards for a parcel, a similar planning process can be followed when establishing standards, such as minimum parking requirements, floor-area ratios, setbacks and allowable building types for other land-use zones. Typically, these standards are based upon a single type of use on a single parcel, regardless of what the context might be and under the assumption that peak demand for parking must always be accommodated on site. This methodology and set of assumptions are being rethought for a number of reasons, beyond stormwater management. For example, parking space requirements could be reduced for businesses and multifamily homes along a transit line or adjacent to other uses that allow a shared parking arrangement. Structured parking and two-story commercial and/or residential buildings are arrangements that reduce overall impervious surface and provide room to preserve a natural amenity or design a more attractive stormwater pond. All of these strategies are more effective within a mixed-use area where complementary activities are likely to occur. A parking space for a lunch-seeking office worker will not need to be available at a restaurant parking lot if the person works next door or downstairs. The same concept applies to determining the parking requirements for a supermarket located next to an apartment building. For more information on these ideas, see literature on livable communities, sustainable development, transit-oriented development, neotraditional planning and new urbanism.

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: (1) residential streets and parking lots, (2) lot development, and (3) 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 traffic, the sidewalk and vegetated open channels. Utilities and storm drains should be 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 impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Consider alternative turnarounds.
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 whether 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 or other practices that can be integrated into required landscaping areas and traffic islands.

LOT DEVELOPMENT

Principles 11 through 16 focus on the regulations that 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 to link pedestrian areas.
14. Reduce overall lot imperviousness by promoting alternative driveway surfaces and driveways that are shared by two or more homes.
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 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, storm water credits, and by-right open space development should be encouraged to
22. New stormwater outfalls should not discharge unmanaged storm water 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 together 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.

Taken from *Better Site Design: A Handbook for Changing Development Rules in Your Community,* Center for Watershed Protection (Brown *et al.,* August 1998).

3.40 SITE PLANS

In the past, the focus of stormwater management was on reducing the frequency and severity of flooding, chiefly by leveling peak discharges from new development to predevelopment levels. Concern for volume focused only on providing adequate storage to hold a cap on peak discharge (*e.g.,* detention ponds). Waterways were specifically designed to increase hydraulic efficiency through higher velocities and smooth conveyances (*e.g.,* storm sewers, paved gutters and waterways) and to be self-cleaning. This approach implicitly accepted radical change from predevelopment hydrological conditions as a reasonable and unavoidable consequence of land development.

As concern for water quality increases, developers are finding themselves in a conflicting regulatory environment. First, they face zoning codes and development standards that specifically require significant capital investment in site improvements that reduce infiltration, degrade water quality, increase runoff volumes and boost peak discharges. Then, in the same regulations, they are also required to make further capital expenditures (for the BMPs shown in this handbook) to infiltrate runoff, improve water quality, reduce runoff volumes and level peak discharges. The loser is the consumer or home buyer.

Today, it is clear that development practices and standards that require more than the minimum amounts of impervious surfaces and the use of technologies that increase the hydraulic efficiency of the landscape, create more costly problems than they solve.

The BMPs presented in this manual provide good mechanisms for alleviating problems that cannot be avoided in the site-planning process. However, care must be exercised to avoid simply layering them on top of existing requirements and standard practices. A thorough review of land-development regulations and standards should also be made to remove archaic requirements that ultimately work against the goals of maintaining predevelopment hydrologic conditions and improving water quality. The best approach is to avoid creating a problem in the first place. One important way to avoid problems is to re-think standard approaches in terms of the broad context.

GOALS

In new development, good site planning can reduce excess runoff and the potential for erosion and sedimentation problems. The origins of many accepted site-planning standards and practices can be traced to post-World War II stormwater-management practices. These practices were derived in a context where storm water was regarded as the “wastewater” of the community, to be disposed of as quickly as possible with little regard for downstream consequences and local long-term hydrologic and water-quality impacts.

Although modern stormwater management thinking and sedimentation and erosion-control philosophies have abandoned the idea of runoff as “wastewater,” it remains a generally unacknowledged assumption for many accepted site-planning practices and current standards. As a result, local zoning and subdivision regulations often unwittingly set into motion site-planning strategies that aggravate, and often maximize, many of the problems. This means we must re-think the basic assumptions underlying site planning and development standards. A good starting point for doing this is to identify goals that would help direct the choice of practices and strategies for site development toward those which would reduce the root causes of adverse impact on hydrology and water quality. The following goals provide such direction:

- Restrict development in critical areas: shoreline, natural drainageways, steep slopes and erodible soils.
- Reproduce hydrologic conditions: preserve vegetation, provide infiltration, fit development to the terrain, and preserve and utilize natural drainageways.

RESTRICT DEVELOPMENT IN CRITICAL AREAS

The best way to avoid adverse impacts of development on runoff and water quality is to develop comprehensive site plans that avoid any construction activity in the most sensitive areas. Given the open -space requirements found in most zoning codes, this is a real option which is still too often overlooked. Avoid siting improvements along the shoreline of lakes or streams, in natural drainageways or in areas dominated by steep slopes, dense vegetation or erodible soils.

Shoreline. Construction activity is the most difficult to mitigate with respect to water quality. Vegetated shoreline is a critical part of nature's system for cleansing runoff water of pollutants. Also, once the vegetation is disturbed, shoreline erosion is dramatically increased. Runoff from construction close to the receiving waters is hard to control, making measures to reduce pollutant delivery much more difficult and expensive.

