Prepared by the State of Minnesota
Storm-Water Advisory Group

Storm-Water And Wetlands:

Planning and Evaluation Guidelines for Addressing Potential Impacts of Urban Storm-Water and Snow-Melt Runoff on Wetlands

June 1997

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- Storm-Water and Wetlands: Planning and Evaluation Guidelines for Addressing Potential Impacts of Urban Storm-Water and Snow-Melt Runoff on Wetlands
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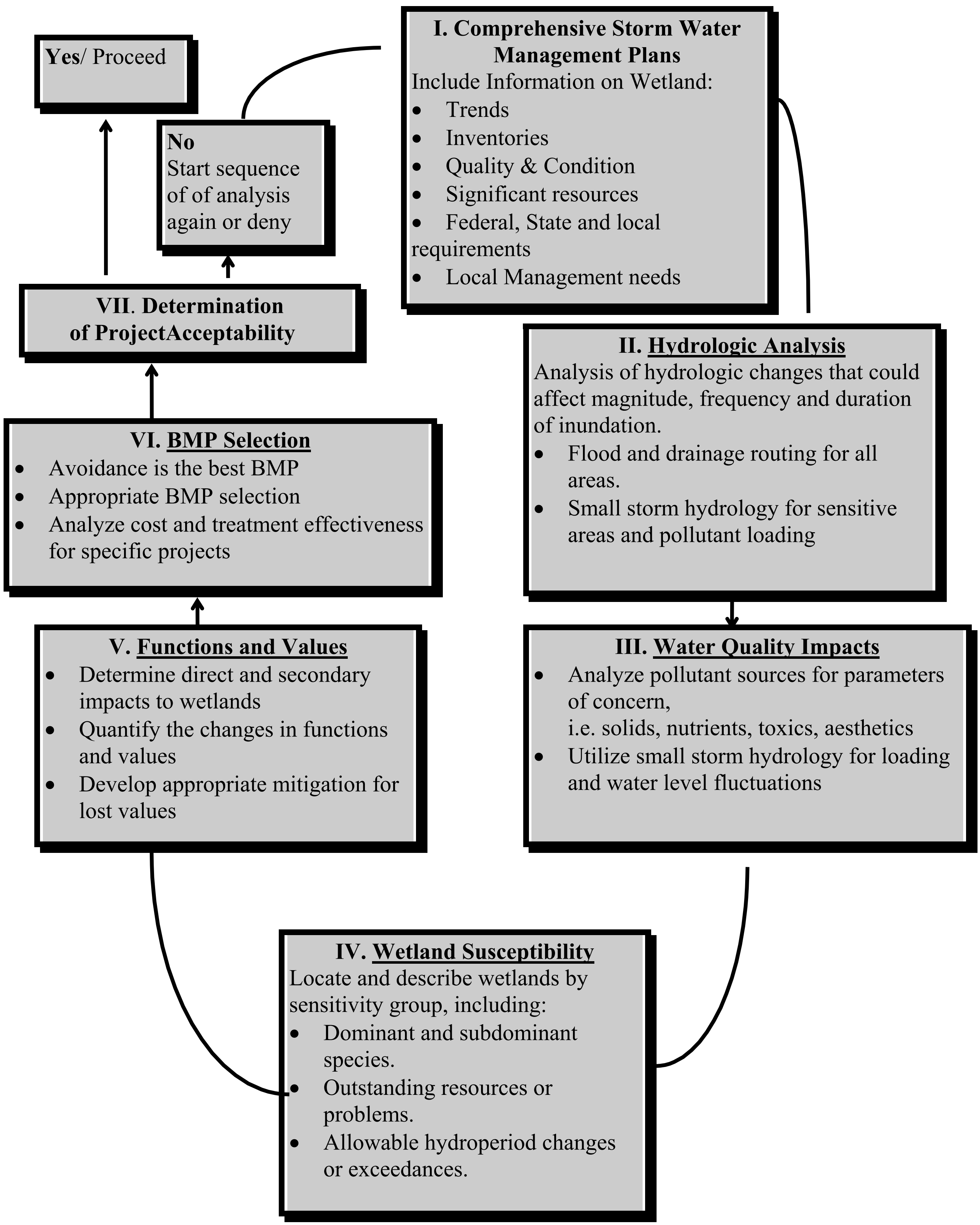
Table of Contents

PROCESS FOR EVALUATING URBAN STORM-WATER AND SNOW-MELT RUNOFF TO WETLANDS AND OTHER WATERS



Preface

This publication presents recommended guidelines of current concepts for managing storm-water and snow-melt runoff when it is necessary to use wetland areas. The Urban Storm Water Advisory Group acknowledges that wetlands are often affected by storm-water management; decisions and wetland responses to changes in storm-water flows can be highly complex and can affect other waters, such as lakes and streams. Though this document focuses on avoiding impacts to wetlands from storm water and snow melt, keep in mind that wetlands are part of a larger hydrologic system. Poor storm-water management can readily damage not only wetlands, but lakes, streams and ground-water resources as well. This guidance seeks to balance storm-water and flood-flow management with ecological protection.

Comprehensive plans for local government units, including cities, counties, and watershed management organizations, should address the management of the effects of urban storm-water and snow-melt runoff on wetlands and associated water courses and basins. These guidelines should be considered whenever there are storm-water discharges to natural water courses and basins, including wetlands, so as to minimize any adverse impacts to the diverse biological systems. The aim of these guidelines is to reduce chemical and physical degradation to water uses, aquatic habitats, and the level of water quality necessary to sustain such uses.

These guidelines are intended to assist managers in designing a process that minimizes wetland impacts. The guidance does not take the place of any criteria administered by local, state, and federal agencies. The project must meet any requirements of the state Environmental Policy Act (M.S. 116D) and the state Environmental Rights Act (M.S. 116B), and comply with all permits issued by any unit of government. The permits include, but are not limited to, those issued by local governments under the state Wetland Conservation Act of 1991 (M.S. 103G), Protected Waters permits (M.S. 103G.245) issued by the Minnesota Department of Natural Resources, permits issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act, and certifications by the Minnesota Pollution Control Agency under Section 401 of Clean Water Act.

This guidance was developed to summarize the existing knowledge about impacts of runoff to wetlands. Recommendations are included that attempt to standardize how various units of government can implement the guidance in existing planning and regulatory processes. New regulatory programs based on the guidelines may need to be developed, but this should be done if current programs cannot effectively incorporate the guidance concepts, and only after significant public and governmental input. The advisory group that developed the guidance intends that it become a source of common understanding so that current required programs can be made more effective in controlling environmental impacts at the same time they can be made less burdensome through procedural simplification and clear statements of regulatory expectations.

Introduction

The purpose of this document is to provide guidance to local governmental units (LGUs) on what they must do if they wish to protect wetlands from storm-water and snow-melt discharges to wetlands. It is not a rule, it provides technical guidance for implementation at the local level. It is the intention of the work groups that the concepts contained in this document be incorporated in planning and regulatory processes.

LGUs often have asked the question, "Will the discharge of storm water to wetlands be prohibited?" The answer is clearly no; wetlands require storm water for their existence. However, changes in the quantity or quality of storm-water discharges can affect or even destroy the ability of wetlands to support aquatic life and other sensitive functions.

So what is the impact of our storm-water discharges to wetlands? The agencies involved in the development of this guidance have reached a general consensus that the type of wetland determines its sensitivity. A plan and process that adequately addresses wetland sensitivity will not allow storm-water discharges that destroy the existing nature of the wetland, including its functions and values. As was stated in the preface (and is worth repeating), keep in mind that wetlands are part of a larger hydrologic system. Poor storm-water management can readily damage not only wetlands, but lakes, streams and ground-water resources as well. This guidance seeks to balance storm-water and flood-flow management with ecological protection.

The implementation of urban storm-water management plans that minimize adverse impacts to wetlands and other waters can be achieved through the use of a comprehensive management approach. All elements of a storm-water plan must consider a watershed or other large-scale areas as opposed to piecemeal, project-by-project approaches.

The complexity of the storm-water runoff and wetlands issue is due to the numerous factors involved when storm water is discharged to wetlands. Those factors include: (1) the nature of the proposed change such as urbanization of a natural watershed; (2) changes in the quantity of storm-water input to each wetland; (3) changes in the frequency and duration of storm-water input; (4) changes in the quality (pollutant concentration and load) of the runoff; (5) the sensitivity of the particular wetland (e.g., a tamarack swamp is more sensitive to storm water input than a reed canary grass or cattail marsh); (6) changes in functions and values of a particular wetland from its current state; (7) need for management practices to minimize the potential losses; and (8) selection of appropriate mitigation to compensate for lost wetland functions, values and uses.

The Metropolitan Watershed Management Act and the enabling rules (MR 8410.0000) require, after January 1, 1995, that watershed and local plans address wetlands in the plans. Because of the new round of plan revisions that are currently being implemented, it is clear that LGUs have a major role to play in the protection of wetlands.

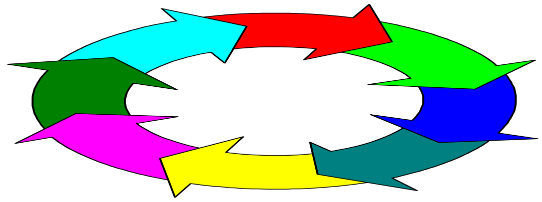
The key element of these recommendations involves developing an inventory of wetlands by vegetation type which then can be placed in a sensitivity group. The purpose of this grouping is to indicate what level of protection is needed and, therefore, indicate the detail of planning needed. A guide to acceptable levels of hydrologic change is presented in this document. For some wetlands this means no change and for others there could be a range of acceptable levels. The more sensitive the wetlands, the more we need to identify existing and proposed land use in the watershed. Land-use changes can create corresponding effects on hydrology and on pollutants.

For most LGUs, this guidance recommends some concepts in hydrologic analysis to determine the effect of the present and proposed development. Most local metropolitan governments analyze flood and drainage events. A great number of LGUs currently analyze only rainfalls of 2 inches or greater for pollutant treatment. This guidance recommends that LGUs analyze small-storm hydrology to understand the hydrologic impacts to sensitive wetlands, stream-bank erosion, and pollutant treatment. Storms of less than 1.25 inches of rainfall depth contribute a large portion of annual runoff and pollutant loads. There are also differences in the runoff characteristics and sources that the LGUs should be aware of when analyzing flood routing.

Through State Executive Order 91-3, Minnesota state agencies were instructed to strictly apply the principles of no-net-loss of wetlands in the conduct of all their activities which affect wetlands. This policy was essentially codified in statute with the passage of the Wetland Conservation Act of 1991. With passage of that Act and subsequent rules, the no-net-loss sequencing process of avoidance, minimize, and compensate for wetland losses was focused on wetland draining and filling activities. This document expands on guidance for avoiding and minimizing wetland losses resulting from storm water so as to meet wetland protection goals. The guidance provides a sequence for decisions made by the developer or governmental agency in order to avoid, minimize, and/or mitigate the impacts of a project. The recommended sequence avoids impacts by design, layout, and site specific action that do not change the basic hydrologic cycle or pollutant loading, a constant theme of all regulatory agencies. The guidance stresses specific measures that help to avoid discharges which will destroy sensitive wetlands, and to bypass or fingerprint the especially sensitive or protected areas. Ponding is often not enough. Special measures may be needed to reach the recommended criteria of “no change” in ambient conditions. Ponds and other measures should be analyzed for their impacts and adjustments made until acceptable protection can be attained. The guidance should also convey the message that mitigation of unavoidable impacts does not occur if you adopt the process of simply replacing wetlands acre per acre. An analysis of values and functions must be made on a site specific basis. The replacement of values and functions should be analyzed “value for value” and “function for function.”

The guidance points out that when approached as an opportunity and not only as a requirement, mitigation provides the opportunity to enhance or benefit the community as you mitigate losses.

Sec. I. - COMPREHENSIVE STORM-WATER MANAGEMENT



Storm-water discharges to wetlands may be a significant portion of the comprehensive storm-water 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 storm-water and wetlands plans. These issues are discussed in detail in some of the appendices to this chapter. As with all plans, the first step should be a survey of existing information. Good wetland management would include a mapping of all the wetlands in the watershed, and associated normal flow paths.

The following five steps are proposed as a method for planning and prioritizing local wetland protection and management needs.

Wetland Trends

Until recent years, wetlands were viewed as wastelands that were best drained or filled. It is estimated the state of Minnesota has lost nearly 42 percent of its original wetland acres (Dahl, 1990). Since wetlands are now recognized as contributing significant functions and values, their historic loss might be viewed as a deficit. It will be useful to quantify on a local level what types and acreage of wetlands historically have been prone to drainage, filling or other impacts. By quantifying this information the local trend of wetland loss can be better understood. It is recommended that existing information such as soil surveys and land-office records be used to determine the historical wetland base within the area of concern or jurisdiction (Galatowitsch, 1994). The county soil and water conservation district office may be able to assist with providing or interpreting this data.

It is recommended that the relative historic acreage and frequency of occurrence of various wetland sensitivity classes be developed. This information will be useful in determining the need and potential for wetland restoration within the watershed when confronted with specific wetland mitigation requirements and other wetland prioritizing needs.

Wetland Inventory

It is recommended that inventories of existing wetland resources be completed by the local unit of government. Existing information such as the National Wetland Inventory (NWI) can be used as a starting point for these inventories. Because very little of the NWI information has been field verified and much of the original aerial photography was made over 10 years ago, it is recommended to use the NWI only as a guide to field activities. Field visits will be necessary to carry out other parts of this process and verification of NWI information can be done at that time. Wetlands should be identified in the inventory and classified according to their appropriate wetland sensitivity group. The size should be estimated and the surface hydrologic connections should be recorded for each wetland identified on the inventory.

A wetland site visit should be conducted to determine each wetland's sensitivity group. The appendix for Section IV, Wetland Sensitivity, contains a fairly comprehensive listing of wetlands types, including a description of their sensitivity type. This classification is key to the plan. Figure I-1 (p. 5) gives a wetlands management process for storm-water-related activities. Once the wetland sensitivity has been categorized, for each individual wetland type, you can enter the chart on the left and be led through the chart by conducting a variety of assessments. The following describes these steps.

Wetland Quality and Condition

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

There are two strategies which it is generally agreed are best for assessing wetland quality and condition:

a) Quantitative research-type method that is resource-intensive. This may be necessary to assess identified high-priority wetlands and continue to monitor their relative condition.

b) 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 contract out for evaluating each wetland basin or complex occurring within the watershed. A useful example that can be adapted for this kind of assessment is the Minnesota Assessment Methodology.

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

Wetland quality can be assessed as excellent, moderate, or highly impacted, depending on the extent to which human activities have affected the wetland. The wetland should be evaluated using the following criteria:

1. Excellent-Quality Wetlands. These wetlands 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

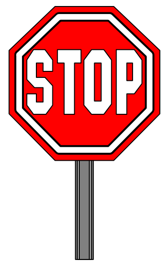
present, are infrequent and do not comprise significant relative cover percentiles. Wetlands which support rare, threatened, or endangered species are likely to be included as high-quality wetlands.

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

3. Highly-Impacted Wetlands. Areas that have been severely degraded such 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. Example wetlands include abandoned gravel pits, nutrient-loaded wetlands, storm-water detention basins, and dredged areas within wetlands that result in extreme hydrologic modifications.

Significant Resources

Wetlands 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 as significant resources. Other significant wetlands would include those which have been restored for specific purposes such as water-quality improvement, wildlife, industrial, or agricultural uses. Wetlands known to be important to local recreation activities such as hunting, fishing or bird watching, wetlands occurring within parks, shoreland areas, and conservation corridors would also be considered to be significant resources.



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

a. is on the Minnesota Department of Natural Resources protected waters inventory (MS 1036.245);
b. has a direct hydrologic association with a designated trout stream;
c. borders the Mississippi or Minnesota Rivers or Lake Superior;
d. borders a state or federal wild and scenic river;
e. has been restored or created for mitigation purposes;
f. is within an environmentally sensitive area or environmental corridor identified in a local water management plan, special area management plan, special wetland inventory study, or an advanced identification study;
g. is recognized as an Outstanding Resource Value Water (Minn. Rules Ch. 7050);
h. is within a local, state or federal park, forest, trail or recreation area;
i. is within a state or federal fish and wildlife management refuge and/or area;
j. is part of an archeological or historic site as designated by the State Historic Preservation Office;

k. is part of a sole-source aquifer recharge area;
l. provides endangered species habitat;
m. has biological communities or species that are listed in the Natural Heritage inventory database;
n. is recognized as an important local recreation resource.

Notes:

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

2. The flow chart I-1 indicates that excellent-quality wetlands and those that involve red flags are of special concern and every attempt should be made to apply these guidelines.

3. Excellent-quality wetlands of all types are very rare and becoming more rare as time and development goes on. They are therefore given red flags.

4. It should be noted that highly sensitive wetlands, even of moderate quality, are red flagged because of the care that must be taken in order to preserve them. Also, these types of wetlands are not easily mitigated by providing off-site compensation. They often cannot be reproduced through artificial means.

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

Management Needs

It is the intent of these guidelines that local option wetlands will, at some point in the future, require less state and federal regulatory review such as general permits. Projects that affect excellent-quality wetlands and "red flag" wetlands still would go through normal regulatory processes.

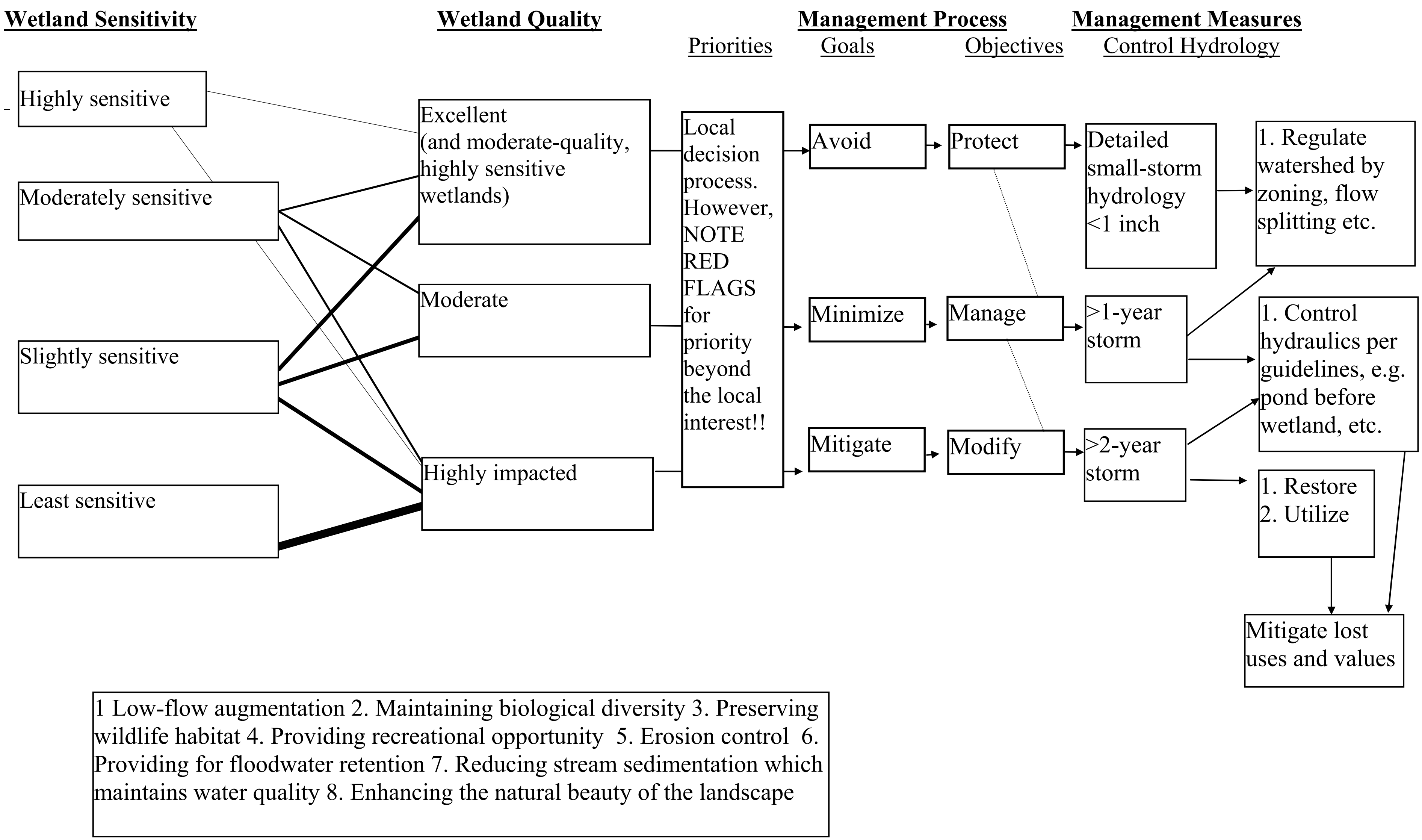
While there probably will not be a complete cessation of state/federal regulatory activity for wetlands of less concern, there may be a great deal more latitude allowed in decisions relating to hydraulic modification or the mitigation sequencing required for these types of projects. It is intended that general permits or other types of regulatory measures be taken to expedite permit issuance procedures. However, even under an expedited regulatory process, compensation should be required for losses of uses and values. Maintaining public uses and values is a very important component of maintaining the entire function of a watershed. Piecemeal destruction of minor wetlands or changes in the hydraulic regime can significantly damage the entire system through changes in erosion, nutrients, or other pollutant loading on the system.

SECTION I

Figure I-1

Wetland Inventory and Management Process

This table provides a decision chart for storm-water-related activities. It is not intended for determining fill or drainage for development, rather for hydraulic utilization and excavation activity related to storm-water conveyance.



Often certain wetlands, because of their position in the watershed, morphometry, surface-flow connections or other physical attributes. are especially well-suited to be part of a storm-water 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.

Considerations for the Local-Option Decision Path

Information layers on wetland 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.

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

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

Wetlands which are of lower sensitivity to storm-water discharge, or are impaired, present opportunities for improving wetland integrity. In the storm-water-related activities decision chart (Figure I-1), these wetlands would be classed as "local option" wetlands. These may be good candidates for applying guidelines for control of "storm bounce" and pollutant loading, or to modify the wetland basin for improved storm treatment. In a planning context, this is not an easy decision to make, and there's no prescriptive means of further defining how these wetlands should be viewed. However, where possible, the following should be considered in making these decisions:

1) Relative rarity of wetland habitat types remaining in the wetlands in comparison with historical ratios of wetland types. Even if they are impaired, a diversity of wetland types is preferred.

2) Amount of fragmentation and isolation of a wetland that would result.

3) The possibility of avoiding, through zoning or other means, development or other pressures which would influence the integrity of the wetland basin.

4) Ability to minimize the impact of storm-water flows on the wetland through consideration of alternatives.

5) The relative position of the wetland within the watershed in relation to other surface waters.

6) Greater recognition of seasonal features of wetland importance, such as ephemeral wetlands which provide 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 fairly shrimp.

Mitigation of Functions and Values

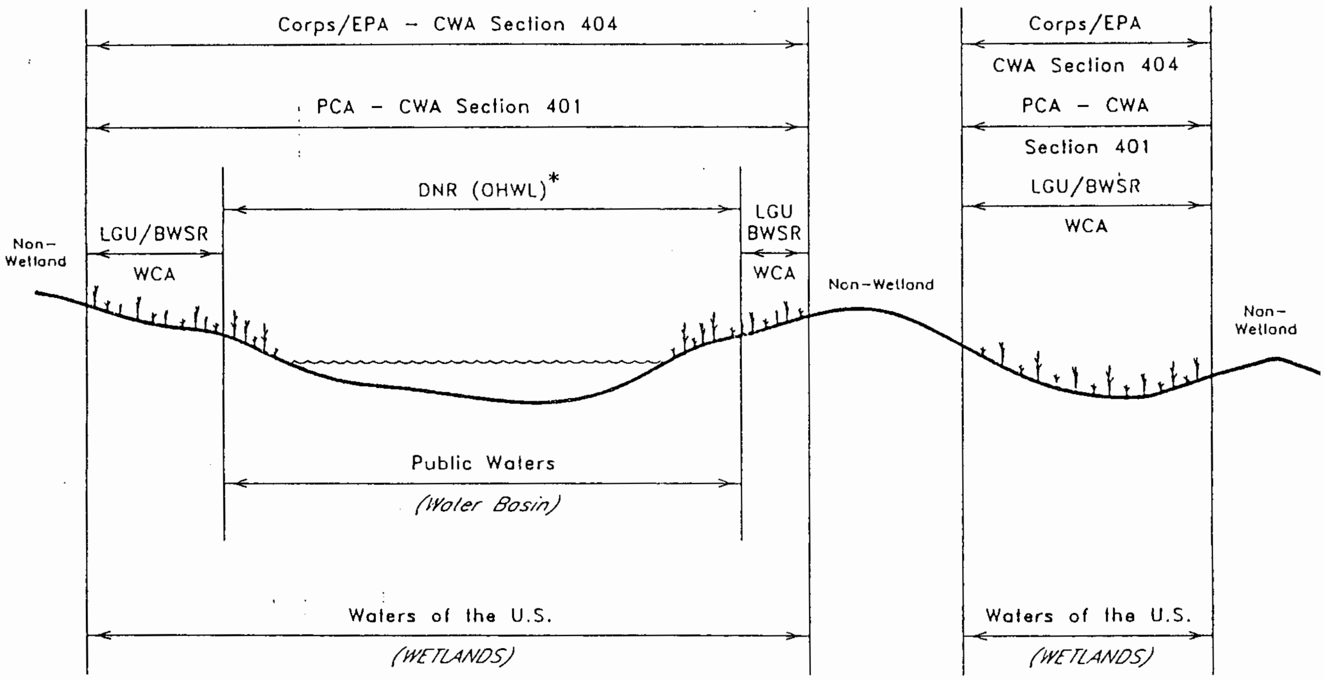
If a wetland must be used, mitigation should be considered, especially in cases where a wetland is targeted for expanded hydrologic utilization that will not comply with the guidelines presented in this document. If utilization will change the wetland character and these conversions result in changes in the uses that a particular wetland can provide, compensation must be provided. Ideally, this compensation must replace the affected wetland's uses and function. At a minimum, compensation is intended to maintain the no-net-loss wetlands policy enacted at the local, state and federal levels of government. One of the prime questions in replacement is whether wetland values can be replaced on-site in the watershed or at remote locations. Section V gives some guidance on the importance of each wetland value and the location in which it must be compensated. Mitigation for all lost functions and values should be provided, even if less-strict regulatory and management options are allowed under these guidelines.

For further information, we recommend the following:

1. EPA, September 1993. "Urban Runoff Pollution Prevention and Control Planning."
2. Minnesota Pollution Control Agency, October 1989. "Protecting Water Quality in Urban Areas."
3. Board of Water and Soil Resources, August 1, 1992. Minn. Rules Ch. 8410, "Metropolitan Area Local Water Management."
4. Minnesota Department of Natural Resources. July 3, 1989. Minn. Rules Ch. 6120, Shoreland Ordinances.
5. Minnesota Department of Natural Resources. __________ 19___. "A Guide to Land and Water Resource Management Programs in Minnesota."
6. Minnesota Board of Water and Soil Resources _________ 19___. "Handbook for Comprehensive Local Water Planning."
7. Minnesota Assessment Methodology. 1995. Board of Water and Soil Resources. Guidelines For Assessment of Wetland Functions and Values In Minnesota.

State and Federal Jurisdiction over "WATERS"

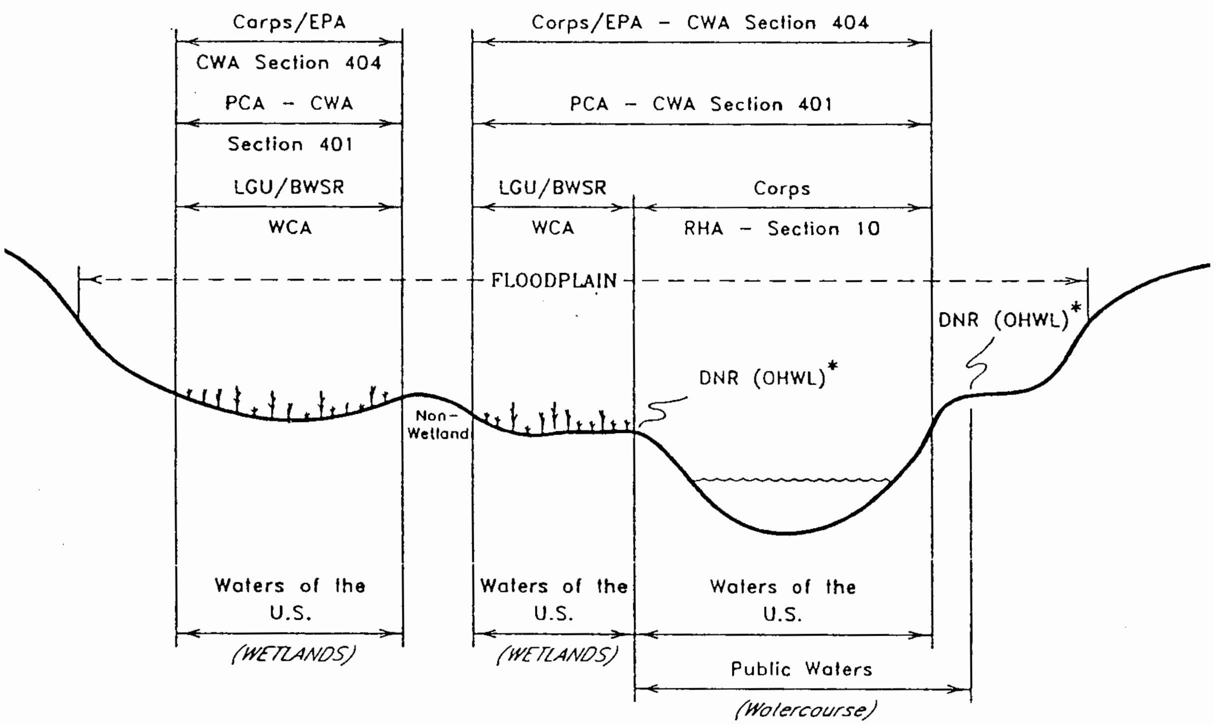
Public Waters: Water Basin



* **Ordinary High Water Level**
The OHWL is an elevation delineating the highest water level that has benn maintained for a sufficient period of time to leave evidence upon the landscape, commonly the point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial.

Note:
Most local government units (LGUS) have adopted state shoreland and floodplain zoning requirements into their zoning ordinances. Check with your local zoning office for requirements related to building sites, sewage treatment, grading and filling and vegetative removal.

Public Waters: Water Course



* **Ordinary High Water Level**
The OHWL (for water courses) is the elevation of the top of the bank of the channel.

Note:
Most local government units (LCUS) have adopted state shoreland and floodplain zoning requirements into their zoning ordinances. Check with your local zoning office for requirements related to building sites, sewage treatment, grading and filling and vegetative removal.

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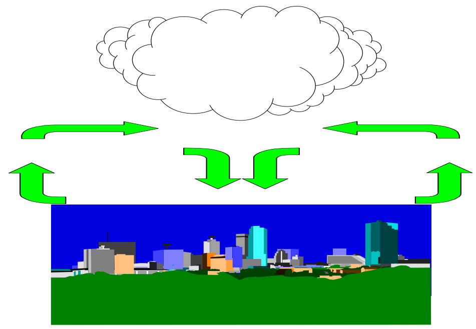
SECTION II

SEC. II - HYDROLOGIC ANALYSIS



Urbanization Changes Hydraulics

When an undeveloped area changes to support urban land uses, drastic changes in the local hydrologic conditions often result. As land is covered with roads, buildings, and parking lots, the amount of rainfall that can infiltrate into the soil is reduced. This increases the volume and changes the timing of runoff from the watershed. Figure II-1 shows the relationship of runoff, infiltration, and evaporation for watersheds with varying degrees of impervious cover. Typical impervious cover percentages are also shown.

Hydrologic Changes in Wetlands and Waterways

Water is the driving force in wetlands. A naturally fluctuating hydrologic cycle over hundreds or thousands of years has helped shape the plant and animal communities present in wetlands. Many of the organisms and plants have become adapted to fluctuating water levels, saturated soils, and anaerobic conditions. Wetlands have adopted to natural cycles of wet and drought. These are important factors in natural wetland hydrology that maintain the functions and values that wetlands provide.

In the pre-settlement landscape of the Midwest, entire watersheds were in vegetative cover (e.g., prairie, oak savanna) with maximum infiltration and minimum runoff. With the massive conversion of this landscape to agricultural and urban uses came substantial changes in runoff to wetlands as well as lakes and streams.

Removal of perennial vegetation led to a decrease in infiltration and an increase in the volume of runoff. Soils exposed to wind and water erosion led to increased sediment loads carried by runoff, and artificial drainage systems accelerated removal of water from the landscape. Fertilizers, pesticides, automobile exhaust residues, animal waste and other sources greatly increase nutrient loading and contaminants carried by runoff. All of these factors had prominent roles in altering and degrading wetlands.

Impact of Development

When an urban area is developed, natural drainage patterns are modified as runoff is channeled into road gutters, storm sewers, and paved channels. These modifications can increase the velocity of runoff, which decreases the time required to convey it to

FIGURE II-1

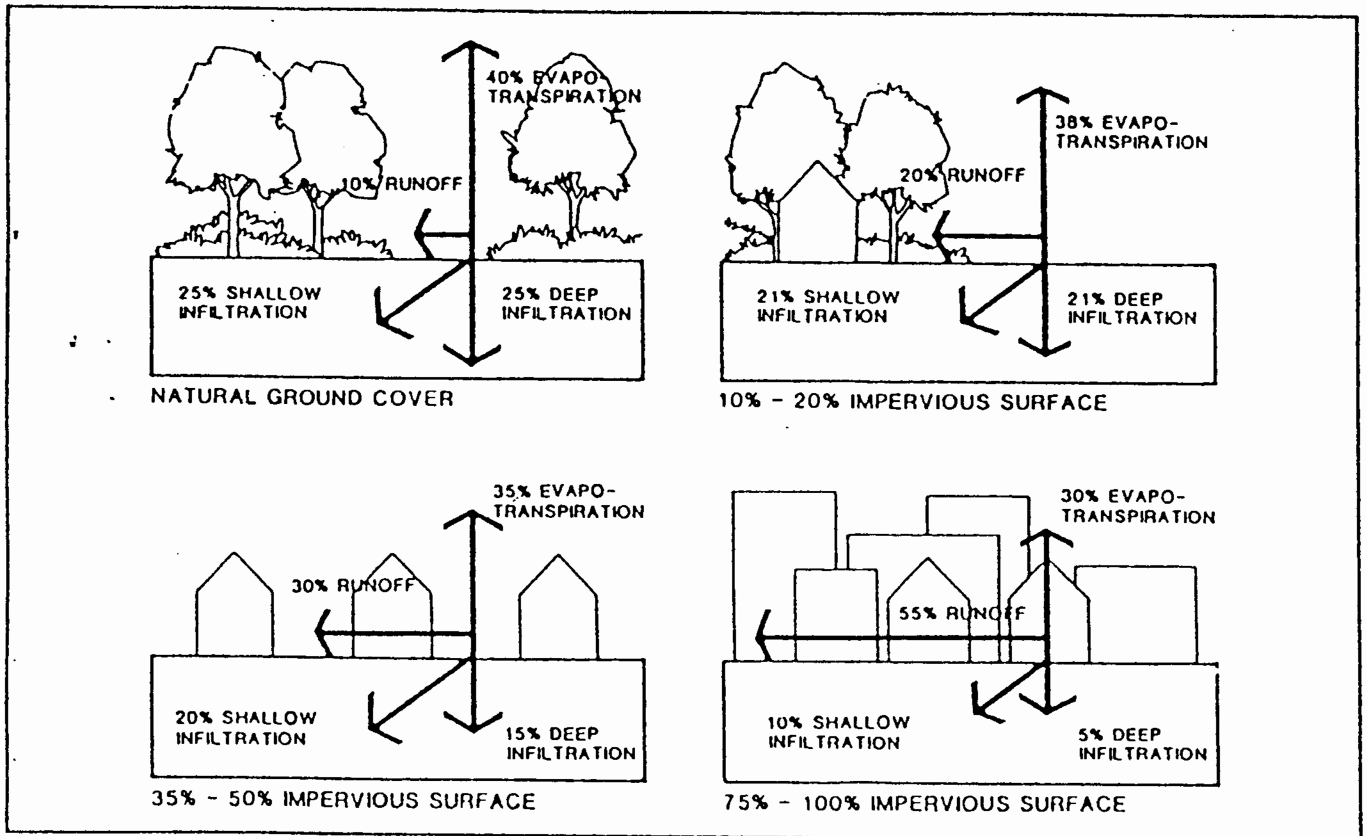


Figure II-1. Changes in runoff flow resulting from increased impervious area (NC Dept. of Nat. Res. and Community Dev., in Livingston and McCarron, 1992).

the mouth of the watershed. This results in higher peak discharges and shorter times to reach peak discharge. Figure II-2 shows typical pre-development and post-development hydrographs for a watershed that is being developed for urban land uses. The area below the hydrographs represents the volume of runoff. The increased volume of runoff after development is significant because of the increased pollutant loading it can deliver as well as potential flooding and channel erosion problems.

Base flow (low flow) in streams is also affected by changes in hydrology from urbanization because a large part of base flow is supplied by shallow infiltration. As shallow infiltration is reduced by increased impervious cover, the volume of water available for base flow in streams is reduced. These changes in hydrology, combined with increased pollutant loading, can have a dramatic effect on the aquatic ecosystems of urban streams. Studies of streams affected by urbanization have shown that fish populations either disappear or are dominated by rough fish that can tolerate a lower level of water quality (Klein, 1979).

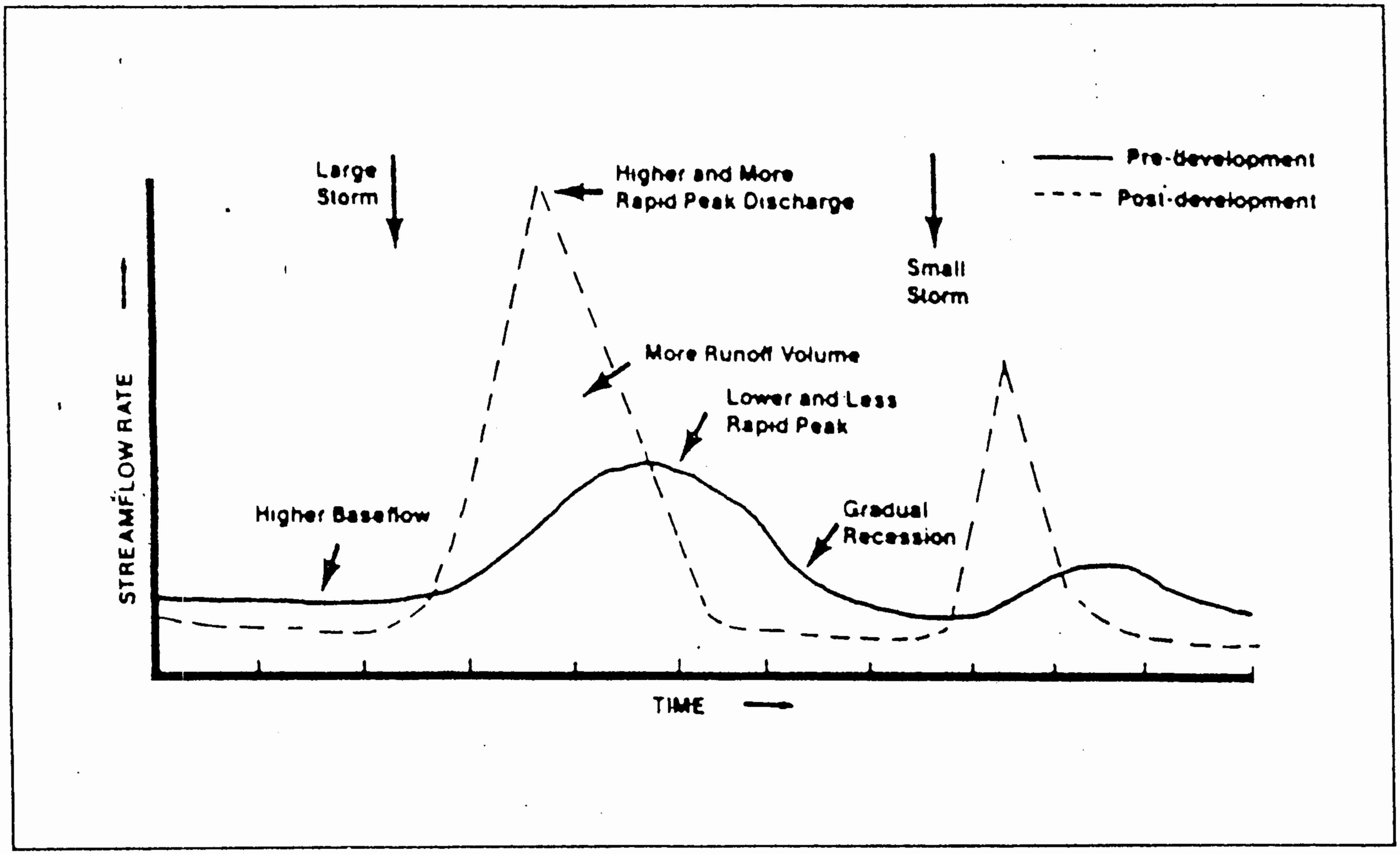
One-hundred-year storms can cause flooding and have adverse effects on natural waterways. This is a fairly well understood but infrequent phenomena. What seems to be less well understood is that less severe but more frequent storm events can also have significant impacts. Studies have shown that most "natural" streams have a bank-full flow approximately equal to the two-year frequency peak discharge (Anderson, 1970; Leopold et al, 1964). After urbanization, increased flows may cause bank-full flow to be exceeded several times each year. In addition to flood damage, this condition causes previously stable channels to erode and widen. Much of the material that erodes becomes bed load and can smother benthic organisms. Sediment from stream bank erosion eventually settles and silts in wetlands, streams, rivers, and lakes.

Hydrologic Modeling Concepts

Computer hydrologic models are used extensively for hydrologic predictions. A hydrologic model can be defined as a mathematical model representing one or more of the hydrologic processes resulting from precipitation and culminating in watershed runoff. Hydrologic models aid in answering questions about the effect of land management practices on quantity and quality of runoff, infiltration, lateral flow, subsurface flow (both unsaturated and saturated) and deep percolation. The models should be used with caution and within their span of applicability. Each model is developed for a specific purpose with certain underlying assumptions. Precautions should be taken that the assumptions of the model are not violated. (For further discussion of these issues see MPCA, 1988.)

Pitt has observed that there are limitations with the commonly accepted hydrologic runoff modeling methods currently used on a widespread basis (Pitt, 1987 & 1994). The methods Pitt discussed are the Rational Method, SCS TR-20 method, SCS TR-55 tabular method, SCS TR-55 graphical method, and the Corps of Engineers HEC-1 method.

The traditional urban hydrology models often depend on information gained from studies of flood and drainage conditions or



Changes in stream hydrology as a result of urbanization (Schueler, 1992).

rural areas. Appropriate assumptions used for large storms may create problems when used for small storms. The runoff values for small storms do not approach conventional runoff predictions until several inches of rain have fallen. More infiltration occurs through typical street pavement than is generally accepted, and there are highly irregular infiltration rates through disturbed urban soils. These disturbed areas can have much less infiltration than pavement under certain conditions. For example, turf playing fields and unpaved parking lots can have less infiltration than a paved area such as a roadway. However, large paved areas including freeways have less infiltration because of longer drainage paths and sealing overcoats (Pitt, 1987).

Figure II-4 (Pitt, 1994) shows measured rain and runoff distributions for Milwaukee during 1983. Rains between 0.05 and 5 inches were monitored during this period. Two very large events (greater than 3 inches) occurred during this monitoring period which greatly bias these curves, compared to typical rain years. It was found that the median rain depth was about 0.3 inches and 66 percent of all Milwaukee rains were less than 0.5 inch in depth. In addition, 50 percent of the runoff was associated with rains less than 0.75 inches in depth for medium-density residential areas. In contrast, a 100-year, 24-hour rain of 5.6 inches for Milwaukee could produce about 15 percent of the average annual runoff volume, but only contribute about 0.15 percent of the average annual runoff volume when amortized over 100 years. Similarly, typical 25-year-drainage-design storms (4.4 inches in Milwaukee) produce about 12.5 percent of the typical annual runoff volume but only about 0.5 percent of the average runoff volume.