Natural Drainageways. Construction in natural drainageways destroys the natural vegetation that protects the soil from erosion and, with it, the filtering capacity of the vegetation. This type of vegetation is among the most difficult to reestablish. Natural drainageways contribute large amounts of runoff directly to receiving lakes or streams, and once disturbed, they become high-energy, high-volume conduits for moving massive amounts of pollutants to receiving waters. Site plans that disturb these areas result in much larger volumes of water to manage and treat (and much greater costs for BMPs) than would be required by using other areas of the site for the same purpose.

Steep Slopes. Generally, the steeper the slope, the greater the erosion hazard. This is because the effects of gravity and reduced friction between soil particles on steep slopes means it takes less energy for water to dislodge and transport soil particles. Development often results in making flat areas for such things as roads, buildings and lawns. Creating flat areas on steep slopes exposes more soil surface area to erosion during construction than the same action on flat slopes (Figure 3.40-1). Good site planning avoids placing houses and roads on steep slopes.

Erodible Soils. When denuded of vegetation, areas with easily eroded soils yield greater volumes of transported soil than those with erosion-resistant soils. Proactive planning can avoid disturbing erodible soils in the land development process, so that erosion and sedimentation problems will be avoided.

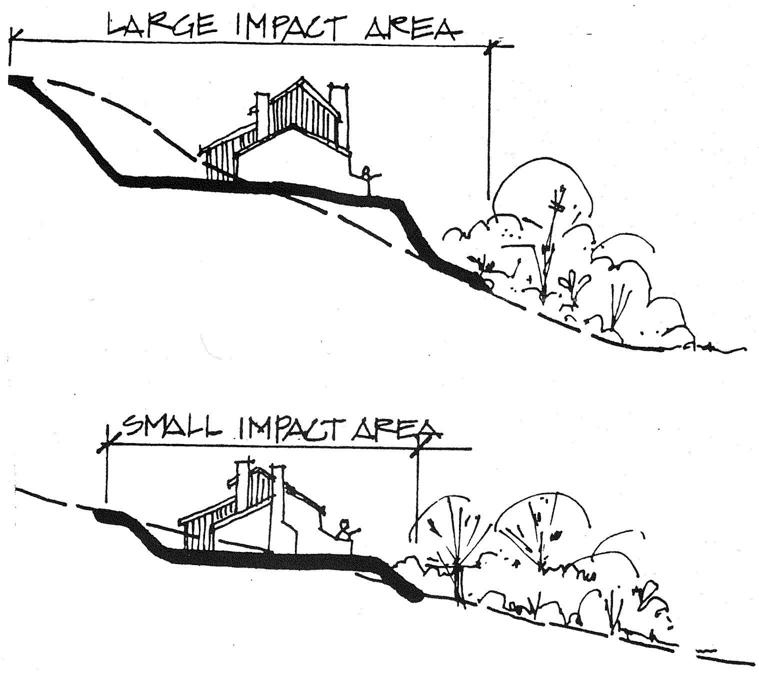


Figure 3.40-1 Making flat areas for home sites on steep slopes disturbs more land area than making flat areas on gentle slopes.

Sensitive areas can be set aside as natural open-space areas to meet open-space-area requirements. Sensitive areas can be used as buffer spaces between land uses on the site or to buffer land uses on adjacent sites as shown in section 3.30. Preserving mature woodlots not only prevents erosion, but can be used to provide visual screening and to establish entry character or boundary definition for the site. Preserved woodlots can be used to preserve views from home sites, and to provide privacy separation between home sites, such as along back property lines. Where preservation needs exceed the open-space requirement for development under straight zoning, cluster development under the planned unit development (PUD) provisions of the zoning code can usually be used to avoid sensitive areas while preserving the gross density allocated to the parcel.

REPRODUCE HYDROLOGIC CONDITIONS

Reproducing hydrologic conditions is a goal that can only be addressed comprehensively at the level of site planning (Schueler, 1987). It means looking at reproducing the full spectrum of hydrological conditions: peak discharge, runoff volume, infiltration capacity, base-flow levels, ground water recharge, and maintenance of water quality.

In the past, peak discharge was considered to be the only problem. As such, it was narrowly defined and easily solved by providing detention facilities.

A comprehensive approach is more difficult, and involves the whole context of site planning, especially in terms of standards and philosophical approach. Runoff volume, infiltration recharge and water quality are greatly affected by the amount of impervious surface. Also important is the configuration of the drainage paths, amount of infiltration and vegetative cover.

In other words, policies are needed that decrease impervious surface and that decrease pipes, sewers and ditching while providing infiltration and protecting natural systems.

Preserve vegetation. Healthy vegetative cover is an important factor in preventing erosion. Disturbance of areas with a well-established vegetative cover causes the greatest increase in erosion risk. Wooded areas with understory cover are the most runoff-absorbent types of cover in the landscape (U.S. Department of Agriculture, Soil Conservation Service, 1986). Destruction of such vegetation adds significant expense to the construction budget for clearing, and destroys trees which are an inherently valuable attribute of the site.

Destruction of a given area with dense vegetative cover produces a greater impact than destruction of the same area of sparse vegetative cover. Destruction of a large area of a given vegetative cover produces greater effects than destruction of a small area of the same vegetative cover. A good site plan preserves large areas of existing dense vegetation.