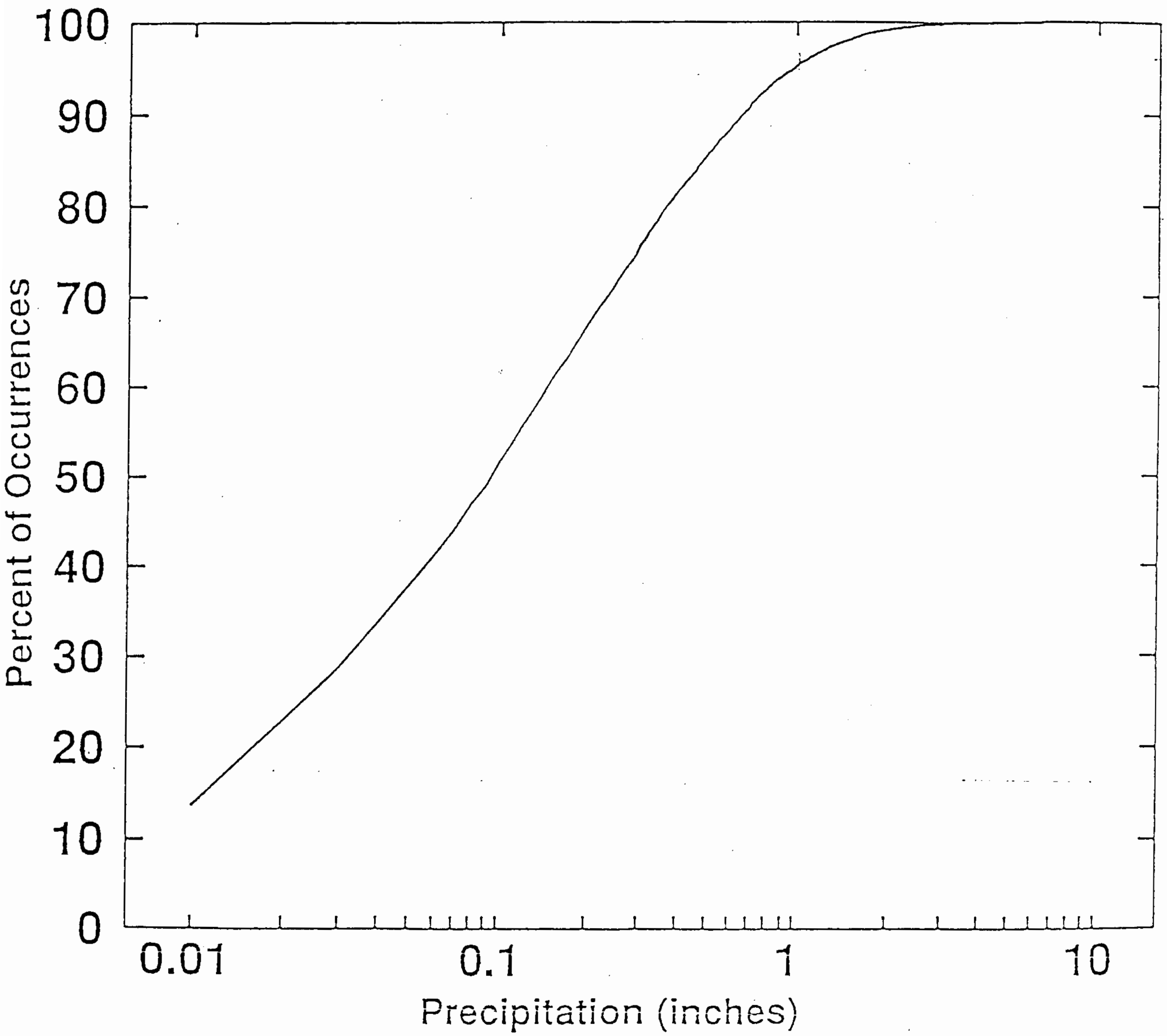
Figure II-5 (Pitt, 1994) shows actual measured Milwaukee pollutant discharges associated with different rain depths for a medium density residential area. Monitored discharges of suspended solids, COD, lead, and phosphates are seen to closely follow the runoff distribution shown in Figure II-4. These figures substantiate typical statistical analysis results that show that concentrations of most runoff pollutants do not significantly vary for runoff events associated with different rain depths. Therefore, being able to accurately predict runoff volume is very important in order to reasonably predict runoff pollutant discharges.

These figures show three distinct rainfall categories:

- Common rains less than about 0.5 inches in depth have relatively low pollutant discharges (<25 percent of the annual pollutant mass discharges from residential areas), but occur very frequently (on about 95 days a year in Minneapolis/St. Paul). These are key rains when evaluating runoff-associated water-quality violations, especially for bacteria and heavy metals. These pollutants in the storm water exceed water-quality standards for almost all rains.
- Rains between 0.5 and 1.5 inches are responsible for about 75 percent of the annual runoff-pollutant mass discharges from residential areas and are the key rains that need to be addressed when concerned with mass discharges of pollutants.
- Rains greater than 1.5 inches occur rarely (on only about two days a year in Minneapolis/St. Paul) and are needed for designs and evaluations of storm drainage systems. However, these rains

FIGURE II-3

Daily Precipitation - Cumulative Frequency Distribution
Minneapolis/St. Paul
(1891 to 1992)



State Climatology Office
D.N.R. - Division of Waters
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are only responsible for relatively small portions of the annual pollutant mass discharges.

The bottom line is that you must understand the areas that you are attempting to model, spending time to get to know the area that is involved in discharging to your watershed. While understanding the low-frequency, larger storm events is critical to flood control, it is probably as important to understand small-storm hydrology to predict the runoff volumes, pollutant loading, impacts to vegetation, and water-quality impacts. For discharges with sensitive or moderately sensitive wetland vegetation, the key to this protection will be understanding the low-flow hydrology.

The best way to be certain of how well a model and the included assumptions perform is to compare the results with independent data from that used for calibration, whether it be collected on-site or considered adequately representative of the site. This verification of model results is often overlooked. Encouraging or requiring verification is the only way to have confidence in the results. More on-site data collection should be encouraged.

Implications of Wetland and Pollutant Sensitivity for Hydrologic Studies

A large percentage of cumulative runoff events occur from rainfall of one inch or less. Urbanization will increase the runoff volume that occurs from each storm event, thereby overloading the natural drainage systems that have adapted themselves to the pre-existing conditions. The frequency of bank-full events increases with urbanization, and the stream attempts to enlarge its cross-section to reach a new equilibrium with the increased approximate two-year flows. Increased flow volumes therefore increase the erosive force of the channel flows and can significantly upset the sediment load equilibrium that has established itself over centuries or thousands of years.

In Minnesota, over 96 percent of the daily precipitation events are under one inch in depth (Figure II-3). These rainfall events also account for the majority (approximately 65 percent) of the cumulative runoff quantity and proportionately large amounts of the pollutant loading associated with these rainfall events, Figure II-4, II-5 (Pitt, 1987 & 1994). The pollutant loading is more closely associated with total runoff volume than with peak runoff rates. For wetlands that are highly sensitive and moderately sensitive, the significance of hydrologic changes and pollutant loads is clear: For water quality and for wetland protection, small-storm hydrology is a critical component of the hydrologic investigation.

While the significance of the large flood events should not be underestimated, the smaller but cumulatively very erosive flows have not usually been given significant consideration. Several states have developed policies regarding erosive flow controls. A copy of the state of Washington's policy is attached as Appendix II-A. The implication with regard to hydrologic studies is clear: While we continue to look at flood and peak flow conditions and total flow, small-storm hydrology is a critical component for protection of property, water quality, and habitat.

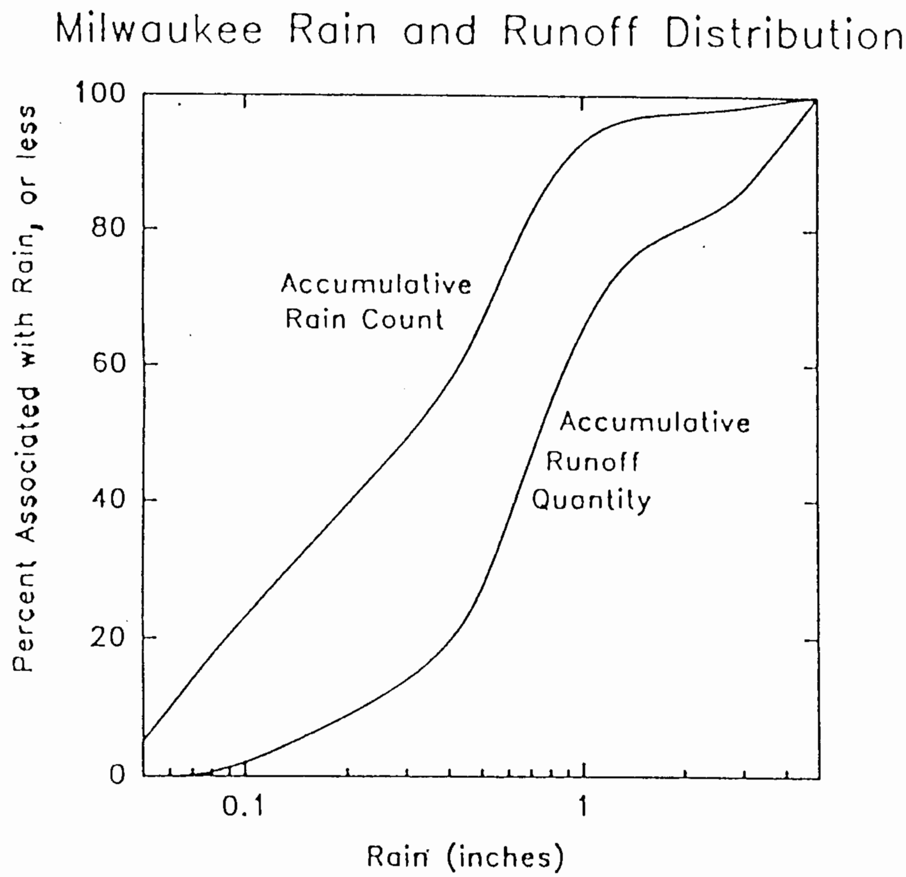


FIGURE II-4

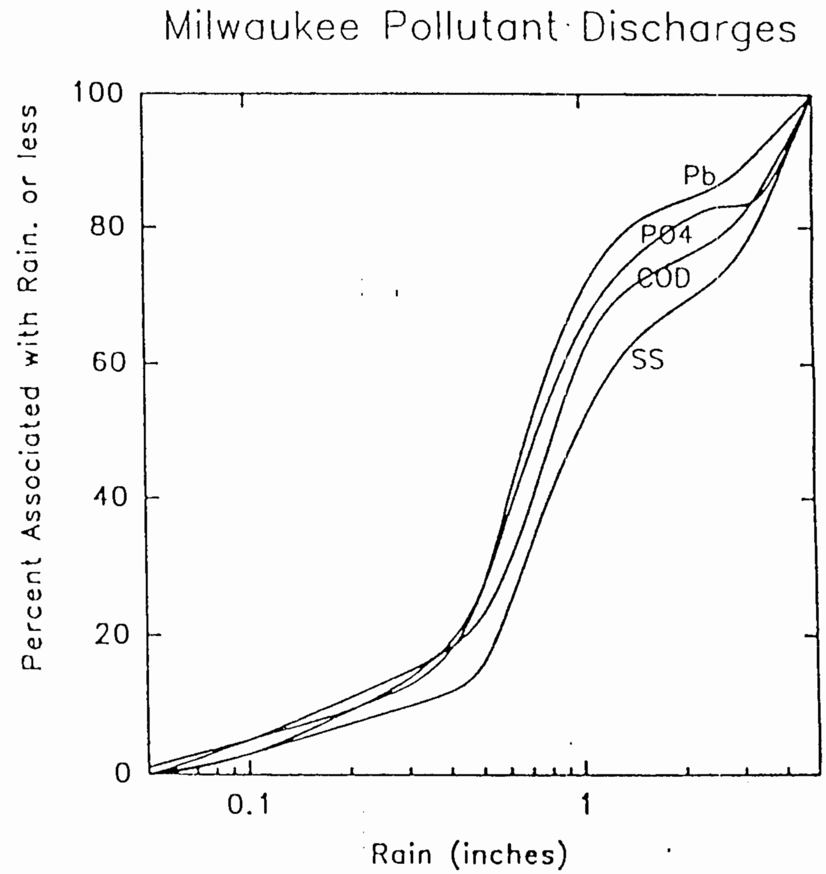


FIGURE II-5

SECTION II

Conclusions

Predicting the magnitude of adverse impacts to wetlands when natural watersheds are converted to urban development is a complex task. The assumption must be made that any change directing more or less water into wetlands beyond what would naturally occur as a result of any given rainfall event, is not necessarily good. Also, do not assume that, when urban development surrounds a wetland basin but does not actually encroach upon it, that the wetland will be preserved. Most urban flows are diverted by pipes or flow through channels and therefore they are unaffected by grassed areas or buffer zones that could modify the influences of development. If the supply of water is increased or reduced beyond the limits that the wetland's sensitivity allows, or if it carries excess pollutants, the wetland may not persist. Maintaining the pre-existing hydrologic conditions should be stressed in all cases, but especially in those wetlands that are highly or moderately susceptible to storm-water impacts. The relationship between any storm event, no matter how small or large, and runoff volumes must be thoroughly understood. BMPs which address the full range of hydrologic conditions should be employed in the process of minimizing impacts.

For further information, we recommend the following:

1. Minnesota Pollution Control Agency, October 1989. "Protecting Water Quality in Urban Areas."

2. Washington State Department of Ecology, February 1992. Storm Water Management Manual for the Puget Sound Basin (The Technical Manual).

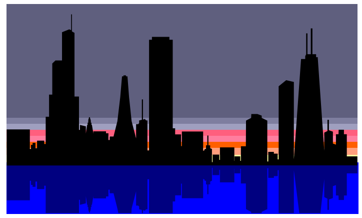
3. Pitt, Robert E., 6 November 1987, Small-Storm Urban Flow and Particulate Washoff Contributions to Outfall Discharges, Ph.D. Dissertation; Civil and Environmental Engineering Department, University of Wisconsin, Madison, Wisconsin.

4. Pitt, Robert E., August 1994, General Urban Runoff Model for Water-Quality Investigations, ASCE 1994 Conference on Hydraulic Engineering, Buffalo, New York.

5. Sandstrom, Bruce, March 14, 1994, Minnesota Board of Water and Soil Resources, Interoffice memorandum.

Section III

Sec. III - WATER-QUALITY IMPACTS



Introduction

Often the discharge of storm water and snow melt into wetlands can have an adverse and sometimes devastating impact on a wetland because of the contaminating material carried by runoff. The following discussion describes the changes that can occur in water quality when an area undergoes urbanization.

Quantity of Runoff

Changes in runoff character usually yield much larger volumes of runoff water over shorter time periods. This high-energy runoff moves over less permeable surfaces and picks up virtually anything that has been deposited there. The concentrated runoff flows through the urban conveyance system and may exit a storm sewer into a stream or natural channel where erosion can be accentuated.

Quality of Runoff

Urban surfaces are subject to the deposit of contaminants, which are then subject to wash-off by rainfall or snow melt. Typical contributors to pollutants in runoff include vehicular traffic, industry and power production, lawn care, pets, eroded sediments, and vegetative litter.

Some kinds of pollution that urban activities produce and the problems they cause are as follows:

Solids

- Inorganic (sediment, salt) and organic (vegetative, animal waste) debris can be moved by urban runoff in both particulate and dissolved forms.
- The particulate suspended and bed-load solids are caused by such things as de-icing grit, windblown dust and dirt, litter, vegetative debris, lawn clippings, and construction erosion.
- The dissolved forms include de-icing salt and various dissolved organics.
- Problems caused in receiving waters by these pollutants include turbidity, aquatic habitat destruction (burying, alteration of bottom material), transport of adsorbed contaminants, clogging of drainage systems, and direct impact on aquatic organisms (respiration, light penetration, increased temperature). Road salt can also become a ground-water problem where infiltration occurs and a lake problem when allowed to concentrate and alter water density.
- Control of solids prior to wetland discharge can be achieved by such BMPs as detention (ponding), housekeeping (street sweeping), and

enhanced infiltration to reduce total water movement.

Nutrients

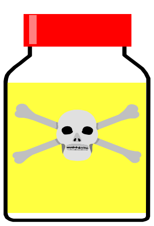
Phosphorus and Nitrogen

Many naturally occurring materials are essential for life, and are therefore termed "nutrients." However, an excess of these elements can lead to explosive growth of noxious life such as algae, or can be toxic to some forms of aquatic life, such as with ammonia.

Of particular concern for receiving waters are nutrients which get into urban runoff from such sources as lawn-care products, vegetative and animal debris, automotive additives, and atmospheric deposition (wind erosion, industrial activity). Nitrate nitrogen, most commonly from fertilizer over-use, can also adversely impact ground water when concentrated to high enough levels.

Control of nutrients prior to wetland discharge can be achieved by such measures as source control (fertilizer application limits), housekeeping (pet control ordinances, street sweeping), detention, and enhanced infiltration.

Toxicants



Many of the everyday activities that go on in an urban area also contribute substantial amounts of toxic material to urban receiving waters. Essentially, anything that is applied to the land or emitted from fertilizer or pesticide applications, a smokestack, or a vehicular tailpipe can be deposited on and washed off of an urban surface.

- Hydrocarbons and Organic Chemicals: These materials permeate urban waters and can exert a detrimental effect on aquatic life if the toxins are at a high enough level. These materials also move easily, exist for extended periods of time in a toxic state, and concentrate in sediments, from which they can be re-suspended later. The petroleum that leaks from cars or comes out the tailpipe, or the pesticides applied to urban lawns, can wash into gutters and eventually drain to a receiving waterbody.
- Metals: All airborne sources of metal and all of the worn metals that erode within an urban area can generate toxic input to our waters. Sources of these metals include automobiles, industrial emissions, and downspouts on houses.
- Control of toxic materials prior to discharge to a wetland can be achieved through such BMPs as detention, source control, proper vehicular maintenance, and good housekeeping.

Oxygen-Demanding Substances

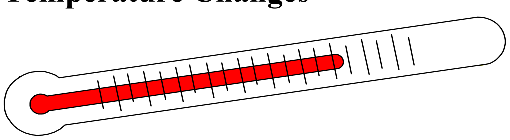
- Much of the material washing off from urban surfaces exerts a demand for oxygen as it degrades in the water. Organic debris, oxidizable metals, and nutrients all require some oxygen in their material degradation. If the levels of these materials are high enough, the oxygen otherwise available for aquatic life is depleted, resulting in stress or death for these organisms. Oxygen depletion can cause water-quality problems in any kind of receiving water body.

- Oxygen-demanding substances can be limited through such BMPs as erosion control, leaf and litter management, and detention.

Bacteria and Virus

- Numerous bacteria and virus strains occur in high concentrations in urban runoff. The sources of these pathogens include sanitary sewer leaks, pets, vermin, and discarded infected material. The result of contact with these pathogens can be disease.
- Pathogens can be controlled by good urban housekeeping, disconnection of illegal sanitary sewer connections, and pet control.

Temperature Changes



While temperature is usually not considered a critical factor for discharges to most wetlands, streams can be significantly impacted by temperature differences

There are various types of temperature criteria which can affect the success and mortality of organisms in waterways. Temperature changes which occur over a short period of time can have a shock effect, resulting in the death of organisms. There can also be long-term temperature effects which cause changes in the growth, reproduction, or mortality of organisms. These mean and maximum temperature changes vary from organism to organism and can be different even for the same organism in a different waterway. In Minnesota, the water-quality standards reflect daily maximum average temperatures for most waterways, or changes above the ambient which are limited to a few degrees on a monthly average basis (Minn. Rules 7050).

The Washington Council of Governments (Galli, John, December 1990) concluded that several factors affect extreme temperatures. Assuming that the air in other local meteorological conditions and the size of the stream cannot be realistically adjusted (an assumption that is not always true), the primary determinants of extreme temperature were indicated by watershed imperviousness and riparian canopy coverage. In addition, they studied four BMP types: 1) an infiltration dry pond; 2) extended detention artificial wetland; 3) extended detention dry pond; and 4) wet pond. They concluded that all four caused positive temperature increases, and each monitored BMP violated applicable water temperature standards at least once.

It is important to note that BMPs cannot completely mitigate the impacts caused by urbanization. A combination of practices, including land-use controls, riparian or stream buffer requirements, and employment of temperature sensitive BMPs will be required to maintain water quality, especially in cold-water streams. The significance of thermal impacts and their mitigation through appropriate BMP implementation needs further research and careful site-specific evaluation for critical areas.

CITY OF MILWAUKEE
BANNERMAN ET AL
APRIL 23, 1992
FIGURE III-1

Table 6: Means and coefficient of variation for the source area and stormsewer outfall concentrations. (1)

Source Area	Total Solids (mg/L)	Susp. Solids (mg/L)	Total Phos. (mg/L)	Diss. Phos. (mg/L)	Diss. Cd (µg/L)	Diss. Cu (µg/L)	Total Cd (µg/L)	Total Cr (µg/L)	Total Cu (µg/L)	Total Pb (µg/L)	Total Zinc (µg/L)	Total Hard. (mg/L)
Geometric Mean												
S_IndustRoof	78	41	0.11	0.02	0.2	2	0.3	--	6	8	1155	--
S_ArterialST	879	690	0.94	0.20	0.6	14	2.5	23	74	60	575	38
S_FeederST	958	763	1.50	0.53	0.4	18	3.3	15	76	86	480	43
S_ParkingLot	531	312	0.39	0.05	0.3	15	1.0	12	41	38	304	42
S_Outfall	267	146	0.34	0.14	0.2	10	1.0	6	28	25	265	31
M_ResiDriveway	306	173	1.16	0.49	0.5	9	0.5	2	17	17	107	33
M_FlatRoof	113	15	0.20	0.08	0.5	6	0.3	--	9	9	331	34
M_CollectorST	494	326	1.07	0.31	0.3	24	1.4	12	56	55	339	30
M_ArterialST	374	233	0.47	0.10	0.9	18	1.8	16	46	50	508	35
M_ParkingLot	127	58	0.19	0.05	0.4	9	0.6	5	15	22	178	22
M_ResiLawn	600	397	2.67	1.45	--	6	--	--	13	--	59	39
M_ResiRoof	91	27	0.15	0.06	0.2	3	0.1	--	5	8	149	20
M_FeederST	796	662	1.31	0.37	0.5	9	0.8	5	24	33	220	29
M_Outfall	369	262	0.66	0.27	0.3	5	0.4	5	16	32	204	26
Arithmetic Mean												
S_IndustRoof	83	54	0.13	0.02	0.3	2	0.3	--	7	8	1348	--
S_ArterialST	993	875	1.01	0.25	1.0	17	2.8	26	85	85	629	41
S_FeederST	1134	969	1.57	0.62	0.6	22	3.7	17	97	107	574	47
S_ParkingLot	603	474	0.48	0.07	0.5	18	1.2	16	47	62	361	48
S_Outfall	293	174	0.38	0.16	0.2	12	1.1	7	31	26	295	32
M_ResiDriveway	328	193	1.50	0.87	1.3	11	0.5	2	20	20	113	34
M_FlatRoof	126	19	0.24	0.11	0.8	8	0.4	--	10	10	363	44
M_CollectorST	544	386	1.22	0.36	0.8	30	1.7	13	61	62	357	32
M_ArterialST	389	241	0.53	0.14	2.0	22	2.6	18	50	55	554	37
M_ParkingLot	165	91	0.26	0.07	0.7	14	0.8	7	21	30	249	24
M_ResiLawn	656	457	3.47	2.40	--	7	--	--	13	--	60	51
M_ResiRoof	105	36	0.19	0.08	0.2	3	0.2	--	5	10	153	22
M_FeederST	1152	1085	1.77	0.55	1.3	11	0.8	7	25	38	245	30
M_Outfall	462	374	0.86	0.34	0.7	7	0.6	5	20	40	254	27
Coefficient of Variation												
S_IndustRoof	0.40	0.71	0.72	0.54	0.75	0.81	0.47	--	0.44	0.30	0.46	--
S_ArterialST	0.52	0.64	0.38	0.90	1.25	0.68	0.49	0.53	0.47	0.85	0.40	0.39
S_FeederST	0.60	0.66	0.29	0.60	0.62	0.63	0.49	0.57	0.77	0.60	0.56	0.39
S_ParkingLot	0.44	0.61	0.50	0.65	1.04	0.70	0.51	0.64	0.44	0.65	0.50	0.63
S_Outfall	0.41	0.60	0.50	0.59	0.70	0.79	0.44	0.42	0.50	0.42	0.45	0.39
M_ResiDriveway	0.43	0.51	0.84	1.08	1.60	0.67	0.42	0.46	0.62	0.53	0.37	0.32
M_FlatRoof	0.48	0.68	0.54	0.75	1.19	0.59	0.87	--	0.52	0.42	0.44	0.72
M_CollectorST	0.42	0.58	0.54	0.58	1.95	0.64	0.75	0.43	0.32	0.49	0.33	0.38
M_ArterialST	0.30	0.26	0.53	0.86	1.78	0.62	1.18	0.47	0.43	0.48	0.44	0.43
M_ParkingLot	0.74	0.91	0.95	0.96	1.22	1.07	0.86	0.84	0.86	0.82	0.90	0.57
M_ResiLawn	0.48	0.58	0.68	0.90	--	0.58	--	--	0.21	--	0.24	0.79
M_ResiRoof	0.60	0.68	0.59	0.82	0.73	0.47	0.57	--	0.25	0.58	0.24	0.36
M_FeederST	1.02	1.19	0.90	1.02	1.48	0.53	0.41	0.91	0.38	0.50	0.44	0.29
M_Outfall	0.64	0.75	0.70	0.67	1.97	0.63	0.81	0.54	0.67	0.66	0.66	0.25

1) Double dash indicates insufficient sample size.