Provide infiltration. Infiltration into the soil is a natural, cheap, and often the best way to provide stormwater storage volume on a site. Infiltration reduces both the volume of runoff and the peak discharge from a given rainfall event, as well as providing treatment of water by filtration through the soil strata and recharge of ground water. The placement of impervious roofs and pavements in an area removes absorptive capacity. Site planning that locates impervious surfaces in porous soil areas creates the greatest possible change in infiltration between predevelopment and post-development conditions. Placement of the same surfaces in tight-soil areas produces the least change. By devising a site plan that avoids, as much as possible, the placement of impervious surfaces in highly porous soil areas, soil absorption of runoff in a development can be maximized. Such a strategy will pay dividends to the developer in terms of reduced volumes and peak discharges of runoff, which will require the use of BMPs for on-site treatment. It will also significantly reduce the land area that must be committed to detention facilities required for peak-discharge leveling.

Fit development to the terrain. Choose road patterns to provide access schemes that match landform. For example, in rolling or dissected terrain (typical in much of Minnesota), use strict street hierarchies with local streets branching from collectors in short loops and cul-de-sacs along ridge lines. This approach results in a road pattern that resembles the branched patterns of ridge lines and drainageways in the natural landscape, facilitating the development of plans which work with the landform and minimize disruption of existing grades and natural drainage.

Where the topography is characteristically flat, the use of fluid grids may be more appropriate. In this type of scheme, natural drainageways are preserved by interrupting and bending the grid around them. Artificial grassed waterways may then be constructed (at very gentle slopes to maximize pollutant removal), at the back of lots or along the street right-of-ways, to channel runoff to natural drainageways without abrupt changes of direction.

Preserve and utilize natural drainage. Keep pavement and other impervious surfaces out of low areas, swales and valleys. This means preparing site plans in which roads and parking are high in the landscape and along ridges wherever possible, as shown schematically in Figure 3.40-2.

Some development standards and approaches encourage the exact opposite pattern. An example of this is the seemingly desirable requirement for the use of curbing on streets and parking areas in low- and medium-density subdivisions. Curbs are widely held to be the signature of quality development;

they provide a neat, "improved" appearance and also help delineate roadway edges. Because curb-and-gutter streets trap runoff in the roadbed, storm inlets and sewers are logical solutions to providing good drainage for the roadbed. As a result of such thinking, several municipalities require the use of storm sewers and curb-and-gutter streets.

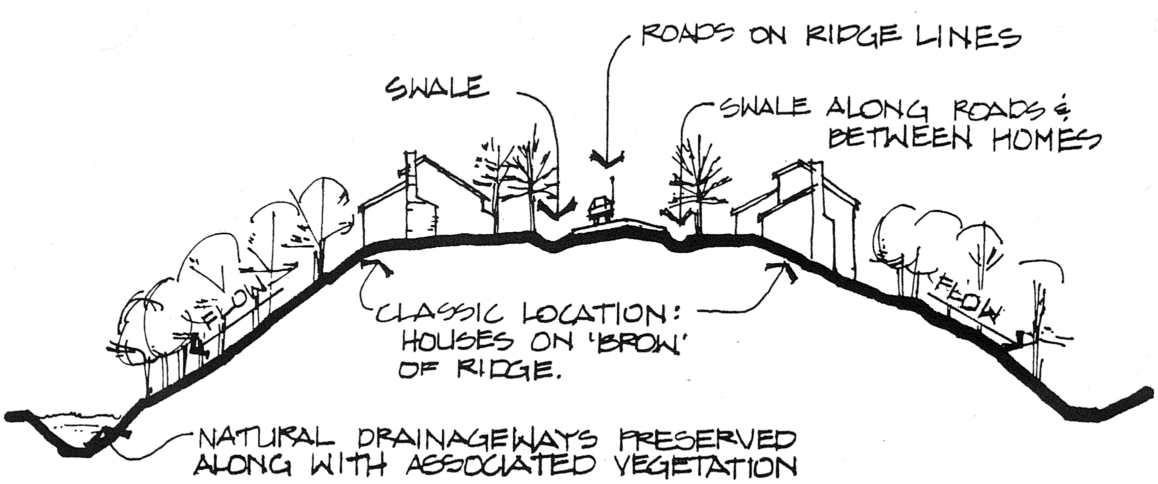


Figure 3.40-2 Place roads along ridge lines. Keep construction areas away from low areas and valley flow lines.

Unfortunately, this solution can create significant stormwater-management problems when looked at in the broader context of devising an environmentally sound land-development scheme. The problem scenario goes something like this. Because storm sewers operate on gravity-flow principles, their efficiency is maximized if they are located in the lowest areas of the site. Since storm sewerage is the preferred technology for providing drainage for the curb-and-gutter streets, it is logical to locate the streets where the storm sewers are best located — in the valleys and low areas, which are the natural drainageways of any site. In this way, natural drainageways can be targeted for destruction; the natural vegetative cover in the most hydrologically critical areas of the landscape is replaced by impervious pavement. Natural filtration and infiltration capacity is lost in the most strategic locations.

Further, in most locations, storm sewers are designed only for short-duration, high-frequency storms (one-hour duration with two-, five-, or 10-year return periods) with flood flows (24-hour duration, 100-year return) handled by street and gutter flows. after the storm sewer capacity is exceeded.

Traditional sewer design often means that the floodways in the landscape are converted from slow-moving, permeable, absorptive, vegetated waterways to fast-moving, impervious, self-cleaning, paved waterways. Hydraulic efficiency is increased, as are peak discharges and flood volumes. Since the natural waterways are paved and specifically designed to be quickly drained by storm sewers, channel storage time is minimized and base flows are sharply reduced together with ground water recharge. The net effect of a seemingly beneficial decision to use curbs can — when thought through in the full, integrated context of site planning decision-making — initiate a snowball effect which amplifies the extremes in the hydrologic cycle, increasing flood flows and reducing base flows.

This scenario also has important effects on water quality. Trace metals from automobile emissions and hydrocarbons from automobile crankcase oil and fuel spillages are directly deposited on the now-paved surfaces of the site's waterways. For the most frequent rainfalls, the first flush of stormwater runoff washes these deposits into the storm sewer system, which is designed to keep in suspension the particles to which the pollutants adhere. The particles, with their attached pollutants, are delivered by the runoff water to receiving waters, where changes in velocity permit the particles to settle out. Nutrient-rich runoff from surrounding lawns is also quickly moved through the paved system with no opportunity to come in contact with plant roots and soil surfaces. The result is efficient delivery of these materials to lakes and streams.

If natural vegetated drainageways are strictly preserved in the site-planning process, flood volumes, peak discharges and base flows will be held closer to their predevelopment levels. Trace metals, hydrocarbons and other pollutants will have a much greater opportunity to become bound to the underlying soil. The infiltration, which would occur along the entire drainageway, would not only contribute to the reduction of runoff volumes, but would also allow nutrients to be taken up by the vegetation lining the drainageway.

A MODERN CLASSIC EXAMPLE

The modern classic example of a comprehensive approach to development incorporating all of these goals is Woodlands New Community located north of Houston, Texas, planned and designed by Wallace, McHarg, Roberts and Todd, Landscape Architects and Planners, Philadelphia, Pennsylvania. This is a 20,000-acre development. This new town was sited on heavily wooded, flat land with extensive areas of poorly drained soils. By working closely with a multidisciplinary team of specialists, including ecologists, hydrologists, engineers and market specialists, a comprehensive plan was developed that preserved the natural drainage system, avoided critical areas, worked with existing topography and maintained predevelopment hydrological conditions.

In the original planning, engineers compared the cost of the natural drainage system to that of a conventional approach and found that the natural drainage option saved over $14 million (Juneja and Veltman, 1980). Further, the conventional approach to stormwater management would have destroyed thousands of trees, lowered water tables, increased runoff volume 180%, degraded downstream water quality and caused a 15-million-gallons-per-day drawdown from the underlying aquifers. The plan avoided or sharply reduced the impact of all of these problems.

The general plan used the existing natural drainage system to provide the major storm subsystem of the stormwater-management plan (WMRT, 1973 and 1974a, b, c). This was accomplished by locating major roads and dense development on ridge lines and higher elevations, while preserving the floodplains in parks and open space and low-density housing on intermediate areas. The minor stormwater-management system focused on maintaining the absorptive capacity of the soil. This was accomplished by careful design of roads, parks and golf courses to maximize infiltration, and the establishment of home-site development strategies that limited impermeable surfaces and included extensive overland drainage systems. Building construction and site grading were also tightly controlled and supervised to preserve the existing soil structure and minimize the area disrupted during construction. The final development increased the volume of runoff generated by only 55% (Juneja and Veltman, 1980).

The ultimate measure of the Woodlands approach occurred in April of 1979. At that time, a record storm hit the Houston area, dropping nine inches of rainfall within five hours. No houses within the Woodlands sustained any flooding (Juneja and Veltman, 1980). Neighboring areas were awash and hard hit with flood damage.

Source: Sykes, August 1989, pp. 3.1-7 through 3.1-8

SITE-PLANNING PROCEDURES[1]

The following procedure for site planning will help designers avoid hydrologic and nonpoint-source water-pollution impacts in housing development:

1. Inventory and map the site.
2. Plan the subdivision.
3. Adapt clusters to the site.
4. Adapt lots to the site.

1. Inventory and map the site.

Working over a topographic map of the site as a base, carefully locate and map all of the critical areas that may exist on the site as described in the previous section on restricting development in critical areas.

The list of goals developed above can be used as a checklist. Map the boundary of each area by carefully determining the limit that should not be crossed by construction activity without causing significant impact. For example, when plotting a natural drainageway, map its flow line, but also be sure to include that area of the adjoining side slopes which, if disturbed, would cause a loss of integrity in its hydrologic function (*i.e.*, side slopes to the top of bank).

The accurate graphic representation of mapped areas is crucial to properly use the map as an aid in site planning. The goal of this map is to provide a clear visual representation of the major patterns of critical areas to avoid, and noncritical areas where it is acceptable to build. To do this, the map must be drawn in a way that facilitates visual pattern recognition. The most difficult figures to recognize and integrate are those that are only outlined. Figures that are both outlined and fully shaded in with a color or pattern are much easier to identify and integrate into concepts for site-planning strategies.

Here are some suggestions for determining the mapping units used, by type of critical area.

- *Shoreline.* Map the water edge and the adjoining areas of riparian vegetation along the water edge.
- *Natural drainageways.* Map flow lines of drainage paths and adjacent areas to top of bank.
- *Steep slopes.* Map slope categories which correspond to the different lot/housing-type combinations to aid matching units to the land and thus avoid excessive lot grading. As a guide, use the slope categories identified below to establish the “boundaries” for the mapping units used. For example, for slopes of 0 to 4%, use flat lots with streets parallel to the contours and rambler housing units. For slopes of 4 to 8%, use sloped lots, with streets parallel to the contours and split-entry or walkout housing units. For streets that run perpendicular to the contours, use side-to-side, split-level housing. For slopes of 8 to 11%, use sloped lots with split-level housing units. For streets that run perpendicular to the contours, use side-to-side, split-level housing units. Slopes steeper than 11% cannot be easily used for residential lots.
- *Dense vegetation.* Map wooded areas with dense undergrowth and forest litter. These areas can be tentatively identified from aerial photographs, but must be field checked to verify actual

[1] This procedure is based upon the Woodlands New Community and the work of Rahenkamp and Associates, Landscape Architects, Philadelphia (Sykes, October 1989).

boundaries and character. Boundaries for these areas should be 10 to 15 ft outside the tree canopy edge to allow for protection of the trees and their feeder roots.