CITY OF MINNEAPOLIS
FIGURE III-2

AVERAGE EVENT MEAN CONCENTRATIONS
1991 and 1992 Storm Water Runoff Studies

SITE Minneapolis	BOD mg\l	COD mg\l	TSS mg\l	TDS mg\l	TN mg\l	NH3-N mg\l	TP mg\l	DP mg\l	Cd ug\l	Cu ug\l	Pb ug\l	Zn ug\l
Chain of Lakes (1991)	30.000	na	135.000	na	2.640	0.670	0.430	0.250	1.010	16.900	4.780	67.230
South Side	17.070	110.008	42.491	56.436	0.632	0.213	0.728	0.476	bdl	6.537	93.074	41.040
Target Center	32.185	35.935	29.017	50.357	0.562	0.098	0.085	0.032	bdl	30.231	0.924	66.240
Jimmy's	31.321	468.965	373.501	69.964	12.450	0.734	1.770	0.796	bdl	62.250	188.929	329.036
Seymour	13.715	64.929	83.280	71.692	1.394	0.335	0.443	0.234	bdl	16.467	49.174	83.382
Metrodome	5.203	58.460	56.857	55.568	1.832	0.349	0.301	0.163	bdl	22.674	10.413	88.225
HERC	6.284	98.909	176.436	132.444	1.004	0.173	0.529	0.352	10.176	57.420	224.035	462.572
Average (1992)	17.630	139.534	126.930	72.744	2.979	0.317	0.643	0.342	na	32.597	94.425	178.416
Std. Dev.	10.787	149.398	120.264	27.794	4.258	0.206	0.541	0.246	na	20.570	85.225	159.192
Max	32.185	468.965	373.501	132.444	12.450	0.734	1.770	0.796	10.176	62.250	224.035	462.572
Min	5.203	35.935	29.017	50.357	0.562	0.098	0.085	0.032	na	6.537	0.924	41.040
Mean (1991 & 1992)	24.912	141.924	133.333	69.232	2.694	0.629	0.456	0.261	1.105	18.581	14.463	78.383
Mean (1991 & 1992) w/o Jimmy's	24.454	71.844	126.723	69.075	2.486	0.627	0.428	0.249	1.105	17.652	10.751	73.050

SITE Richfield	BOD mg\l	COD mg\l	TSS mg\l	TDS mg\l	TN mg\l	NH3-N mg\l	TP mg\l	DP mg\l	Cd ug\l	Cu ug\l	Pb ug\l	Zn ug\l
Wood Lake	13.754	79.105	58.167	53.916	1.183	0.087	0.320	0.129	bdl	6.009	16.156	42.574
Legion Lake	25.039	78.028	18.090	60.077	0.408	0.046	0.452	0.223	bdl	1.347	3.142	13.344
Average (Richfield Sites)	19.3965	78.5665	38.1285	56.9965	0.7955	0.0665	0.386	0.176	0	3.678	9.649	27.959
Std. Dev.	5.6425	0.5385	20.0385	3.0805	0.3875	0.0205	0.066	0.047	0	2.331	6.507	14.615
Max	25.039	79.105	58.167	60.077	1.183	0.087	0.452	0.223	0.000	6.009	16.156	42.574
Min	13.754	78.028	18.090	53.916	0.408	0.046	0.320	0.129	0.000	1.347	3.142	13.344

TABLE 6. MEDIAN STORMWATER POLLUTANT CONCENTRATIONS FOR ALL SITES BY LAND USE
(Nationwide Urban Runoff Program, NURP)

Pollutant	Residential		Mixed Land Use		Commercial		Open/Nonurban	
	Median	COV[1]	Median	COV	Median	COV	Median	COV
BOD_5, mg/L	10.0	0.41	7.8	0.52	9.3	0.31	--	--
COD, mg/L	73	0.55	65	0.58	57	0.39	40	0.78
TSS, mg/L	101	0.96	67	1.14	69	0.85	70	2.92
Total Kjeldahl Nitrogen, µg/L	1900	0.73	1288	0.50	1179	0.43	965	1.00
NO_2 - N + NO_3 - N, µg/L	736	0.83	558	0.67	572	0.48	543	0.91
Total P, µg/L	383	0.69	263	0.75	201	0.67	121	1.66
Soluble P, µg/L	143	0.46	56	0.75	80	0.71	26	2.11
Total Lead, µg/L	144	0.75	114	1.35	104	0.68	30	1.52
Total Copper, µg/L	33	0.99	27	1.32	29	0.81	--	--
Total Zinc, µg/L	135	0.84	154	0.78	226	1.07	195	0.66

[1]COV: coefficient of variation = standard deviation/mean

Source: EPA 1983

Section III

Sources of Pollutants

Bannerman and others have studied the runoff of pollutants, trying to determine their source and the relationship between concentration and loading from various urban land uses. The table showing the findings of the studies is in Figure III-1. The studies (Bannerman, April 23, 1992) show that one or two source areas in each land use usually contribute most of the pollutants. Data from Minneapolis (Figure III-2) compare reasonably well with the Bannerman data. In order to determine pollutant loading, the study areas must be accurately characterized for both pollutant concentration and the volume of runoff. As discussed in other papers (Pitt, 1993), determining the infiltration rates for pervious areas can be a significantly difficult, especially if the models used have been derived from agricultural areas or from storm-water flood and drainage models which are generally derived for higher flow events. Since 90 percent of the storms in Minnesota occur are under one inch of rainfall (State Climatologist, 1993), a significant portion of the runoff occurs from smaller storm events. Pitt has estimated that 75 to 85 percent of the runoff volume in Milwaukee, which has similar events to Minneapolis and St. Paul, is from rainfalls under 1.25 inches (Pitt, 1993).

It is important to understand the pollutants of concern to the system, their sources (especially by land-use type), the source-area concentrations in runoff, and the source-area loading. This requires a knowledge of the hydrology of the source areas, especially the small-storm hydrology and the differences between small-storm and flood-water routing models.

For further information, we recommend the following:

1. Minnesota Pollution Control Agency, October 1989. "Protecting Water Quality in Urban Areas."

2. EPA, December 1983. "Results of the National Urban Runoff Program."

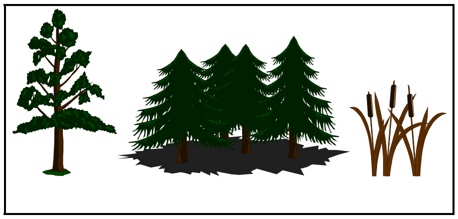
3. Hennepin Conservation District, February 1991. "Toxic Hazardous Substances in Urban Runoff, An Interim Report."

4. Bannerman, Roger T., et al., April 23, 1992. "Sources of Pollutants in Wisconsin Storm Water," Wisconsin Department of Natural Resources, for EPA Region V.

5. City of Minneapolis, 1993. Storm Water Runoff Permit, Phase I Application.

6. Pitt, Robert E., (1994) "Storm Water Detention Pond Design for Water Quality Management," 1994, Lewis Publishers.

SEC. IV - WETLAND SUSCEPTIBILITY



Alteration and degradation of wetlands typically occurs when a predominately rural watershed is converted to urban use, as with the growth of the Twin Cities Metropolitan Area. Urban runoff is often directed into wetlands via storm-sewer systems. Some municipalities have designed their entire storm-sewer system using wetlands as the discharge point. Cases also exist where numerous isolated wetland basins were artificially connected via a storm-sewer network creating a "flow through" system where none existed previously. Use of wetlands for such storm-water purposes is often justified on the basis of cost savings, convenience, or ease of construction, since many wetlands are topographic depressions. But it could also reflect a lack of understanding or lack of concern about how the input of urban storm water can degrade wetlands and the functions and values they provide.

Wetland Sensitivity

The many types of wetlands are determined by their hydrology, vegetation and soils. Figure IV-1 lists wetland types according to their susceptibility to degradation by storm-water input. It is important to note that there can be exceptions to the general categories listed. Figures IV-2, 3, 4 and 5 (found on pages39 and 40) give a quick summary of wetland types and a general indication of wetland susceptibility by type. A summary of Eggers and Reed is provided on pages 33-38 for detailed descriptions of the types of wetlands found in Minnesota. Given this diversity of wetland types, it's not surprising that wetlands have a broad range of tolerance to urban storm-water input. Some wetlands (e.g., bogs and fens) are sensitive to any disturbance and will show signs of degradation with even low-level inputs of urban storm water. On the other hand, some wetlands (e.g., floodplain forests) are better adapted to handle the fluctuating water levels and influx of sediment often associated with urban storm water. Each wetland should be carefully evaluated to determine potential impacts from a proposed urban storm-water project.

Discussion

Diverse, sensitive, native plant communities can be readily degraded by storm-water impacts, resulting in monotypes of sediment- and nutrient-tolerant species such as reed canary grass and/or cattails..

SECTION IV

Highly Susceptible Wetland Types:[1]	Moderately Susceptible Wetland Types:[2]	Slightly Susceptible Wetland Types:[3]	Least Susceptible Wetland Types:[4]
Sedge Meadows	Shrub-carrs[a.]	Floodplain Forests[a.]	Gravel Pits
Open Bogs	Alder Thickets[b.]	Fresh (Wet) Meadows[b.]	Cultivated Hydric Soils
Coniferous Bogs	Fresh (Wet) Meadows[c.,e.]	Shallow Marshes[c.]	Dredged Material/Fill Material Disposal Sites
Calcareous Fens	Shallow Marshes[d.,e.]	Deep Marshes[c.]	
Low Prairies	Deep Marshes[d.,e.]		
Coniferous Swamps			
Lowland Hardwood Swamps			
Seasonally Flooded Basins			

1. Special consideration must be given to avoid altering these wetland types. Inundation must be avoided. Water chemistry changes due to alteration by storm water impacts can also cause adverse impacts.
Note:
All scientific and natural areas and pristine wetlands should be considered in this category regardless of wetland type.

2. **a**.,**b**.,**c**. can tolerate inundation from 6 inches to 12 inches for short periods of time. May be completely dry in drought or late summer conditions. **d**. can tolerate +12" inundation, but adversely impacted by sediment and/or nutrient loading and prolonged high water levels. **e**. some exceptions.

3. **a**. Can tolerate annual inundation of 1 to 6 feet or more, possibly more than once/year. **b**. Fresh meadows which are dominated by reed canary grass. **c.** Shallow marshes dominated by reed canary grass, cattail, giant reed or purple loosestrife.

4. These wetlands are usually so degraded that input of urban storm water may not have adverse impacts.

NOTES:
° **There will always be exceptions to the general categories listed above. Use best professional judgment.**
° **Appendix A contains a more complete description of wetland characteristics under each category.**
° **Pristine wetlands are those that show little disturbance from human activity.**

FIGURE IV-1

Greater frequency and duration of inundation can destroy native plant communities, as can depriving them of their water supply The construction of curb and gutter systems diverts surface runoff and can have either of these effects depending on the direction of diversion. Other modifications, such as granular bedding used for installing utility pipelines, can cause more subtle alteration of ground-water flows by acting as a conduit that accelerates ground-water movement. Furthermore, changes in water or soil chemistry can lead to degradation of wetlands that have a specific pH range and/or other parameter, such as the acidic conditions of sphagnum bogs and alkaline conditions of calcareous fens.

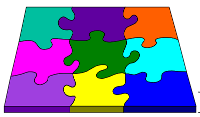
Highly Susceptible wetland communities can be composed of dozens of species of native trees, shrubs, grasses, sedges and forbs, providing habitat for a variety of wildlife in addition to providing excellent water-quality functions. In sedge meadows, the formation of tussocks by some species of sedges is an adaptation to fluctuating water levels; but urban storm-water input can exceed the water depths and frequency/duration of inundation that occurred under natural conditions, leading to a die-out of the sedges. Deposition of sediment carried by urban storm water can have the same effect, causing replacement of diverse species with monotypes of reed canary grass or cattails, which are much more tolerant of sedimentation and fluctuating water levels. In contrast to sedge meadows, monotypes of reed canary grass consist of a single, aggressive species. The result is no vegetative diversity and lower-quality wildlife habitat values.

Moderately susceptible wetland types are generally more likely to tolerate some degree of urban storm-water input compared to sensitive wetlands. But, as is true of all natural systems, there are limits to this tolerance. These wetlands, which include shrub-carr, alder thicket and shallow/deep marshes, typically have water regimes ranging from saturated soil conditions to three feet or more of standing water in the case of deep marshes. Soil saturation and water levels can fluctuate within a certain range from year to year and season to season. However, urban storm-water input can change the hydrology/hydroperiod of these wetlands. In some cases, the changes could be drastic. Depending on the magnitude, frequency and duration of inundation due to storm-water input, these wetlands can be degraded and even converted to cattail monotypes, mud flats, or deep, open water.

Slightly Susceptible wetlands, such as fresh or shallow meadows dominated by reed canary grass, giant reed, purple loosestrife, cattail, and / or floodplain forests, are less likely to be degraded by urban storm-water input compared to the highly and moderately sensitive wetland types discussed above. As mentioned previously, monotype-vegetation wetlands, especially those dominated by reed canary grass and cattail, are more tolerant of nutrient and sediment loading (that's why so many urban wetlands are composed of these monotypes). Floodplain forests are well adapted for fluctuating water levels and sediment deposition (within limits), as that is similar to what occurs under natural conditions. Use for urban storm-water purposes may, within limits, mimic or at least not significantly alter this condition.

Least-susceptible wetlands are highly degraded and should be viewed as candidates for rehabilitation or restoration. These serve functions such as flood storage and should be maintained for the values and functions they may provide. However, if there is no feasible alternative to directing storm-water to wetlands, it would be less environmentally damaging to discharge urban storm water to these types of wetlands rather than the more sensitive wetland types described above. Consideration should be given to enhancing the effectiveness of these highly degraded wetlands to process storm-water runoff.

Wetland "Connectedness”



Establishment of “green corridors” is a crucial factor when looking at the “big picture” and how wetlands fit into an urbanizing landscape. Linking wetlands, lakes, streams and high-value upland habitats has many benefits that can offset to some degree the fragmentation that occurs due to urbanization. An excellent example of this planning tool is the system of primary environmental corridors identified by the Southeastern Wisconsin Regional Planning Commission for the seven-county area that includes the cities of Milwaukee, Waukesha, Racine and Kenosha.

Wetland connections and linkage may not directly affect vegetation but may be a significant factor in the habitat value and function of the wetland. Maintaining the wetland connections in a natural state will also help to avoid impacts from subtle hydrologic changes that may be caused by disturbance of these connections.

Hydroperiod Standards

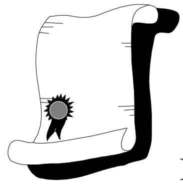


Figure IV-6 describes the recommended hydroperiod standards for wetlands. This guidance recommends these standards unless site-specific guidelines can be developed.

The term “existing” in this chart means the existing hydrologic conditions. If there have been recent significant changes in conditions, it means the conditions that established the current wetland. Recent hydrologic changes may alter or destroy a currently existing wetland unless retrofitting can be accomplished. To protect some long-lived species (e.g., tamarack trees), the conditions that established the original vegetation may need to be analyzed through many previous years to determine the appropriate hydrologic regime.

The hydrologic analysis must be conducted on an annualized basis or a broad range of storm events from very small (1/4-inch) to large, i.e. 10- or 25-year storms. The storm bounce -and inundation should be the maximum that occurs for each event over the ambient conditions for similar events.

In some cases, these guidelines can allow for changes in hydraulics. Storm-water input to wetland basins supporting monotypes, such as purple loosestrife or reed canary grass, could flood out this vegetation, creating open water areas that may eventually revegetate with greater diversity.

Figure IV-6

Recommended Hydroperiod Standards For Wetlands

A number of considerations factor into how storm water should be routed through a natural wetland. The best approach is for local governments to set standards based upon a truly comprehensive watershed management plan that considers local goals for water quality and quantity in conjunction with assessments of wetland functions and values, existing and future land uses, finances available, existing problems, and government structure. Until that has been done, some guidance needs to be followed to limit the negative impacts of storm-water discharges on a community's wetland resources. Based upon the foregoing discussions and in consideration of the chapter on the susceptibility of wetlands to storm-water discharges, the following criteria should be followed when no specific design standards have been established.

Relative Susceptibility Of Wetlands To Storm-Water Impacts

Hydroperiod standard	Highly susceptible wetlands	Moderately susceptible wetlands	Slightly susceptible wetland	Least-susceptible wetlands
Storm bounce	Existing	Existing plus 0.5_ft	Existing plus 1.0_ft	No limit
Discharge rate	Existing	Existing	Existing or less	Existing or less
Inundation period for 1 & 2 yr. precipitation event	Existing	Existing plus 1 day	Existing plus 2 days	Existing plus 7 days
Inundation period for 10 yr. precipitation event & greater	Existing	Existing plus 7 days	Existing plus 14 days	Existing plus 21 days
Run-out control elevation (free flowing)	No change	No change	0 to 1.0 feet above existing run out	0 to 4.0 feet above existing run out
Run-out control elevation (landlocked)	Above delineated wetland	Above delineated wetland	Above delineated wetland	Above delineated wetland

SECTION IV

Wetland alteration for any reason, even for improvements, should only be conducted after careful analysis to insure that the desired outcome will result.

The baseline condition of some wetland types may be so degraded that urban storm-water input may not cause appreciable adverse impacts. Some gravel pits, dredge /fill disposal sites, and cultivated hydric soil areas are examples. An analysis of other potential impacts such as ground-water contamination, or opportunity for enhancement, should determine the storm-water discharge tolerances in these cases.

However, for most wetlands, especially the sensitive and highly sensitive wetlands, changes in the hydroperiod may have detrimental impacts

Conclusion

Wetlands are susceptible to changes in water quality and quantity Therefore, it is essential to avoid hydrologic changes to sensitive wetlands and to minimize the impacts where discharges of urban storm water to wetlands are unavoidable. For some highly sensitive wetlands, flow controls which split the flow to the wetland may be needed. Discharges to some wetlands can be altered to some extent, but the hydroperiod guidance should be observed and monitored.

For further information, we recommend the following:

1. Cowardin et al. December 1979. "Classification of Wetlands and Deep Water Habitats of the United States." U.S. Fish & Wildlife Service, USDI.

2. Eggers, Steve D. and Donald M. Reed. December 1987. "Wetland Plants and Plant Communities of Minnesota and Wisconsin." U.S. Army Corps of Engineers, St. Paul District, December 1987, 201 pp.

3. Eggers, Steve D. February 1992. "Compensatory Wetland Mitigation: Some Problems and Suggestions for Corrective Measures." U.S. Army Corps of Engineers, St. Paul District, 63 pp.

4. U.S. EPA,. February 1993. "Natural Wetlands and Urban Storm Water: Potential Impacts and Management."

5. Wisconsin Department of Natural Resources. November 1992. "Rapid Assessment Methodology for Evaluating Wetland Functional Values." 9 pp.

6. Southeastern Wisconsin Regional Planning Commission. 1992, "A Regional Land Use Plan for Southeastern Wisconsin 2010," SEWRPC Report No. 40, 473 pp.

7. Minnesota Department of Natural Resources. January 1995, "Technical Criteria for Identifying and Delineating Calcareous Fens in Minnesota," 22 pp.

SECTION IV

WETLAND SUSCEPTIBILITY TO STORM-WATER DEGRADATION [1]

1. Highly Susceptible Wetland Types

Sedge Meadows

Sedge meadows are dominated by the sedges (*Cyperaceae*) growing on saturated soils. Most of the sedges present are in the genus *Carex,* but also present are those of *Eleocharis* (spike rushes), *Scirpus* (bulrushes), and *Cyperus* (nutgrasses). Grasses (*Gramineae*), especially Canada bluejoint grass, and true rushes *(Juncus)*, may also be present. The forb species are diverse but scattered, and may flower poorly under intense competition with the sedges.

Soils are usually composed of peat or muck. Some sedges, especially the hummock sedge, form hummocks that may be accentuated by grazing and frost action. The peat/muck and hummocks are composed of undecayed fibrous roots and rhizomes. Sedge meadows often grade into shallow marshes, calcareous fens, low prairies, and bogs. Occasional fires stimulate spring growth of the sedges while setting back invading woody vegetation.

There are over 150 species of *Carex* in Minnesota and Wisconsin, many of which are found in wetland habitats. Because they have specific habitat requirements, *Carex* are good indicators of environmental conditions such as soil and water chemistry, water levels, shading, silt deposition, and floating mats.