- *Porous soils and erodible soils.* These can be located using the county soil surveys done by the USDA's Natural Resources Conservation Service. The boundaries should be mapped and verified with field checks. Outdated aerial photos should be used only as general guides for site planning.
- In addition to the mapping units suggested, add information that shows the extent of additional flooding, especially into forested areas. If possible, project the increase in the subsurface water levels along the outflow path. This will be useful in determining the areas that could suffer tree mortality from flooding.

2. Plan the subdivision.

Begin planning the subdivision by working on an overlay of the inventory map. Try to arrange clusters of houses so that drainageways and preserved areas fall along the back lot lines between clusters as much as possible. This will provide buffer spaces between clusters. Position clusters so the roads follow ridges or join high points as much as possible. Set and check trial grades for both roads and lot clusters to ensure that prototype slope assumptions are met and to determine the area disturbed by earthwork operations. Adjust layout and slopes as needed to minimize disturbed areas without compromising existing drainage patterns.

3. Adapt clusters to the site.

By working out the objectives and problems of lot-street relationships in a systematic and generalized way in advance, one can more readily see opportunities to capitalize on the physical characteristics of the site to minimize impact and maximize amenities. Systematic lot layout avoids many of the pitfalls encountered by siting the roads before the lots, especially the error of siting the roads through the best home sites. Many municipalities now have planned unit development (PUD) provisions in their zoning codes. The PUD process was developed to provide the flexibility in zoning and subdivision standards needed to accomplish many of the following objectives in the context of a comprehensively designed subdivision:

- Reduce front setbacks to lessen the per-unit amount of paved area via shortened driveways and entry walks. A setback of 20 ft is more than adequate to allow a car to be parked in the driveway without encroaching into the public right-of-way, and it reduces driveway and walk pavement by 30% or more compared to a setback of 30 feet. Setbacks may be needed to separate the home from the noise of the street. But by carefully limiting the number of lots on a local access street, traffic volume (and with it traffic noise) can be held to a minimum. At low traffic levels, it is difficult to justify large setbacks from a health, safety and welfare standpoint.
- Reduce to one, or eliminate, on-street parking lanes on local access roads with less than 200 ADT (average daily traffic) on cul-de-sac streets and 400 ADT on two-way loops. This will reduce impermeable road surface area per unit by 25 to 30%. Even the complete elimination of on-street parking would still provide four parking spaces per unit (two in the garage and two in

the driveway), which is more than is required for rental townhouses in many areas. Single-family, detached housing lots with 75-foot minimum frontages on streets with parking on both sides have parking space for six and one-half cars per house (two in the garage, two in the drive, and two and one-half on the street), which is more than double that typically required for rental townhouses. Because of the low ADT, moving vans and occasional overflows can be parked on the street without seriously obstructing routine and emergency access.

- Limit sidewalks to one side or eliminate them altogether on local access roads with less than 200 ADT on cul-de-sac streets and less than 400 ADT on two-way loops. This reduces impermeable cover per unit by 4 to 8%.
- Use shallow, grassed roadside swales instead of curb-and-gutter/storm sewer technology to handle runoff and provide snow storage. This is very feasible up to net densities of six to eight units per acre. Above that, it is difficult to commit land to swales. The use of roadside swales is especially easy to achieve if roads are placed high or along the ridges, where the drainage area that contributes runoff to the swales is minimized.
- By using the techniques described above, right-of-ways need not be increased by the use of roadside swales. In post-World War II housing developments, the use of such roadside swales was standard. It often resulted in a net decrease in runoff and soil loss levels compared to those generated by the predevelopment agricultural conditions (Jones, 1971).
- Choice of vegetation for the swales is critical to minimizing maintenance. If swales are designed for mowed turf, routine maintenance becomes a part of the abutting homeowners' responsibilities. Repair and removal of sediment then becomes the major maintenance concern, and this should be scheduled on a cycle as with storm sewer repair and cleanout. Such maintenance can be provided by the public works department as a new technology needed to achieve community water-quality goals.
- Properly designed transitions between pavement edge and turfgrass areas are key to the success of roadside swales. Refer to MnDOT standard rural road cross-section templates for proper edge treatments that avoid pavement unraveling and virtually eliminate the problem of snow plow damage. Where off-street parking is a concern, consider using turf reinforcement systems such as pavers, and turf reinforcement mat systems along the pavement edge. All of these systems are capable of protecting turfgrass from even the damage caused by fire truck wheel loads, while still preserving the infiltration capacity of the turf.

4. Adapt lots to the site.

Design the building-to-lot relationships to match site conditions and meet hydrologic objectives. The building-lot relationship is a facet of site planning that is too often not adapted to the site, but is accepted as a given from the zoning code. There are many opportunities to exercise flexibility within the context of zoning. Planned unit-development, cluster development, and the use of restrictive covenants, separately or in combination, provide flexibility to create unit-lot prototypes which help reduce — rather than increase — runoff peaks, volumes and velocities.