The fertile organic soils associated with sedge meadows have traditionally been used for muck farming. The lowering of water tables through artificial drainage is suspected of causing shrub invasion in some of the remaining sedge meadows.

Bogs

Bogs are a specialized wetland type found on saturated, acid peat soils that are low in nutrients. They support a unique assemblage of trees, low shrubs and herbs growing on a mat of *sphagnum* mosses (Curtis 1971). In Minnesota and Wisconsin, most bogs are found north of the vegetation tension zone, which is the zone where both prairie-forest floristic province and the northern forest species coexist. The area separates the northeastern third of the state from the south and western thirds of the state.

Bogs are one stage in succession from open-water lake to climax mesic hardwood forest (Curtis 1971). The bog originates on a floating mat of sedges, which becomes colonized by sphagnum mosses. As the mat gradually thickens and becomes more stable, it is invaded by the evergreen shrubs of the heath family (*Ericaceae*). Eventually, tamarack and black spruce can be supported by the mat. The final stage of succession is, theoretically, climax mesic hardwood forest. Note that succession is rarely without

[1] From (Eggers and Reed, December 1987).

interruption. It is typically a series of advancements and setbacks, primarily due to fire. Also note that there are similar successional patterns for other wetland plant communities.

The values and uses of bogs include harvesting of sphagnum moss, aesthetics, and conversion to commercial cranberry production.

Coniferous Bogs

Coniferous bogs are similar to open bogs in plant community composition and structure except that mature trees (breast-height diameter greater than six inches) of black spruce and/or tamarack are the dominant species growing on the sphagnum moss mat. Sphagnum mosses are still the dominant ground-layer species, and a few sedges, orchids and pitcher plants that have endured the shaded conditions are often present, along with the shrubs of the heath family (*Ericaceae*).

Open Bogs

Open bogs are composed of a carpet of living sphagnum moss growing over a layer of acid peat. Herbs and/or the low shrubs of the heath family (*Ericaceae*) colonize the sphagnum moss mat. Scattered, usually immature or stunted (breast-height diameter less than six inches) trees of black spruce and/or tamarack may be present. Lack of forest is probably due to conditions too wet for the tree species, sphagnum moss mat too thin to support trees, recurrent fires, summer frosts, and/or lack of a seed source for the tree species.

Calcareous Fens

Calcareous fens are the rarest wetland plant community in Minnesota and Wisconsin, and probably one of the rarest in North America. A calcareous fen is a peat-accumulating wetland dominated by distinct ground-water inflows having specific chemical characteristics. The water is characterized as circumneutral to alkaline, with high concentrations of calcium and low dissolved oxygen content. The chemistry provides an environment for specific and often rare hydrophytic plants. Characteristic species include shrubby cinquefoil, sterile sedge, fen beak-rush, Ohio goldenrod, common valerian and lesser fringed gentian. Also included are species disjunct from the tundra, alpine meadows, and salt marshes. Therefore, calcareous fens have been referred to as a hybrid community by Curtis (1971).

Calcareous fen communities in general have a disproportionate number of rare, threatened, and endangered plant species as compared to other plant communities in the Great Lakes region.

Low Prairies

Prairies are open, herbaceous plant communities covered by low-growing plants dominated by native grass-like species; at least half of the vegetative cover is made up of true grasses (Curtis 1971). Low prairies include both wet and wet-mesic prairies as described by Curtis (1971). These communities are similar to fresh (wet) meadows, but are dominated by native grasses and forbs associated with the prairies, such as prairie cord-grass, big bluestem, gayfeather, New England aster, culver's root, prairie dock, and sawtooth sunflower. Low prairie communities only occur south of the vegetation tension zone, although a few low prairie species may be found in sandy barrens and wet swales north of the tension zone.

Coniferous Swamps

Coniferous swamps are forested wetlands dominated by lowland conifers, primarily northern white cedar and tamarack, growing on soils that are saturated during much of the growing season, and that may be inundated by as much as a foot of standing water. Soils are usually organic (peat/muck) and can vary from nutrient-poor to acid, to fertile and alkaline or neutral. Tamarack typically dominates on the former soils, and northern white cedar on the latter. A sphagnum moss mat is not present. Coniferous swamps occur primarily in and north of the vegetation tension zone.

Lowland Hardwood Swamps

Lowland hardwood swamps are dominated by deciduous hardwood trees, have soils that are saturated during much of the growing season, and may be inundated by as much as a foot of standing water (Shaw and Fredine 1971). Dominant trees include black ash, red maple, yellow birch and, south of the vegetation tension zone, silver maple. Northern white cedar can be a subdominant species in stands north of the vegetation tension zone. American elm is still an important component of this community, although its numbers have been greatly reduced by Dutch elm disease. These communities are commonly found on ancient lake basins.

Seasonally Flooded Basins

Seasonally flooded basins are poorly drained, shallow depressions that may have standing water for a few weeks each year, but are usually dry for much of the growing season. These basins may be kettles in glacial deposits, low spots in outwash plains, or depressions in floodplains. They are frequently cultivated. However, when these basins are not cultivated, wetland vegetation can become established. Typical species include smartweeds, beggarticks, nut-grasses, and wild millet. One unique aspect of seasonally flooded basins is that the alternating periods of flood and drought can eliminate perennial plants so that annual plant species typically dominate the community.

Seasonally flooded basins are important for waterfowl and shorebirds. These temporary water-holding basins frequently have an abundance of plant seeds and invertebrates, which makes them ideal feeding and resting areas for migrating waterfowl and shorebirds. In spring, seasonally flooded basins are used as pairing ponds by ducks, and the abundant invertebrate population provides a protein-rich diet for egg-laying hens.

2. Moderately Susceptible Wetland Types:

Shrub-carrs

Shrub-carrs are plant communities composed of tall, deciduous shrubs growing on saturated to seasonally flooded soils. They are usually dominated by willows and/or red-osier dogwood, and sometimes silky dogwood. Shrub-carrs usually retain some of the forbs, grasses, and sedges of the inland fresh meadows. These communities are common both north and south of the vegetation tension zone.

It should be noted that three alien (non-native) shrub species are invading shrub-carrs, especially where disturbances such as drainage and pasturing have occurred. These are honeysuckle *(Lonicera* x *bella)*, fen buckthorn *(Rhamnus frangula)*, and common buckthorn *(Rhamnus cathartica)*.

Alder Thickets

Alder thickets are a tall, deciduous shrub community similar to shrub-carrs except that speckled alder is dominant. Speckled alder can pioneer exposed peat or alluvial soils because of its tiny seeds and ability to fix nitrogen. Alder thickets are generally found in and north of the vegetation tension zone.

Speckled alder may occur as a monotype, but the alder thicket community can have a diversity of shrubs including high-bush cranberry *(Viburnum trilobum)*, sweet gale *(Myrica gale)*, and common winterberry holly *(Ilex verticillata)*.

Fresh (Wet) Meadows

Fresh (wet) meadows are dominated by grasses, such as red-top grass and reed canary grass, and by forbs such as giant goldenrod, growing on saturated soils. The grass family (*Gramineae*) and aster family (*Compositae*) are well represented in fresh meadows. The forbs and grasses of these meadows are characterized by less competitive, more nutrient-demanding, and often shorter-lived species than the sedges of the sedge meadow community. Therefore, fresh meadows probably represent younger communities that indicate recent disturbances and degradation of other inland fresh meadows by drainage, siltation, cultivation, pasturing, peat fires, and/or temporary flooding. Once established, the forbs and grasses of the fresh meadow community may persist for extended periods of time.

Shallow and Deep Marshes

Shallow marsh plant communities have soils that are saturated to inundated, by standing water up to six inches in depth, throughout most of the growing season (Shaw and

Fredine 1971). Herbaceous emergent vegetation such as cattails, bulrushes, arrowheads, and lake sedges characterize this community.

Deep Marsh

Deep marsh plant communities have standing water depths of between six inches and three or more feet during most of the growing season (Shaw and Fredine 1971). Herbaceous emergent, floating, floating-leafed, and submergent vegetation occurs in this community, with the major dominance by cattails, hardstem bulrush, pickerelweed and/or giant bur-reed.

The vegetation of marshes is characterized by emergent aquatic plants growing in permanent to semi-permanent shallow water. Also present are species of shallow open-water communities, as well as those found in sedge meadows and seasonally flooded basins. The species of sedge meadows and seasonally flooded basins may be found growing on muskrat lodges, on floating mats, and on muck soils exposed during droughts or artificial drawdown. Emergent aquatic plants typically become established and spread when water levels are low or when the marsh substrate is exposed, and then persist when water levels rise. However, if water levels rise too quickly, or rise to higher than normal levels, emergent vegetation may not survive, or it may rise to the water surface as floating mats. Muskrats may "eat out" emergent vegetation, creating open water areas within the marsh that favor waterfowl use. Unchecked, however, muskrats can eliminate emergent vegetation, leaving an open water area until the next drought or draw-down allows emergent vegetation to recover.

Marshes are among the most productive of all wetlands for water birds and furbearers, and they can also provide spawning and nursery habitat for some fish species. Birds that use marshes for breeding and feeding include ducks, geese, rails, herons, egrets, terns, and songbirds. Raptors such as the osprey, bald eagle, and northern harrier frequent marshes in search of prey. Important furbearers inhabiting marshes include muskrat and mink. Excellent winter habitat can be provided for upland wildlife, including ring-necked pheasant and eastern cottontail. Marshes can help replenish fish populations in adjacent lakes and rivers by providing spawning habitat, most notably for northern pike and muskellunge.

In addition to providing fish and wildlife habitat, marshes have other functions including floodwater retention, protection of shorelines from erosion, aesthetics, and water-quality functions involving the trapping of sediments and assimilation of nutrients.

3. Slightly Susceptible Wetland Types:

Floodplain Forests

Floodplain forests are wetlands dominated by mature, deciduous hardwood trees growing on alluvial soils associated with riverine systems. The soils are inundated during flood events, but are usually somewhat well-drained for much of the growing season (Shaw and Fredine 1971). The most characteristic feature of floodplains is the alluvial soil that is constantly being deposited in some locations while being eroded away in others. Floodplain forests typically include the northern and southern wet-mesic hardwood forest associations described by Curtis (1971). Dominant hardwoods include silver maple, green ash, river birch, eastern cottonwood, American elm, and black willow. The herbaceous ground layer is commonly composed of jewelweed and nettles.

Floodplain forests have a great diversity of plant and animal species because they serve as migration corridors. Some of the many species of wildlife that inhabit floodplain forests are wood duck, barred owl, herons, egrets, and a variety of songbirds. Pools within the forest may provide habitat for amphibians and invertebrates, while adjoining areas of open sand may provide habitat for reptiles. During high-water periods, these forests even provide habitat for fish.

Floodplain forests are extremely important for floodwater storage. Diking of floodplain forests to allow development or agricultural use can aggravate both upstream and downstream flooding impacts.

Fresh Wet Meadows and Shallow Marshes

When dominated by cattail giant reed, reed canary grass or purple loosestrife, these wetland types can be considered slightly susceptible wetland types. These wetlands provide a variety of wetland benefits, but they are not as diverse and are dominated by species able to tolerate more fluctuation of water level. Some opening of the vegetation by additional water may even be beneficial.

4. Least-Susceptible Wetland Types:

The baseline condition of some wetlands may be already degraded to such an extent that storm-water input would not cause any additional adverse impacts. Cultivated hydric soils, dredge/fill disposal sites and some gravel pits are examples of this condition.

SECTION IV

SUSCEPTIBILITY OF WETLANDS TO STORM WATER INPUT

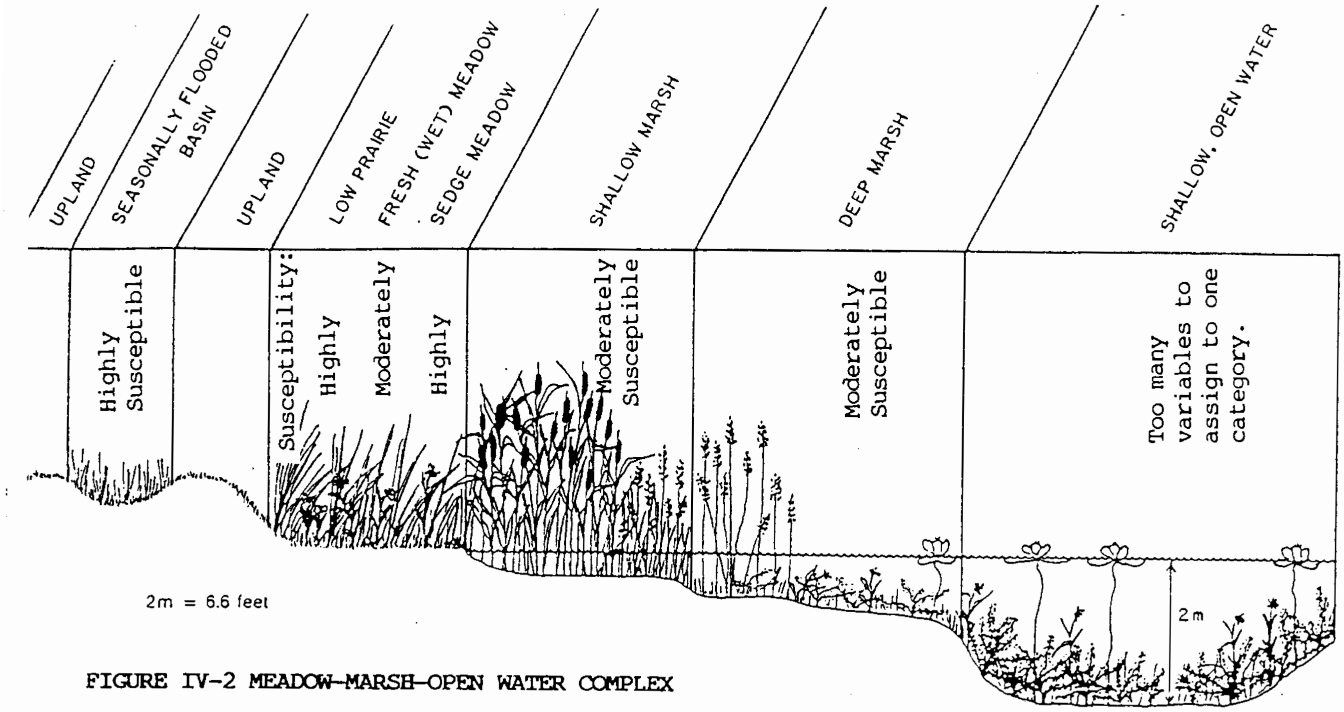


FIGURE IV-2 MEADOW-MARSH-OPEN WATER COMPLEX

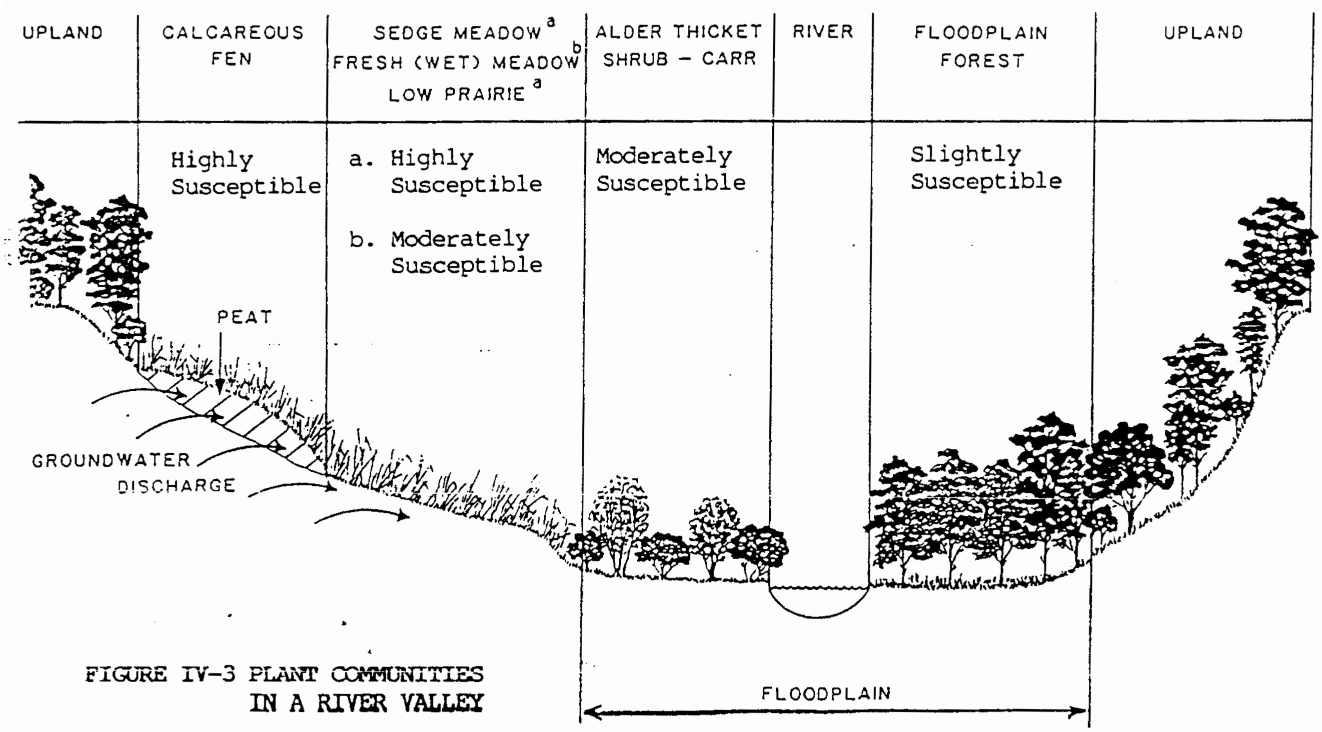


FIGURE IV-3 PLANT COMMUNITIES IN A RIVER VALLEY

SUSCEPTIBILITY OF WETLANDS TO STORM WATER INPUT

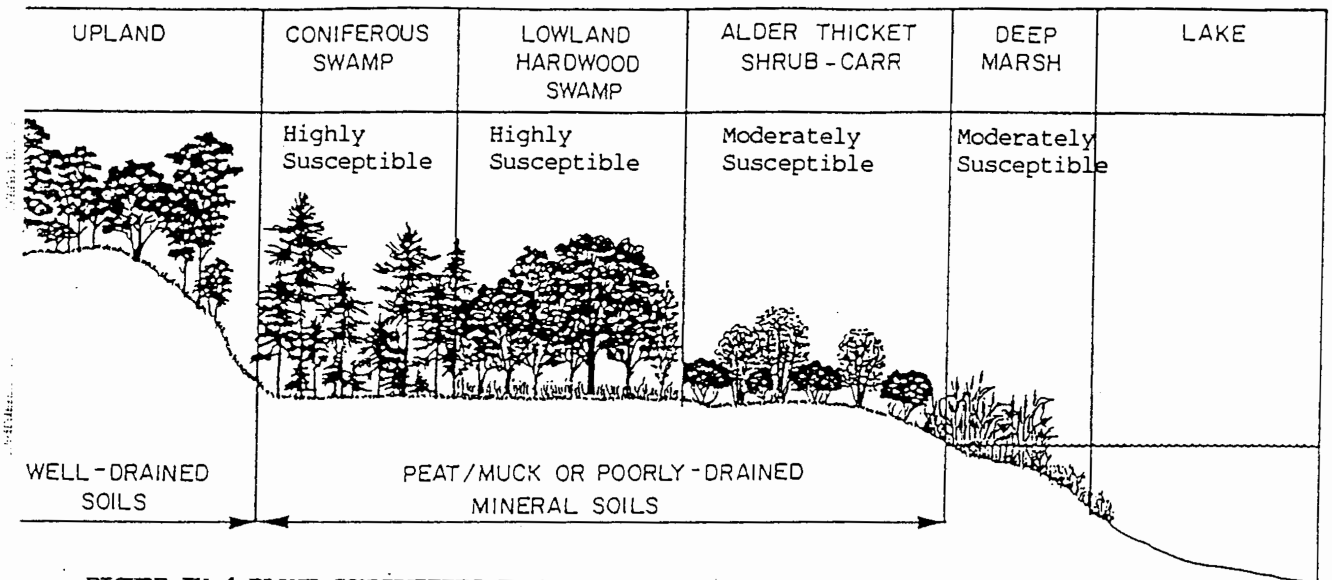


FIGURE IV-4 PLANT COMMUNITIES IN A LAKE BASIN

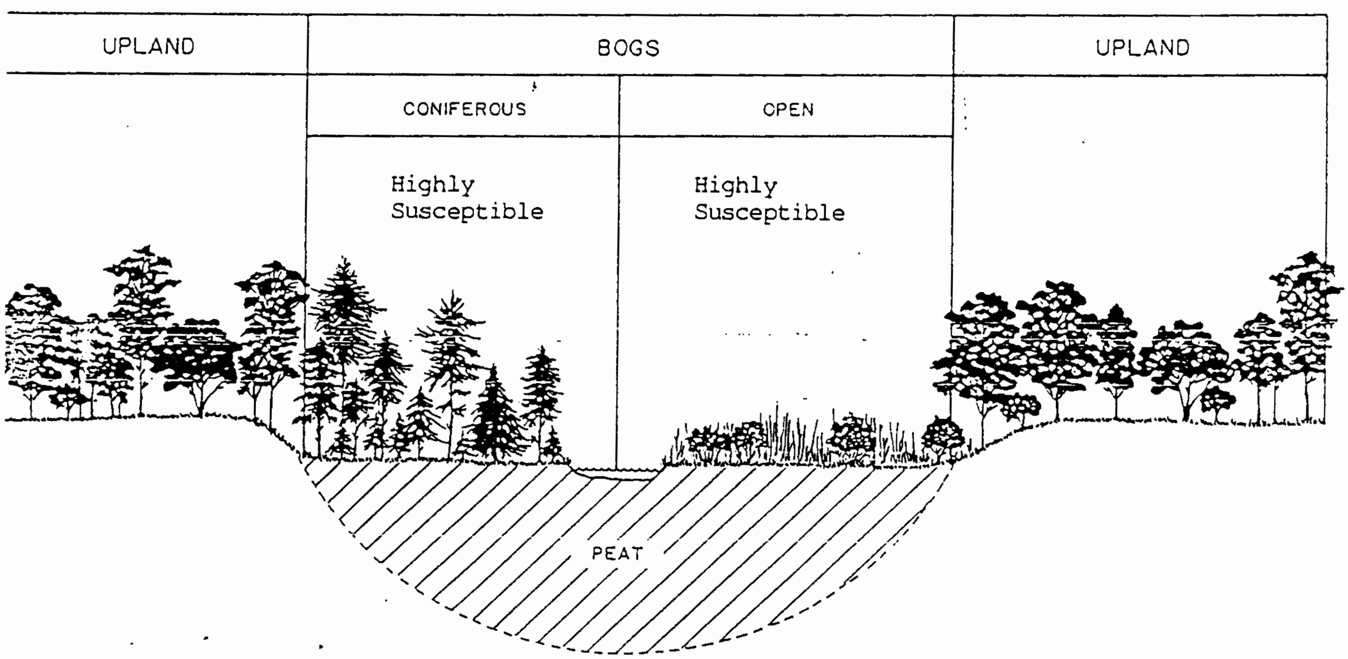
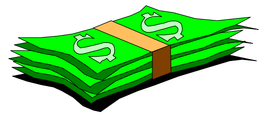


FIGURE IV-5 GENERALIZED CROSS SECTION OF A BOG

SECTION V

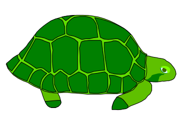
Sec. V - VALUES AND FUNCTIONS OF WETLANDS



Wetland Values

Wetlands have widely been cited as providing numerous ecological and socioeconomic values. In enacting the Wetland Conservation Act of 1991 the state Legislature acknowledged the importance of comprehensive planning to maintain and increase the quantity, quality and biological diversity of Minnesota's wetlands. Among the many reasons for preserving and protecting wetlands is their benefit to water quality, which is recognized in the state water-quality standards, Minn. Rules Ch. 7050. These standards establish the designated uses for all waters of the state including wetlands.