- Design the unit-lot relationship in the context of the overall site topography. The slope map will aid in directing this task. Try to use unit floor plans that match the slopes. Do some schematic cross sections through various street-lot combinations to arrive at prototypes that match the site.
- Look at the total pavement and roof area for the unit-lot combination. This requires trying some of the house and site arrangements on paper. Very often, zoning requirements imply large amounts of paving or do not restrict all of the impervious surfaces on home sites. Consider using

deed restrictions to limit total impervious surface area below that permitted by zoning. A maximum of 2,200 square feet (ft^2) of impermeable surface (roofs, walks, drives, patio, etc.) on a 1/4-acre lot can reduce the amount of impervious surfaces by as much as 25% compared to typical development. This would still allow a maximum building footprint (house plus garage) of 1,400 to 1,600 ft^2 per unit usable living space. Totals from 1,800 to 3,300 ft^2 can be achieved by using split-entry, two-story or walkout floor plans.

- Use the PUD provisions for cluster development. This can enable the use of narrower lot frontages so that the area of road pavement required to serve a given lot area can be reduced. With careful site planning, this can significantly reduce the per-unit amount of impervious surface generated by development. Clustering will also yield further savings by reducing the cost of street and utility extension needed to serve a given number of lots.

- One of the areas of greatest potential for reducing impervious surfaces is commercial development.

  Conventional Design. Figure 3.40-3 represents a typical "strip" commercial development. Very little natural open space is maintained in this design due to the amount of space consumed by parking. In addition, this type of site design necessitates automobile use. Given the open nature of the site design, one would most likely drive to get from the bank to the grocery store.

  Strategy for Innovative Design. Figure 3.40-4 incorporates features that preserve open space and reduce impervious cover. Specifically, the parking ratio is reduced compared to the conventional site design, and compact and pervious overflow parking spaces are used. In addition, the design encourages pedestrian use by arranging the buildings in a U shape, to reduce walking distances.

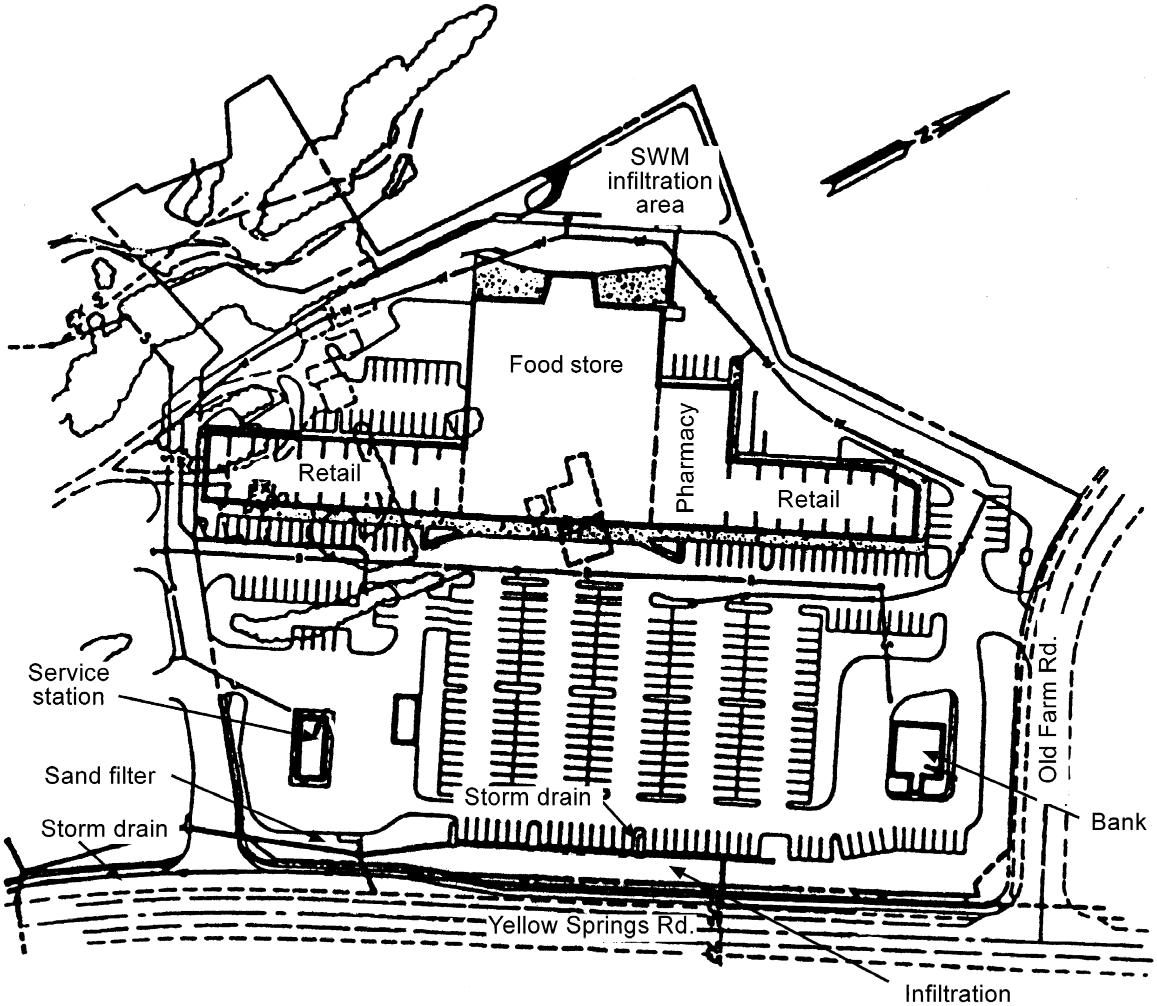


Figure 3.40-3 Retail shopping center: conventional design

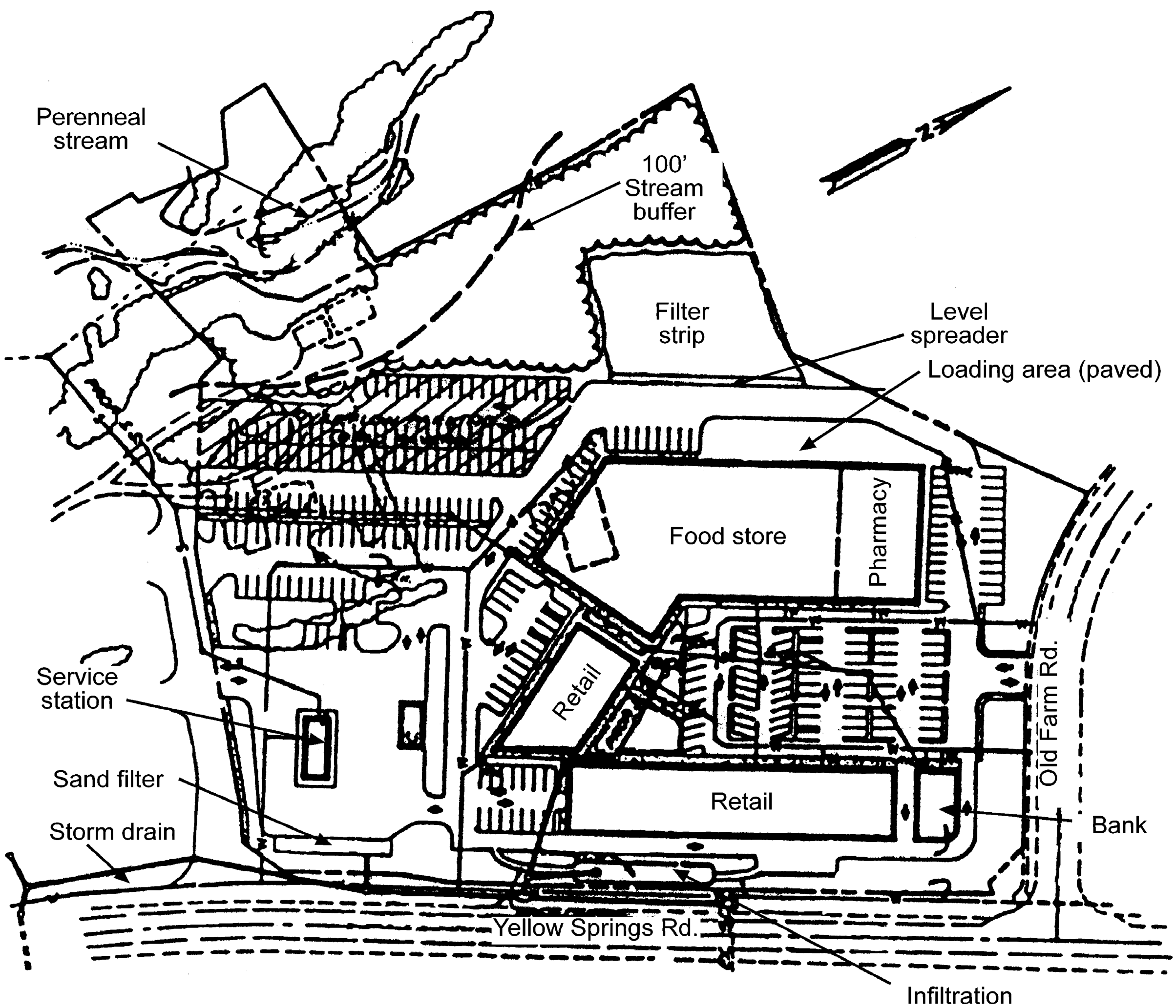


Figure 3.40-4 Retail shopping center: innovative design

3.50 REHABILITATION AND RESTORATION POLICIES

If nonpoint-source pollution has degraded existing water resources, a different process must be used to select practices. However, this is much less desirable than protecting water quality in the first place. Once an area is developed, the options to improve water quality are much more limited. Invariably, the options are also more expensive.

When BMPs are being selected to correct an existing water-quality problem, the process used to arrive at the proper mix of practices includes the following steps:

1. Identify water-quality problems.

Some water-quality problems are easy to identify because they are associated with visible effects, such as streambank erosion or heavy sedimentation in lakes. But water-quality problems can be difficult to define if they are subtle and develop over a period of years. Identifying water-quality problems involves both scientific judgment and public perception. A three-level definition of a water-quality problem was adopted by the Nationwide Urban Runoff Program (NURP) (USEPA, 1983). This definition lists three ways by which water-quality problems can be identified. The three ways are (1) impairment or denial of a beneficial use, (2) violation of a water-quality criterion and (3) local public perception.

The first way to identify water-quality problems involves cases where the water can no longer be used for its intended purpose. An example is a lake that should support swimming, but which can no longer be used for this purpose.