The designated uses for wetlands can be partitioned into three broad groups of wetland functions or values: biological, physical/hydrological, and socioeconomic.



Biological benefits of wetlands:

- Maintenance of biological diversity indigenous to wetlands
- Wildlife habitat

Physical/hydrological benefits of wetlands:

- Erosion control
- Ground water recharge
- Low-flow augmentation
- Stream sedimentation

Socioeconomic benefits of wetlands:

- Maintaining recreational activities associated with wetlands
- General commercial and industrial needs
- Maintain agricultural benefits
- Storm-water retention
- Aesthetic values
- Water-quality enhancement

Many of these designated uses occur in individual wetland basins, however, others occur on a landscape scale. The regulatory/permitting structure typically focuses on project-specific activities. The Corps of Engineers acknowledges the importance of cumulative impacts:

"*The impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable actions... Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time*."[2]

Any single wetland loss may not cause any noticeable impacts to water quality, but similar changes in many basins within a watershed will adversely affect water quality. To maintain the integrity of water resources it is important to undertake a comprehensive planning process.

The values and functions which nature and society derive from wetlands are varied and complex, often depending on wetland type.

[2] 40 CFR pt. 1508.7

SECTION V

Freshwater wetlands are separated into types by various classification systems. These types range widely in characteristics. Some are saturated for only a few weeks a year, while others are flooded all year. Some wetlands are treeless, containing only grasses and/or shrubs, while others are completely forested. The difficult task is to properly allocate the proportions and many types of public values each wetland might provide.

Water-Quality Protection

Protecting the water quality of other water bodies is one major value of wetlands. But, because they are waters of the state, the water quality of wetlands themselves must also be protected since their own water supports aquatic life. The loss of wetlands results in a depletion of water quality both in the wetland and downstream. Filtering of pollutants by wetlands is an important function and benefit. Wetland forests retain ammonia during seasonal flooding. Wetlands take up metals both by adsorption in the soils and by plant uptake via the roots. They also allow metabolism of oxygen-demanding materials and reduce fecal coliform populations. These pollutants are often then buried by newer plant material, isolating them in the sediments.

The assimilation of nutrients by wetlands helps reduce excessive plant growth in lakes and rivers. The main nutrients of concern are phosphorus and nitrogen. Common sources of nutrients in runoff are urban storm water, cultivated fields, and feedlots. If a lake becomes polluted because of excess nutrients or sediments, lake restoration must be undertaken. Most lake restoration methods are very costly, and this cost is borne by the public. Thus, the public value of wetlands that assimilate nutrients can be significant.

Low-Flow Augmentation and Ground-Water Interchange

The value of wetlands for low-flow augmentation and ground-water interchange may not be significant in all cases. However, increased impervious surface related to urbanization significantly affects ground-water interflow, or the shallow ground-water flow, which maintains the lower base flow to streams. With every increment of impervious surface, the contribution of water to the interflow becomes more critically threatened. Therefore, the contribution of wetlands to streams maintaining the low flows and the ground-water interchange can be cumulatively significant.

These values can be replaced by structural measures, such as infiltration devices. Some examples of infiltration devices include French drains, infiltration ponds, and other measures that directly put water back into the ground. The value of these types of structures is probably not a one-to-one replacement value for the existing ground-water recharge system, especially in unaffected natural areas. These structures replace large areas of infiltration with deep discharge facilities to handle hydraulic capacities. This may change the nature of the deep vs. shallow interflow.

One of the main concerns of these devices is that ground water may become vulnerable to greater pollutant loading, based on new land uses in the vicinity and on the direct discharge of storm water to the ground utilized by some of these devices. Precaution should be taken to prevent ground-water contamination whenever infiltration practices are used.

Maintaining Biological Diversity and Preserving Wildlife Habitat

These are some of the most difficult designated uses to replace because there are so many factors to consider in maintaining biological diversity and preserving wetland wildlife habitat. A wetland may provide a singular but important value such as temporary foraging or breeding area for waterfowl, as with as prairie potholes or northern pike spawning areas, which may not be inundated most of the year. Other wetland types may provide essential habitat throughout the year, including habitat for upland species such as deer and pheasants. We must also account for the value these areas might have as corridors and strive to maintain the environmental continuity and integrity of the watershed or of the wildlife corridor. Maintaining rare and endangered species habitat is an important part of maintaining diversity.

Maintaining wildlife diversity and habitat may not be specific to any location. It may be possible to replace a duck pond in another location and maintain the same number of animals. But diverse habitat types and wildlife species require careful site-specific determinations when we strive to maintain wetland functions and values.

Providing Recreational Opportunities and Enhancing the Natural Beauty of the Landscape

Preserving the aesthetic and recreational uses of wetlands can be the most subjective judgment in the evaluation process. People may have various perspectives on whether a natural setting or park-like setting is more appropriate. A community's desires in recreational values and aesthetic qualities must be factored in to land-use decisions made by local, state and federal agencies. The total package of public uses should be considered in the determination, and the value of a specific site should not be underestimated. For example, it may be difficult to offset the lost value of a scenic porch view with a mitigation site constructed miles or even blocks away.

Erosion Control, Floodwater Retention, Sedimentation Controls

By reducing the velocity and volume of flow, wetlands provide erosion control, floodwater retention, and reduced stream sedimentation. Although there are many other ways to provide erosion control, such as riprap or other structural solutions, we have to look at the primary and secondary impacts of our projects and remember that our solutions may create impacts downstream.

Dams and impoundments can reduce peak storm-water flows, but they do not reduce the total flows that have been increased by increased impervious surface area due to development. They also cause temperature increases and/or dissolved oxygen depletion in some situations. A pond or a dam with widely fluctuating water levels does not provide the quality of habitat a natural wetland with a seasonal or less frequently flooded condition provides. Therefore, the total impact should be considered, not just the primary impacts.

SECTION V

Designated uses of wetlands include:	Dredge	Drain	Inundate	Fill	On Site	Community	Region	Statewide
Low-flow augmentation		X		X	2	1	3	4
Maintaining biological diversity	X	X	X	X	3	2	1	4
Preserving wildlife habitat	X	X	X	X	3	2	1	4
Providing recreational opportunities	X	X	X	X	3	1	2	4
Erosion control		X		X	1	2	3	4
Floodwater retention		X		X	2	1	3	4
Reducing stream sedimentation which maintains water quality		X		X	2	1	3	4
Ground-water recharge		X		X	2	1	3	4
Enhancing the natural beauty of the landscape	X	X	X	X	1	2	3	4

NOTE: "X" indicates a potential loss of use caused by a physical alteration.

1 = most important
4 = least important

Mitigation should be provided in the area where there is most basis of concern.

Communities and regions should consider the value of wildlife corridors, watersheds and subwatersheds for maintaining environmental continuity and integrity.

SECTION V

Sediments are trapped in wetlands in several ways.

1) When the narrow channel of a stream widens into a wetland, stream velocity slows. This allows the sediments to drop out and settle in the wetland. We should note that it is possible for sediment to be resuspended from wetlands, that is, settling might not equal permanent removal.

2) Sedimentation also occurs along the riparian grassy border of a stream where vegetation filters the sediment load, capturing eroded sediments before they can get to the stream.

3) When wetlands decrease stream velocity, downstream bank scouring is also diminished. This further decreases sediment downstream of the wetland and enhances water quality.

Conclusions

Wetlands have varied and diverse characteristics, functions, and benefits. Recognizing public values and determining trade-offs are major challenges but are necessary if we are to maintain no-net-loss of wetlands and their functions.

For further information, we recommend the following:

1. MPCA 1993. "Minn. Rules Ch. 7050" and "Statement of Need and Reasonableness."

2. Board of Soil and Water Resources, 1993 and 1996 "Wetland Conservation Act," Minnesota Statute Ch. 103B.

3. Board Of Soil And Water Resources, 1995. "Minnesota Assessment Methodology," State of Minnesota.

4. Wisconsin Department of Natural Resources, November 1992, "Rapid Assessment Methodology for Evaluating Wetland Functional Values."

Sec.VI -.BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) are generally defined as the best practices available for a particular site to prevent damage to water quality. They have also been defined as "a combination of land use, conservation practices, and management techniques which, when applied to a unit of land, will result in the opportunity for reasonable development with an acceptable level of water quality." There are also many other legal and commonly used definitions. (See Appendices - p.92)-

Avoidance

The first and best BMP is to avoid impacts. In order to avoid impacts, we must develop policies that reproduce pre-development hydrological conditions. It means looking at reproducing the full spectrum of hydrologic conditions, including peak discharge, runoff volume, infiltration capacity, base flow levels, ground-water recharge, and maintenance of water quality. A comprehensive approach to hydrology is difficult and involves the whole context of site planning. The issues of runoff volume, infiltration recharge, and water quality revolve around the amount of impervious surface required by development and its configuration in terms of its relationship to drainage paths and vegetative cover. Try to avoid connecting streets, roofing and parking areas with pipes or other structures. Utilize natural topography and vegetated waterways to convey acceptable levels of runoff (Figure VI-1).

One goal should be to preserve and utilize the natural drainage system. Keep pavement and other impervious surfaces out of low areas, swales and valleys. This means working toward site plans that keep the roads and parking areas high in the landscape and along ridges wherever possible (as shown schematically in Figure VI-2).

This is more difficult to achieve than it appears, because it goes against long-established policies which too often increase flows and destroy the waterways we wish to utilize.

Avoid development-related construction activity in the most sensitive areas. This means avoiding development along the shorelines of lakes or streams, in natural drainage ways, or in areas which are dominated by steep slopes, dense vegetation, porous soils, scientific and natural areas, or other identified resources.

Fit development to the terrain by choosing road patterns that provide access schemes which match the and form. 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 which resembles the branched patterns of ridge lines and drainage ways in the natural landscape.

SECTION VI

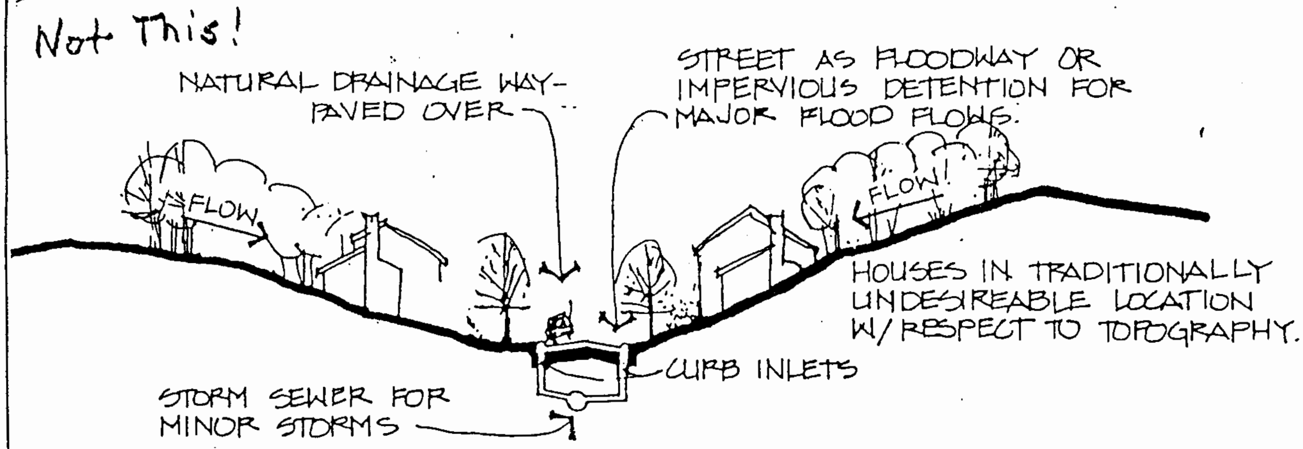


FIGURE VI-1 Conventional curb-and-gutter streets with storm sewers tend to gravitate to low areas where the hydraulic efficiency of the storm sewer is maximized.

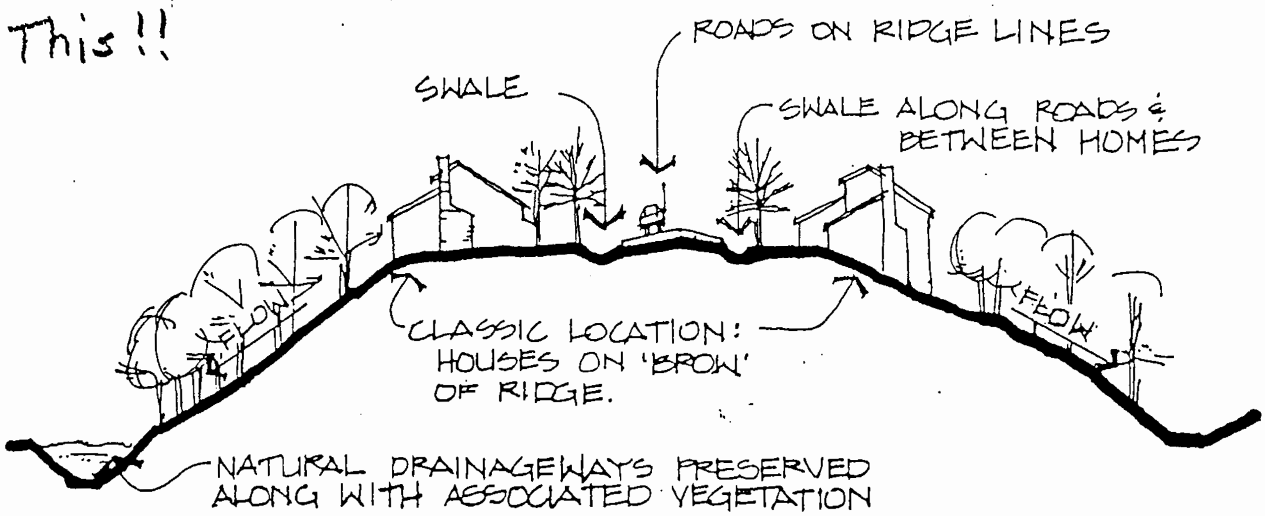


FIGURE VI-2 Place roads along ridge lines. Keep construction areas away from low areas and valley flow lines.

FIGURE VI-3 Use sensitive areas such as natural drainage areas to form boundaries or buffer zones between clusters of housing.

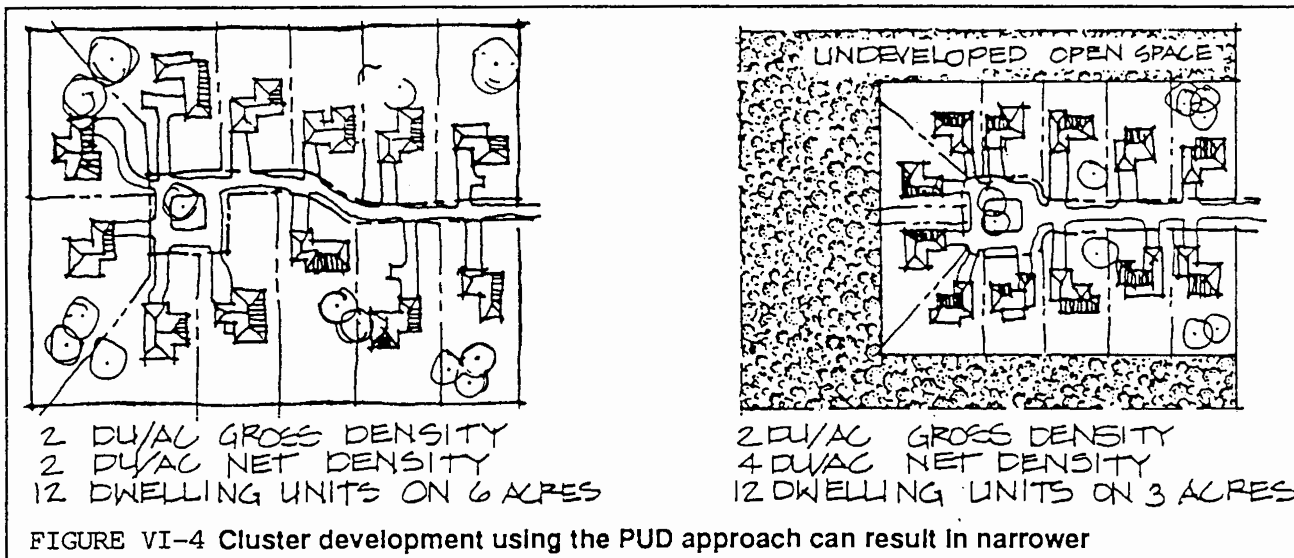


FIGURE VI-4 Cluster development using the PUD approach can result in narrower lot frontages, shorter street and utility rows plus the preservation of significant blocks of undeveloped open space.

This facilitates the development of plans which work with the land form and minimize disruption of existing grades and natural drainage (See Figures VI-3 and 4).

Quantity and Quality Connections

To properly implement BMPs it is important to understand the storm-water problems that need correction. This means identifying the sources of problem pollutants, including concentrations, loading, and flows. Then design the control program to fit local needs. There are important differences between the pollutants expected from various source areas (Bannerman, 1992). We should also be aware that source areas can vary in importance, depending on the type of rainfall (Pitt, 1993). If the hydrology does not correctly predict sources of pollutants and flows, then we cannot get the expected storm-water control benefits.

As explained in detail in the section on hydrology, most of the pollutant loads from storm water are associated with relatively small rain events of less than one inch. It is estimated that 75 to 85 percent of runoff is generated by storms under 1.25 inches in depth (Pitt, 1993). In the Minnesota metropolitan area, we know that over 90 percent of our daily rainfall events are under 1 inch in depth (State Climatologist, 1993). Since many existing urban runoff models originate from drainage- and flood-evaluating procedures that emphasize flood events, this has lad to some incorrect assumptions regarding runoff from the smaller, but important, rainfall events (Pitt, 1993). Assumptions about impervious and pervious areas that could be correct for large rainfall events are often incorrect for small events.

The significance of storm hydrology to receiving waters increases with the sensitivity of the receiving water. Ponds which provide pretreatment prior to discharge to a wetland (see Figure VI-5) may be acceptable for most situations, but may not be acceptable for highly sensitive wetlands or areas where thermal impacts could be critical. Sensitive wetlands can be affected by small changes in water depth and duration of inundation. Therefore, sensitive wetlands, and water bodies that have been stressed by flow changes and pollutant loading, will need to have the small-storm hydrology addressed in detail. Without proper hydrologic data, we cannot correctly assess hydrologic and pollutant loading changes. Chapters on hydrology and wetland sensitivity discusses these issues in greater detail.

BMPs for Highly Sensitive Wetlands

A common method of utilizing wetlands for storm water has been to increase the depth of ponding on a permanent or temporary basis. The end result is the transformation of a natural wetland into a storm-water wetland, with the attendant loss of diversity and functional values. The transformation occurs regardless of whether the natural wetland is replaced by a permanent pool or by temporary extended detention.

No single BMP will reproduce predevelopment hydrology once development has occurred upstream. However, the Washington Metropolitan Council of Governments suggests several structural alternatives that are close to reproducing natural hydrology (Schueler, 1992).