The second way to identify a problem is when criteria such as water-quality standards are violated. Water-quality standards vary, depending upon a number of factors, including designated use. This method of identifying a water-quality problem is especially important when the effects of pollution may not be visible for a number of years. For example, the effects of excessive nutrient loadings from urban runoff in a lake may not be visible until after serious damage has occurred and problems such as frequent algal blooms are present.

The final method of problem identification is public perception. Public perceptions of water-quality problems vary widely because of the many uses that people have for water. Often, public perception involves visible problems, such as turbidity, odor, algal blooms and fish kills. If the water-quality problem is not obvious, an educational effort may be needed to increase public awareness and understanding.

Public perception is especially important when developing a program to control nonpoint source pollution. In most cases, a local unit of government will be the entity that deals with this issue. For a local unit of government to effectively address nonpoint-source problems, the public must be aware of the water-quality problem and support the needed measures. For more information on identifying water-quality problems in lakes, refer to Heiskary and Wilson, 1988.

2. Identify the pollutants causing the problem.

Before nonpoint-source pollution can be controlled, the contributing pollutants and their sources as well as their effects on the water resource must be identified. The identification process often involves water-quality monitoring and a diagnostic study. A water-quality-monitoring plan should be developed that identifies monitoring needs. In all cases, these monitoring plans should be designed by qualified persons. Sampling, laboratory analysis and data analysis should also follow proper procedures.

Computer modeling may have a role in determining pollutant loading, but it is generally not an appropriate substitute for monitoring. However, computer models can be quite effective for comparing relative changes in water quality with the use of various BMPs. When computer models are used, it is important to select the proper model and understand its limitations. The MPCA has prepared a summary of many of the computer models that are available to evaluate nonpoint-source pollution. This summary is available in chapter 8.

For information on existing water-quality-monitoring data for particular areas, contact the MPCA. This agency has water-quality-monitoring data for many locations in Minnesota.

3. Set the water-quality goal.

Once a water-quality problem is identified, a realistic goal for water quality must be set. A realistic goal is one that is attainable, given the land use and physical characteristics of the watershed and available methods of treatment. If an unrealistic goal is set, it may never be achieved or may be prohibitively expensive. Some goals may not even be appropriate for a particular waterbody. Once the point of diminishing returns for water-quality benefits is reached, the cost of additional treatment can increase drastically. The question that must be addressed is, what level of treatment is justified for a given situation?

It is also important to have a realistic expectation of the time needed for water quality improvement. It may take many years before improvements are seen in lakes and ground water. For more information on setting water quality goals, refer to Heiskary and Wilson, 1988.

4. Select appropriate BMPs.

Selection of individual BMPs is very site and situation specific. Chapter 2 and Chapter 4 of this manual provide guidelines for BMP selection.

5. Implement, operate and maintain BMPs.

Before BMPs can be selected, a method of implementation must be chosen. There are several approaches that can be taken to implement urban BMPs. They include:

- information and education programs with voluntary compliance,
- local regulation of certain land-use activities, and
- local government ownership and operation of regional BMPs.

Although educational programs can be an important part of a nonpoint-source-pollution program, their effectiveness can vary greatly. If an education program is to succeed, the public must be convinced that a problem exists, and that their actions can help correct it. Information and education programs should be an ongoing effort. A one-time campaign may result in some short-term improvement with few long-term benefits. Information and education programs can be useful in addressing problems, such as improper use of fertilizer on home lawns.

Local regulation can also be an effective approach. For example, sediment and erosion control on construction sites is an activity that may be most appropriately controlled with regulation. All land users involved in the regulated activity will be required to meet the same criteria.

Several elements have been suggested for successful regulation in a nonpoint-source-pollution program. First, the regulation must be at the local level. Second, the standards for the regulation must be reasonable. Finally, there must be uniform enforcement of the regulations so that developers and others affected will know what it will cost them.

Involvement of local units of government in the ownership and operation of regional BMPs is another alternative that may be appropriate. For practices such as detention ponds, regional structures that control several hundred acres or more may be the best alternative. Some advantages of regional basins are that costs of control are reduced, control of developed areas is possible, and fewer structures will need maintenance (USEPA, 1983).

Also, if peak discharge control is a goal, regional detention facilities can be more effective than on-site structures. Several investigators have concluded that random placement of stormwater detention facilities in a watershed may have little or no effect on peak discharges downstream (Pitt, 1998).

Local units of government incur significant capital costs when regional treatment measures are used. These costs can be recouped by “in-lieu-of fees” charged to developers or by other mechanisms. Because of the economies of scale involved, the cost to developers may end up to be less than with the on-site BMP alternative.

The final program will often include all three of these methods, with each one targeting a specific problem or category of land users. For example, a local unit of government dealing with a nutrient problem in surface water may decide that the following mix is appropriate:

- An education program directed to homeowners about fertilizer use and control of lawn and leaf litter.
- Local ordinances to regulate fertilizer application rates used by commercial applicators on lawns.
- Regulation of sediment- and erosion-control practices on construction sites.
- Construction of detention ponds that also provide flood control.

Operation and maintenance of structural BMPs is crucial, and it must be carefully considered in the planning stages of a project. A detailed maintenance plan should list inspection intervals and regular maintenance as well as identifying responsible persons or organizations.

After BMPs are implemented, an evaluation should be made of their effectiveness. This may involve a monitoring program to determine the benefit to water quality. For educational programs on housekeeping practices, part of the evaluation may be a survey to determine how many residents have changed practices on their property. In any case, an assessment should be made to determine whether additional measures are needed to meet the water-quality goal.