FIGURE VI-5

PRETREATMENT OF STORM WATER

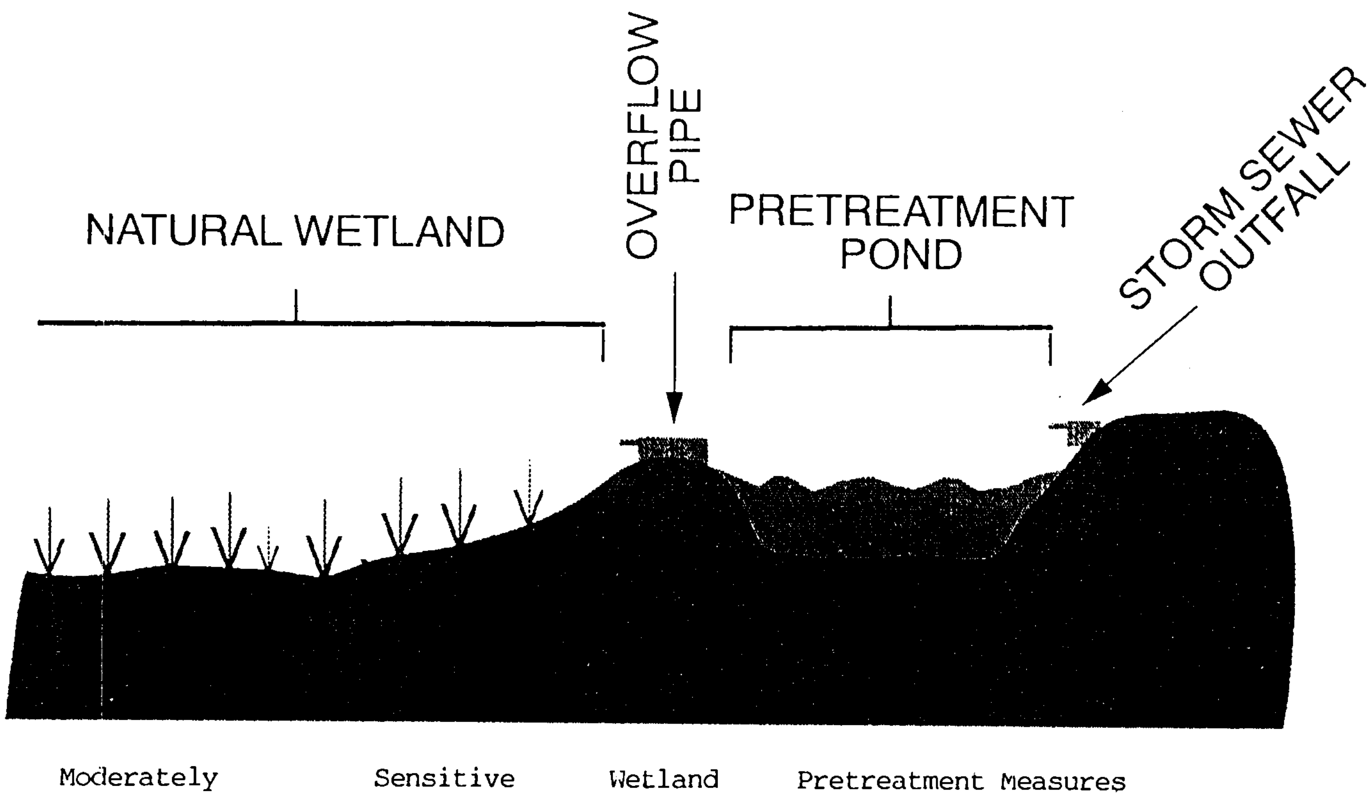
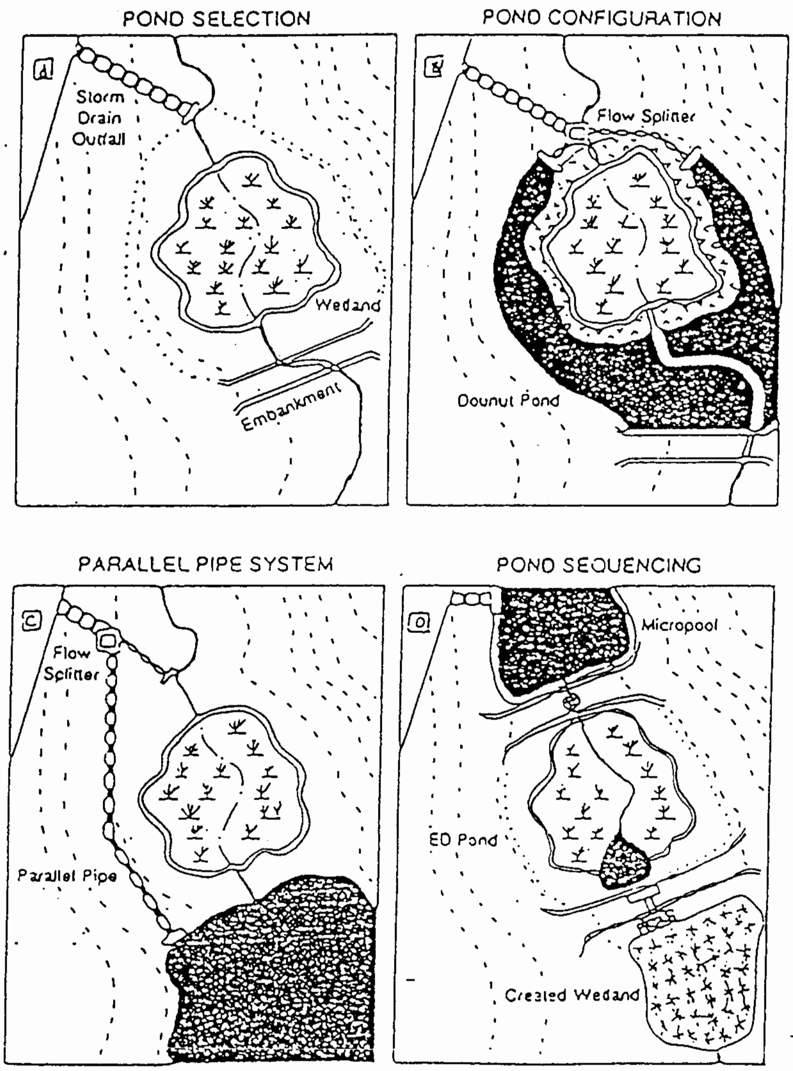


FIGURE VI-6

Highly Sensitive Wetland
Pretreatment Measures

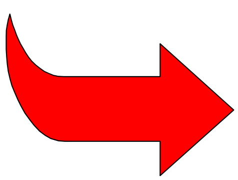
Techniques for Fingerprinting a Stormwater Wetland Around a Natural Wetland



Panel A. Existing natural wetland is severely impacted by upstream stormwater inputs and frequent inundation. Panel B. Existing wetland is protected by berm; stormwater bypassed to the two arms of the wet pond. Panel C. Excess stormwater diverted around natural wetland to a more favorable location via a parallel pipe system. Panel D. Stormwater pretreated before it reaches wetland, where temporary extended detention is provided. A downstream stormwater wetland is created to compensate for impacts to the existing wetland.

The preferred course of action is to locate the storm-water control in an upstream or off-stream location. This is easier said than done, as some quantity of base flow is required to maintain water elevations within a storm-water wetland. (See Figure VI-6, Panel A.)

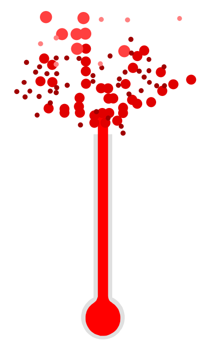
An alternative is to create a “donut” configuration around the wetland, as shown in Figure VI-6, Panel B. In this scenario, a flow splitter is installed upstream of the sensitive wetland. The required storage for the storm-water pond or wetland is then excavated outside of the natural wetland. The upstream flow splitter is used to apportion flow to the wetland and the storm-water system. The base flow is directed into the existing wetland while the storm flow is routed to the storm-water ponds.



A second technique is to install a parallel pipe system that diverts storm flows around the existing wetland to a downstream storm-water control system (Figure VI-5, Panel C). Again, a flow splitter is installed above the sensitive wetland that diverts the storm flows from the development away from the wetland, yet sends dry-weather base flow to the wetland. The design should attempt to mimic the original water balance to the wetland. In some cases, it is possible to split the needed base flow away from the stream into an off-line or storm-water system, which empties downstream of the wetland to be protected (see Figure VI-6, panel C). This usually involves extensive sewer construction with related storm-sewer costs. It also results in transferring the problem elsewhere rather than solutions which could have provided enhancement opportunities.

A third technique involves employing a series of smaller storm-water pools and wetland areas above and below the sensitive wetland. One such scheme is shown in Figure IV-5 (Panel D). Runoff is pre-treated before it enters the sensitive wetland. This scenario will still result in significant storm-water influence to the existing wetland, but by lowering peak flows it can reduce the overall degradation that might occur.

Temperature



One study (Galli, John, December, 1990) concluded that the temperature in small, free-flowing headwater streams was largely determined by the following interrelated factors:

1) Air temperature and other local meteorological conditions;
2) Watershed imperviousness;
3) Riparian canopy coverage;
4) Stream order/size.

Others (Salo Engineering, MPCA correspondence, September 14, 1994) have summarized the critical factors as:

1) Climate, which means temperature, solar heating, and wind loss;
2) Soil moisture;
3) Rainfall; and
4) Stream level, meaning drought or full-flowing conditions.

These summaries of critical factors do not conflict; rather, they show that there may be different ways of grouping or summarizing the critical data.

The Metropolitan Washington Council of Governments (Galli, December, 1990) studied temperature and dissolved oxygen effects from four BMPs:

1) infiltration-dry pond;
2) extended detention artificial wetland;
3) extended detention dry pond; and
4) wet pond.

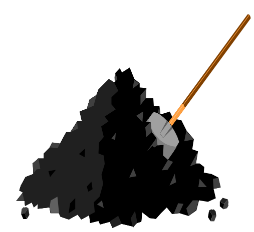
They concluded that none of the four BMPs were "thermally neutral." All four BMPs caused a rise in temperature and each violated Maryland standards some of the time. Temperature-standard violations occurred under both base-flow and storm-flow conditions. The infiltration-dry pond produced the smallest temperature increases, whereas the wet pond had the highest recorded maximum change in temperature.

In Minnesota, it is not clear what the effect of ponding strategies might be on temperature, and especially on the aquatic environment. While most fish species would probably not be significantly affected by the changes in temperature produced by ponds, trout are extremely sensitive to temperature changes and may be significantly affected in certain cases. Another significant affect may be the impact to aquatic macroinvertebrates, that is, aquatic insects. Cold-water aquatic insects such as stone flies could be eliminated or severely stressed under certain temperature change conditions. The change in insect populations may also change the success and viability of the cold-water fishery population.

Comprehensive Approach

The Metropolitan Washington Council of Governments recommends a long-term holistic approach to watershed management. Their BMP design features recommended increasing the performance of infiltration devices by improving the infiltration design capacity and intentionally oversizing the basins. They also recommend buffer strips and shading of pilot and riprap outflow channels via landscaping or other means. Also recommended is the practice of employing long, wide, riprap outfall channels. Whenever possible, outflow channels should be heavily shaded and should include a deep, narrow base-flow channel to quickly return the water back to a natural stream channel. They also recommend carefully examining long periods of extended detention control. They recommend a six- to 12-hour detention-period limit be established for sensitive areas and that shading in the storage pool be required. In addition, they recommend future research on the case-specific effects of BMPs and their effectiveness at controlling temperature increases. Water-temperature monitoring for thermally sensitive areas should be greatly increased.

Construction BMPs



Once a plan is formulated to avoid impacts of the proposed project to the maximum practicable extent, the next step is to minimize impacts of construction. Careful planning is an important part of erosion and sediment control. Careful planning will anticipate problem areas, which will minimize both the erosion potential and the cost of sediment control measures. There are several good manuals listing available BMPs that are appropriate for construction sites. These include the MPCA's "Protecting Water Quality in Urban Areas" and the Board of Water and Soil Resources' "Minnesota Construction Site Erosion and Sediment Control Planning Handbook." The Minnesota Department of Transportation's "Manual of Practice" is also an excellent source. The problem is finding the proper BMPs for site-specific situations.

Housekeeping and Prevention

We must utilize good housekeeping practices and maintenance to avoid problems related to storm-water pollutant loading. Erosion control ordinances, street sweeping, fuel storage plans, trash removal education, and other measures should be implemented as needed.

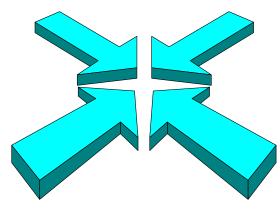
Minimizing and Mitigating Post-Project Hydrologic Changes

Generally, some form of storm-water detention will be needed to achieve a desired level of hydrologic control from developments. The advantage to deciding this in the planning stage is that storm-water detention structures can be made to serve several purposes if properly planned. These structures can trap pollutants, reduce peak discharges, and improve aesthetics and recreation. Storm-water detention practices can also serve as sediment basins during construction on the site. Regardless of the practices selected, the cost of structural measures is usually lower if they are planned and installed at the time of development. The actual post-project BMPs are discussed later.

BMPs as a System

It is usually necessary to use a combination of practices to meet water-quality goals rather than rely upon one practice such as a detention pond. Housekeeping practices should always be used, but will rarely achieve the desired results alone. Figure VI-7 provides a general indication of the effectiveness of various structural BMPs. This is a general chart that is only intended to provide an awareness of the capabilities of various BMPs. Combinations of BMPs must be adopted on a site-specific basis.

Effect on Other Resources



When planning a BMP, consider the effect it will have on other resources. Without proper design, it is possible your BMP will simply shift a water-quality problem elsewhere. Stream temperature, peak-flow timing, aesthetics, and ground water can be adversely affected by improperly designed BMPs. Examples of other resources that can be adversely affected are fish and wildlife. Studies have shown that pollutants such as trace metals can bioaccumulate in plants and fish that live in areas where sediment from urban storm water is trapped (Smith, 1988; Meiorin, 1986). Many BMPs trap pollutants that need to be disposed of in an environmentally sound manner.

Public Acceptance

In an urban environment, aesthetics are an important consideration for gaining public acceptance of BMPs. In many cases, practices such as detention ponds can be a visual asset to the surrounding area.

However, if a detention pond is designed, for example, in a square shape with uniform slopes, it will not appear natural and can detract aesthetically from the surrounding area.

The potential for odor, insects, weeds, turbidity and trash are also important to residents who live near structural BMPs. With regular maintenance, these problems can usually be overcome or be made very temporary.

Physical Site Suitability

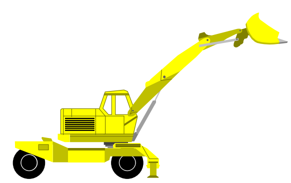
BMPs should only be used in areas where the physical site characteristics are suitable. Some of the physical characteristics that are important are soil type, watershed area, water table, depth to bedrock, site size, and topography. If these conditions are not suitable, a BMP can lose effectiveness, require excessive maintenance, or stop working altogether after a short period of time.

Sometimes, unfavorable site conditions can be overcome with special design features. For example, the bottom of a detention pond can be sealed to prevent seepage into permeable soils at a site where a permanent pool is desired. In other cases, a practice will be excluded from consideration for a site because of conditions that are not practical to overcome. An example of this would be where a high water table or clay soils eliminate an infiltration basin from consideration. The physical site conditions must be examined for each practice.

Cost Effectiveness

Economics is an important consideration in the selection of BMPs that will achieve the water-quality goal at the least cost. This should be considered when selecting BMPs and deciding how they will be implemented. To properly compare alternatives, all costs for the design life of a BMP should be included. These include expected maintenance costs as well as the initial costs for land, engineering and construction. To create a true economic picture of a BMP, benefits other than water quality and flood prevention should also be considered. Some benefits, such as increases in land values for property adjacent to an attractive detention pond, are direct economic benefits. Other benefits, such as incidental recreation benefits or wildlife benefits, may be more difficult to quantify.

Maintenance Requirements



Maintenance is an important part in the operation of any BMP. The initial design of the BMP should take maintenance requirements into account. A feature such as a forebay in a detention pond may increase annual maintenance costs slightly, but the interval between costly sediment cleanouts in the whole pond may be extended significantly. Locations for disposal of material should be taken into account during this phase of planning.

SECTION VI

For further information, we recommend the following:

1. MPCA, October 1989. "Protecting Water Quality in Urban Areas."

2. Metropolitan Washington Council of Governments, March 1992. "A Current Assessment of Urban Best Management Practices, Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone."

3. Metropolitan Washington Council of Governments. "Design of Storm-Water Wetland System, Guidelines for Creating Diverse and Effective Storm-water Wetland Systems in the Mid-Atlantic Region." Anacosta Restoration Team, Department of Environmental Programs.

4. Washington State Department of Ecology, February 1992. "Storm-Water Management Manual for the Puget Sound Basin," Olympia, Wash.

A COMPARATIVE ASSESSMENT OF THE EFFECTIVENESS OF STRUCTURAL URBAN BEST MANAGEMENT PRACTICES

GROUP	URBAN BMP OPTIONS	RELIABILITY FOR POLLUTANT REMOVAL	LONGEVITY*	APPLICABLE TO MOST DEVELOPMENTS	REGIONAL CONCERNS	ENVIRONMENTAL CONCERNS	COMPARATIVE COST	SPECIAL CONSIDERATIONS
I	Extended Detention Ponds	Moderate, but not always reliable	20+ years, but frequent clogging and short detention common	Widely applicable	Very few ** ***	Possible stream warming and habitat destruction	Lowest cost alternative in size range	Recommended with design improvements and with the use of micropools & wetlands
	Wet Pond	Moderate to high	20+ years	Widely applicable	** ***	Possible stream warming, trophic shifts, habitat destruction, safety hazards, sacrifice of upstream channels	Moderate to high compared to conventional storm water detention	Recommended, with careful site evaluation
	Storm Water Wetlands	Moderate to high	20+ years	Space may be limiting	winter die off release of P ** ***	Stream warming, natural wetland alteration	Marginally higher than wet ponds	Recommended
	Multiple Pond Systems	Moderate to high; redundancy increases reliability	20+ years	Many pond options	** ***	Selection of appropriate pond option minimizes overall environmental impact	Most expensive pond option	Recommended
II	Infiltration Trenches	Presumed moderate	50% failure rate within five years	Highly restricted (soils, ground water, slope, area, sediment input)	Arid and cold regions; sole-source aquifers ****	Slight risk of ground water contamination	Cost effective on smaller rehab costs can be considerable	Recommended with pretreatment and geotechnical evaluation
	Infiltration Basins	Presumed moderate, if working	60-100% failure within five years	Highly restricted (see infiltration trench)	Arid and cold regions; sole-source aquifers ****	Slight risk of ground water contamination	Construction cost moderate, but rehab cost high	Not widely recommended until longevity is improved
	Porous Pavement	High (if working)	75% failure within five years	Extremely restricted (traffic, soils, ground water, slope, area, sediment input).	Cold climates; wind erosion; sole-source aquifers ****	Possible ground water impacts; uncontrolled runoff	Cost-effective compared to conventional asphalt when working properly	Recommended in highly restricted applications with careful construction and effective maintenance
III	Sand Filters and Peat Filters	Moderate to high	20+ years	Applicable (for smaller developments)	Few restrictions	Minor	Comparitively high construction costs and frequent maintenance	Recommended, with local demonstration
IV	Grassed Swales	Low to moderate, but unreliable	20+ years	Low density development and roads	Arid and cold regions	Minor	Low, compared to curb and gutter	Recommended, with checkdams, as one element of a BMP system
	Filter Strips Pocket Wetlands	Unreliable in urban settings	Unknown, but may be limited	Restricted to low density area	Arid and cold regions	Minor	Low	Recommended as one element of a BMP system
V	Water Quality Inlets Expanded Pipes	Presumed low	20+ years	Small, highly impervious catchments (<2 acres)	Few	Resuspension of hydrocarbon loadings. Disposal of hydrocarbon and toxic residuals	High, compared to trenches and sand filters	Not currently recommended as a primary BMP option

I=Ponds; II=Infiltration; III=Filters; IV=Biofilters; V=Inlets

*Based on current designs and prevailing maintenance practices
**Adverse Flood Route Timing can increase peak floods
***Increased flow volume can extend duration of erosive flows
****Significant ground water concerns especially in industrial areas

Adopted from Schuler Oct. 92

APPENDICES

Glossary

Adsorption - Adhesion of the molecules of a gas, liquid or dissolved substance to a surface. Adsorption differs from absorption in that absorption is the assimilation or incorporation of a gas, liquid or dissolved substance into another substance.

Adjustable gate valve - A knife-gate valve, activated by a hand wheel, used to control the internal diameter of reverse-slope pipes or allow rapid opening of the pond drain pipe.

Aggregate - Stone or rock gravel needed to fill in an infiltration BMP such as a trench or porous pavement. Clean-washed aggregate is simply aggregate that has been washed clean so that no sediment is associated with it.

Aquatic bench - A 10- to 15-foot bench around the inside perimeter of a permanent pool that is approximately one foot deep. Normally vegetated with emergent plants, the bench augments pollutant removal, provides habitat, conceals trash and water-level drops, and enhances safety.

Artificial marsh creation - Simulation of natural wetland features and functions via topographic and hydraulic modifications on non-wetland landscapes. Typical objectives for artificial marsh creation include ecosystem replacement or storm-water management.

Bacterial decomposition or microbial decomposition - Micro-organisms, or bacteria, have the ability to degrade organic compounds as food resources and to absorb nutrients and metals into their tissues to support growth.

Bank run - Gravel deposits consisting of smooth round stones, generally indicative of the existence of a prehistoric sea. Such deposits are normally found in coastal plain regions.

Bank stabilization - Methods of securing the structural integrity of earthen stream-channel banks with structural supports to prevent bank slumping and undercutting of riparian trees, and for overall erosion prevention. To maintain the ecological integrity of the system, recommended techniques include the use of willow stakes, riprap, or brush bundles.

Bank-full discharge - A flow condition where stream flow completely fills the stream channel up to the top of the bank. In undisturbed watersheds, this condition occurs on average every 1-1/2 to two years and controls the shape and form of natural channels.

Base flow - The portion of stream flow that is not due to storm runoff, and is supported by ground-water seepage into a channel.

APPENDICES

Berm, earthen - An earthen mound used to direct the flow of runoff around or through a BMP.

Biofiltration - The use of a series of vegetated swales to provide filtering treatment for storm water as it is conveyed through the channel. The swales can be grassed, or contain emergent wetlands or high marsh plants.

Biological monitoring - Periodic surveys of aquatic biota as an indicator of the general health of a water body. Biological monitoring surveys can span the trophic spectrum, from macro-invertebrates to fish species.

BMP (best management practice) - A combination of land use, conservation practices, and management techniques which, when applied to a unit of land, will result in the opportunity for a reasonable economic return with an acceptable level of water quality.

BMP fingerprinting - Refers to a series of techniques for locating BMPs (particularly ponds) within a development site as to minimize their impacts to wetlands, forests and sensitive stream reaches.

Catchment - See **contributing watershed area**

Channel erosion - The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by moderate to larger floods.

Check dam - (a) A log or gabion structure placed perpendicular to a stream to enhance aquatic habitat. (b) An earthen or log structure used in grass swales to reduce water velocities, promote sediment deposition, and enhance infiltration.

Contributing watershed area - Portion of the watershed contributing its runoff to the BMP in question.

Delta-T - The magnitude of change in the temperature of downstream waters.

Design storm - A rainfall event of specified size and return frequency (e.g., a storm that occurs only once every two years) that is used to calculate the runoff volume and peak discharge rate to a BMP.

Detention - Temporary storage of runoff from rainfall and snow-melt events to control peak discharge rates and provide an opportunity for physical, chemical and biological treatment to occur.

APPENDICES

De-watering - Refers to a process used in detention/retention facilities, whereby water is completely discharged or drawn down to a pre-established pool elevation by way of a perforated pipe. De-watering allows the facility to recover its design storage capacity in a relatively short time after a storm event.

Downstream scour - Downstream channel erosion usually associated with an upstream structure that has altered hydraulic conditions in the channel.

Drop structure - Placement of logs with a weir notch across a stream channel. Water flowing through the weir creates a plunge pool downstream of the structure and creates fish habitat.

Draw-down - The gradual reduction in water level in a pond BMP due to the combined effect of infiltration and evaporation.

Dry pond conversion - A modification made to an existing dry storm-water management pond to increase pollutant removal efficiencies. For example, the modification may involve a decrease in orifice size to create extended detention times, or the alteration of the riser to create a permanent pool and/or shallow marsh system.

ED (extended detention) zone - A pondscaping zone that extends up from the normal pool to the maximum water surface elevation during extended detention events. Plants within this zone must be able to withstand temporary inundation from five to 30 times per year.

Embankment - A bank (of earth or riprap) used to keep back water.

Emergent plant - An aquatic plant that is rooted in the sediment but whose leaves are at or above the water surface. Such wetland plants provide habitat for wildlife and waterfowl in addition to removing urban pollutants.

End-of-pipe control - Water-quality control technologies suited for the control of existing urban storm water at the point of storm-sewer discharge to a stream. Due to typical space constraints, these technologies are usually designed to provide control of water quantity rather than quality

Exfiltration - The downward movement of runoff through the bottom of an infiltration BMP into the subsoil.

Extended detention - A storm-water design feature that provides for the gradual release of a volume of water (0.25 - 1.0 inches per impervious acre) over 12- to 48-hour interval times to increase settling of urban pollutants and protect channel from frequent flooding.

Extended detention (ED) pond - A conventional ED pond temporarily detains a portion of storm-water runoff for up to 24 hours after a storm using a fixed orifice. Such extended detention allows urban pollutants to settle out. The ED ponds are normally "dry" between storm events and do not have any permanent standing water.

An enhanced ED pond is designed to prevent clogging and resuspension. It provides greater flexibility in achieving target detention times. It may be equipped with plunge pools near the inlet and a micropool at the outlet, and utilize an adjustable reverse-sloped pipe at the ED control device.

Extended detention wetland - A storm-water wetland design alternative in which the total treatment volume is equally split between a shallow marsh and temporary detention of runoff above the marsh. After a storm, the normal pool of the shallow marsh may rise by up to two feet. The extra runoff is stored for up to 24 hours to allow pollutants to settle out before being released downstream.

Filter fabric - Textile of relatively small mesh or pore size that is used to (a) allow water to pass through while keeping sediment out (permeable), or (b) prevent both runoff and sediment from passing through (impermeable).

Flow path - The distance that a parcel of water travels through a storm-water wetland. It is defined as the distance between the inlet and outlet, divided by the average width. During dry weather, the flow path of a storm-water wetland can be increased by placing marsh wedges perpendicular to the normal flow path.

Flow splitter - An engineered, hydraulic structure designed to divert a portion of stream flow to a BMP located out of the channel, or to direct storm water to a parallel pipe system, or to bypass a portion of base flow around a pond.

Forebay - An extra storage area provided near an inlet of a BMP to trap incoming sediments before they accumulate in a pond BMP. See sediment forebay.

Frequent flooding - A phenomenon in urban streams whereby the number of bank-full and sub-bank-full flood events increases sharply after development. The frequency of these disruptive floods is a direct function of watershed imperviousness.

Fringe wetland - Narrow emergent wetland areas that are created by the use of shallow underwater benches along the perimeter of a wet pond. The benches are usually 15 feet wide and covered with water up to 12 inches deep. Fringe wetlands enhance pond pollutant removal, conceal trash and water-level changes, reduce safety hazards, and create a more natural appearance.

Fringe wetland creation - Planting of emergent aquatic vegetation along the perimeter of open water to enhance pollutant uptake, increase forage and cover for wildlife and aquatic species, and improve the appearance of a pond.

APPENDICES

Gabion - A large rectangular box of heavy-gauge wire mesh which holds large cobbles and boulders. Used in streams and ponds to change flow patterns, stabilize banks, or prevent erosion.

Geomembrane - Lining of filter fabric on the bottom and sides of porous pavement to prevent lateral or upward movement of soil into the stone reservoir.

Geotextile fabric - See **filter fabric**.

Grassed swale - A conventional grass swale is an earthen conveyance system in which the filtering action of grass and soil infiltration are utilized to remove pollutants from urban storm water. An enhanced grass swale, or biofilter, utilizes check dams and wide depressions to increase runoff storage and promote greater settling of pollutants.

Gravitational settling - The tendency of particulate matter to "drop out" of storm water runoff as it flows downstream when runoff velocities are moderate and/or slopes are not too steep.

Head - Hydraulic pressure.

High marsh - Diverse wetland type found in areas that are infrequently inundated or have wet soils. In pond systems, the high marsh zone extends from the permanent pool to the maximum ED water surface elevation.

Hydroperiod - The extent and duration of inundation and/or saturation of wetland systems. Storm-water wetlands tend to have a hydroperiod characterized by frequent to chronic inundation by standing water.

Infiltration basin - An impoundment where incoming storm-water runoff is stored until it gradually exfiltrates through the soil of the basin floor.

Infiltration trench - A conventional infiltration trench is a shallow, excavated trench that has been backfilled with stone to create an underground reservoir. Storm-water runoff diverted into the trench gradually exfiltrates from the bottom of the trench into the subsoil and eventually into the water table. An enhanced infiltration trench has an extensive pretreatment system to remove sediment and oil. It requires an on-site geotechnical investigation to determine appropriate design and location.

Level spreader - A device used to spread out storm-water runoff uniformly over the ground surface as sheet flow (i.e., not through channels). The purpose of level spreaders is to prevent concentrated, erosive flows from occurring and to enhance infiltration.

APPENDICES

Low marsh - Wetland type with emergent plant species that require some depth of standing water throughout the year. The low marsh zone in pond systems is created in areas where the permanent pool is up to 12 inches deep.

Low-flow channel - An incised or paved channel from inlet to outlet in a dry basin which is designed to carry low runoff flows and/or base flow directly to the outlet without detention.

Micropool - A smaller permanent pool used in a storm-water pond due to extenuating circumstances, i.e., concern over the thermal impacts of larger ponds, impacts on existing wetlands, or lack of topographic relief.

Microtopography - Refers to the contours along the bottom of a shallow marsh system. A complex microtopography creates a great variety of environmental conditions that favor the unique requirements of many different species of wetland plants.

Monotype - Dominated by a simple type of vegetation, e.g. cattails.

Multiple pond system - A collective term for a cluster of pond designs that incorporate redundant runoff treatment techniques within a single pond or series of ponds. These pond designs employ a combination of two or more of the following: extended detention, permanent-pool shallow wetlands, or infiltration. Examples of a multiple pond system include the wet ED pond, ED wetlands, infiltration ponds, and pond-marsh systems.

Natural buffer - A low sloping area of maintained grassy or woody vegetation located between a pollutant source and a water body. A natural buffer is formed when a designated portion of a developed piece of land is left unaltered from its natural state during development. A natural vegetative buffer differs from a vegetated filter strip in that it is "natural" and not necessarily intended solely for water-quality purposes. To be effective, such areas must be protected from concentrated flow.

NURP - Nationwide Urban Runoff Program, a study by the U.S. Environmental Protection Agency. A key component of this program was to assess the effectiveness of urban runoff detention/retention basins (e.g., ponds).

Observation well - A test well installed in an infiltration trench to monitor draining times after installation.

Off-line BMP - A water-quality facility designed to treat a portion of storm water (usually 0.5 to 1.0 inches per impervious acre) which has been diverted from a stream or storm drain.

Off-line treatment - A BMP system located outside of the stream channel or drainage path. A flow splitter is used to divert runoff from the channel and into the BMP for subsequent treatment.

APPENDICES

Oil/grit separator - A BMP consisting of a three-stage underground retention system designed to remove heavy particulates and absorbed hydrocarbons. Also known as a water quality inlet.

Outfall - The point of discharge for a river, drain, pipe, etc.

Parallel pipe system - A technique for protecting sensitive streams. Excess storm-water runoff is piped in a parallel direction along the stream buffer instead of being discharged directly into the stream.

Peat sand filter - A BMP that utilizes the natural adsorptive features of fabric or hemic peat. Consists of a vertical filter system with a grass cover crop, alternating layers of peat and sand, and a sediment forebay feature. The peat sand filter is presently used for municipal waste-treatment systems and is being adapted for use in storm-water management.

Permanent pool - A three- to 10-foot-deep pool in a storm-water pond system, that provides removal of urban pollutants through settling and biological uptake. (Also referred to as a wet pond.)

Physical filtration - As particulates pass across or through a surface, they are separated from runoff by grass, leaves and other organic matter on the surface.

Pilot channel - A riprap or paved channel that routes runoff through a BMP to prevent erosion of the surface.

Plunge pool - A small permanent pool located at either the inlet of outfall of a BMP. The primary purpose of the pool is to dissipate the velocity of storm-water runoff, but it also can provide some pretreatment as well.

Pocket wetlands - A storm-water wetland design adapted for small drainage areas with no reliable source of base flow. The surface area of pocket wetlands is usually less than a tenth of an acre. The pocket wetland usually has no deep water cells, and is intended to provide some pollutant removal for very small development sites.

Pondscaping - A method of designing the plant structure of a storm-water wetland or pond using inundation zones. The proposed wetland or pond system is divided into zones which differ in the level and frequency of inflow. For each zone, plant species are chosen based on their potential to thrive, given the inflow pattern of the zone.

Porous pavement - An alternative to conventional pavement whereby runoff is diverted through a porous asphalt layer and into an underground stone reservoir. The stored runoff then gradually exfiltrates into the subsoil.

Retention - The permanent storage of runoff from rainfall and snow-melt events with volume reduction coming from infiltration, evaporation, or emergency release.

Retrofit - The creation/modification of storm-water management systems in developed areas through the construction of wet ponds, infiltration systems, wetland plantings, stream-bank stabilization, and other BMP techniques for improving water quality and creating aquatic habitat. A retrofit can consist of the construction of a new BMP in the developed area, the enhancement of an older storm-water management structure, or a combination of improvements and new construction.

Reverse-slope pipe - A pipe that extends downwards from a riser into a permanent pool that sets the water-surface elevation of the pool. The lower end of the pipe is located up to one foot below the water surface. Very useful technique for regulating ED times that seldom clogs.

Riparian - A relatively narrow strip of land that borders a stream or river, often coincides with the maximum water-surface elevation of the one-hundred-year storm.

Riparian reforestation - The replanting of the banks and floodplain of a stream with native forest and shrub species to stabilize erodible soils, improve both surface and ground-water quality, increase stream shading, and enhance wildlife habitat.

Riprap - A combination of large stones, cobbles and boulders used to line channels, stabilize banks, reduce runoff velocities, or filter out sediment.

Riser - A vertical pipe extending from the bottom of a pond BMP that is used to control the discharge rate from a BMP for a specified design storm.

Rototilling - Mechanical means of tilling, or rotating, the soil.

Runoff, storm water - The overland and near-surface flow from storm water and snow melt.

Runoff conveyance - Methods for safely conveying runoff to a BMP to minimize disruption of the stream network and promote infiltration or filtering of the runoff.

Runoff frequency spectrum - The frequency distribution of unit/area runoff volumes generated by a long-term, continuous time-series of rainfall events. Used to develop BMP and storm-water sizing rules.

Runoff pretreatment - Techniques to capture or trap coarse sediments before they enter a BMP to preserve storage volumes or prevent clogging within the BMP. Examples include forebays and micropools for pond BMPs, and plunge pools, grass filter strips, and filter fabric for infiltration BMPs.

APPENDICES

Safety bench - A 10- to 15-foot bench located just outside the perimeter of a permanent pool. The bench extends around the entire shoreline to provide for maintenance access and eliminate hazards.

Sand filter - A relatively new technique for treating storm water, whereby the first flush of runoff is diverted into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes, and returned back to the stream or channel. An enhanced sand filter utilizes layers of peat, limestone, and/or topsoil, and may also have a grass cover crop. The adsorptive media of an enhanced sand filter is expected to improve removal rates.

Sa/v ratio - The surface area to volume ratio is a useful measure of the capacity of storm-water wetland to remove pollutants via sedimentation, adsorption, and microbial activity. The SA/V ratio can be increased by either increasing the surface area of a wetland or increasing the internal structural complexity within the wetland.

Sediment forebay - Storm-water design feature that employs the use of a small settling basin to settle out incoming sediments before they are delivered to a storm-water BMP. Particularly useful in tandem with infiltration devices, wet ponds, or marshes.

Seedbanks - Refers to the large number and diversity of dormant seeds of plant species that exist within the soil. The seeds may exist within the soil for years before they germinate under the proper moisture, temperature or light conditions. Within wetland soils, this seedbank helps to maintain above-ground plant diversity and can also be used to rapidly establish wetland plants within a newly constructed storm-water wetland.

Short-circuiting - The passage of runoff through a BMP in less than the theoretical or design treatment time.

Slurry - Thin mixture of water and any of several fine, insoluble materials; for example, an oil slurry is a thin mixture of water and oil.

Storm-water treatment - Detention, retention, filtering or infiltration of a given volume of storm water to remove urban pollutants and reduce frequent flooding.

Storm-water-influenced wetland - Refers to a natural wetland in an urban area that receives urban storm-water runoff.

Storm-water wetland - A conventional storm-water wetland is a shallow pool that creates growing conditions suitable for the growth of marsh plants. A storm-water wetland is designed to maximize pollutant removal through wetland uptake, retention and settling.

A storm-water wetland is a constructed system that typically is not located within a delineated natural wetland. In addition, a storm-water wetland differs from an artificial wetland created to comply with mitigation requirements in that the storm-water wetland does not replicate all the ecological functions of natural wetlands.

An enhanced storm-water wetland is designated for more effective pollutant removal and species diversity. It also includes design elements such as forebays, complex microtopography, and pondscaping with multiple species of wetland trees, shrubs and plants.

Stream buffer - A variable-width strip of vegetated land adjacent to a stream that is preserved from development activity to protect water quality and aquatic and terrestrial habitats.

Subsoil - The bed or stratum of earth lying below the surface soil.

Substrate amendments - A technique to improve the texture and organic content of soils in a newly excavated pond system. The addition or organic-rich soils is often required to ensure the survival of aquatic and terrestrial landscaping around ponds.

Sump pit - A single-chamber oil/grit separator used to pretreat runoff before it enters an infiltration trench.

Swale - A natural or constructed depression or shallow-sided ditch used to temporarily store, route, or filter runoff.

Trash and debris removal - Mechanical removal of debris, snags, and trash deposits from stream banks to improve the appearance of the stream.

Treatment volume (Vt) - The volume of storm-water runoff that is treated within a storm-water wetland. Typically expressed in terms of inches of runoff per impervious acre. For example, in the Washington metropolitan area, the recommended Vt for sizing a storm-water wetland is 1.25 inches per impervious acre.

Underdrain - Plastic pipes with holes drilled through the top, installed on the bottom of an infiltration BMP or sand filter, which are used to collect and remove excess runoff.

Vacuum sweeping - Method of removing quantities of coarse-grained sediments from porous pavement in order to prevent clogging. Not effective in removing fine-grained pollutants.

Vegetated filter strip - A vegetated section of land designed to accept runoff as overland sheet flow from upstream development. It may adopt any natural vegetated form, from grassy meadow to small forest. The dense vegetative cover facilitates pollutant removal.

Filter strips cannot treat high-velocity flows; therefore, they have generally been recommended for use in agriculture and low-density development.

A vegetated filter strip differs from a natural buffer in that the strip is not "natural;" rather, it is designed and constructed specifically for the purpose of pollutant removal. A filter strip can also be an enhanced natural buffer, however, wherein the removal capability of the natural buffer is improved through engineering and maintenance activities such as land grading or the installation of a level spreader.

A filter strip also differs from a grassed swale in that a swale is a concave vegetated conveyance system, whereas a filter strip has a fairly level surface.

Water-quality inlet - BMP consisting of a three-stage underground retention system designed to remove heavy particulates and absorbed hydrocarbons. Also known as an oil/grit separator.

Weir - A structure that extends across the width of a channel and is intended to impound, delay or in some way alter the flow of water through the channel. A check dam is a type of weir, as is any other kind of dam.

A ported weir is a wall or dam that contains openings through which water may pass. Ported weirs slow the velocity of flow and, therefore, can assist in the removal of pollutants in runoff by providing opportunities for pollutants to settle, infiltrate or be adsorbed.

Wet pond - A conventional wet pond has a permanent pool of water for treating incoming storm-water runoff. In enhanced wet pond designs, a forebay is installed to trap incoming sediments where they can be easily removed; a fringe wetland is also established around the perimeter of pond.

Wetlands - Areas inundated or saturated by surface or ground water with sufficient frequency and duration to support a prevalence of vegetation typically adapted for saturated soil conditions. In short, wetlands are areas inundated or saturated for long enough periods of time to result in the development of hydric soils and dominance by hydrophytic (water tolerant) vegetation. (See legal definitions in appendix IV A.) (Cowardin System Attached)

Wetland mitigation - Regulatory requirement to replace wetland areas destroyed or impacted by proposed land disturbances with artificially created wetland areas.

Wetland mulch - A technique for establishing low or high marsh areas where the top 12 inches of wetland soil from a "donor" wetland are spread thinly over the surface of a created wetland site as a mulch. The seedbank and organic matter of the mulch helps to rapidly establish a diverse wetland system.

Wetland plant uptake - Wetland plant species rely on nutrients (i.e., phosphorus and nitrogen) as a food source; thus, they may intercept and remove nutrients from either surface or subsurface flow.

APPENDICES

WWAR (wetland/watershed area ratio) - The ratio of the wetland surface area to contributing watershed surface area. Good pollutant removal performance is often achieved when the ratio is greater than one percent

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APPENDICES

Appendix I

laws and rules

Minnesota Rules Chapter 8410
Metropolitan Area Local Water Management
Effective August 1, 1992

Summary of Content : Watershed Management Organization Plan Requirements

Executive Summary

* purpose of WMO
* membership of board of managers
* boundaries of WMO
* brief history
* summary of WMO's goals, problems, potential solutions
* general content of local plans

Land and Water Resource Inventory

* inventory of water resource and physical factors affecting water resource
* precipitation
* geology, topographic relief, aquifers, groundwater and surface water connections, map of subwatershed units
* surface water resource data including;
  a. map of public waters and public ditches
  b. National Wetlands Inventory map
  c. inventory of functional values of wetlands or a process for that
  d. DNR table of hydrologic characteristics of public waters
  e. maps of storm-water system
  f. information on 100-year flood levels, flood profile information
  g. map or discussion of areas of known flooding problems
  h. list of existing flood insurance studies
  i. summary of water-quality data from MPCA, DNR, MDH, MnDOT, Met Council, MWCC, WMO, SWCD, affected counties and cities
  j. map or list of water-quality and -quantity monitoring sites
  k. list of municipalities with approved shoreland ordinances
  l. table of DNR surface water appropriations
* groundwater data
* soil data
* land use and public utility services
* water-based recreation areas and land ownership

APPENDICES

* fish and wildlife habitat
* unique features and scenic areas
* pollutant sources (if this information is included in a county groundwater plan, it may be referenced)
  a. known closed and open sanitary landfills, closed and operating open dumps, hazardous waste sites, summary of water-quality data relating to these sites
  b. feedlots, abandoned wells, under and above ground storage tank sites, permitted wastewater discharges, summary of water-quality data relating to these sites

Impact on other units of government

* inconsistencies between WMO's goals and policies and those of local, regional, and state review authorities

Establishment of Goals and Policies

* specific goals and policies of the plan
* water-quantity goals and policies for storm-water runoff management
* water-quality goals and policies (including land use and standards)
* recreation and fish and wildlife
* information and education
* goals and policies for public ditch systems
* groundwater (if no county groundwater plan)
* wetland management goals and policies including identifying high priority areas
* erosion goals and policies

Assessment of Problems - existing and potential

* specific lakes and streams with water-quality problems
* flooding and storm-water rate control issues
* impacts of water-quality and -quantity management practices on recreation
* impacts of storm-water discharges on water quality and fish and wildlife resources
* impact of soil erosion on water quality and quantity
* impact of land use practices, land development and wetland alteration on water quality and quantity
* adequacy of existing regulatory controls to manage or mitigate adverse impacts on public waters and wetlands
* adequacy of programs to;
  1) limit soil erosion and water-quality degradation
  2) maintain values of natural storage and retention systems
  3) maintain water level control structures

* adequacy of capital improvement programs to correct problems relating to; water quality, water quantity, fish and wildlife habitat and public waters and wetland management, recreational opportunities
* future potential problems within a 20-year period

Implementation Program

* nonstructural, structural, and programmatic solutions to problems issues, and goals listed in previous two parts
* regulatory goals
  a. regulation of activities in wetlands, responsibilities for the WCA
  b. erosion and sedimentation controls
  c. construction erosion controls
  d. shoreland and floodplain ordinances
  e. manage or regulate land uses that constitute a public nuisance
* storm-water and drainage design performance standards
  a. target in-lake nutrient concentrations, and sediment and nutrients loading
  b. runoff rates for design storms
  c. standards to reduce impacts of flooding
  d. design criteria for storm-water outlet structures
  e. pond design methodology for nutrient entrapment
  f. pollutant loading consistent with water-quality standards
* information program about WMO and plan
* data collection programs
* maintenance programs for:
  a. street, parking lot sweeping
  b. inspecting storm-water outfalls, sumps, and ponds
  c. storm-water facilities and water level control structures
  d. public ditches
  e. water body management classification system for water quality and quantity
  f. local spill containment clean-up plans
  g. others as necessary
* potential structural solutions to problems

Impact on Local Government

* existing local controls
* financial impact on local government
  adoption by reference

Implementation Priorities

Implementation Components

* controls
* responsibilities

APPENDICES

* schedule
* capital improvement program
* enforcement
* administration process

Plan Contents; Amendments

Annual Reporting Requirements

* financial report
* activity report
* audit report

Content of Local Plans

* general structure includes at a minimum;
  1. table of contents
  2. purpose
  3. water resource related agreements
  4. executive summary
  5. land and water resource inventory
  6. establishment of goals and policies
  7. relation of goals and policies to local, regional, state, and federal plans, goals and programs
  8. assessment of problems
  9. corrective actions
  10. financial considerations
  11. implementation priorities
  12. amendment procedures
  13. implementation program
  14. appendix
  15. each community should consider including its local plan as a chapter

Determinations of failure to implement

APPENDICES

APPLICABLE FEDERAL AND STATE WETLAND LAWS

Federal Wetland Definitions

Section 404 of the Clean Water Act

> Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

(EPA, 40 CFR 230.3 and CE, 33 CFR 328.3)

Food Security Act of 1985

> Wetlands are defined as areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except lands in Alaska identified as having a high potential for agricultural development and a predominance of permafrost soils.*

(National Food Security Act Manual, 1988)

U.S. Fish and Wildlife Service Wetland Classification System

> Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification, wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

**Special Note:* The Emergency Wetlands Resources Act of 1986 also contains this definition, but without the exception for Alaska.

APPENDICES

State Rules

7050.0130 Definitions.

F. “Wetlands” are those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Constructed wetlands designed for wastewater treatment are not waters of the state. Wetlands must have the following attributes:

(1) a predominance of hydric soils;

(2) inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in a saturated soil conditions; and

(3) under normal circumstances support a prevalence of such vegetation.

Legal Authority

The federal Clean Water Act (CWA) Section. 303 (c)(1) states:

“The Governor of a state or the state water pollution control agency of such state shall from time to time (but at least once every three years period ...) hold public hearings for the purpose of reviewing applicable water-quality standards and, as appropriate, modifying and adopting standards. Results of such review shall be made available to the [U.S. Environmental Protection Agency (EPA)] Administrator.”

CWA Sec. 303 (c)(3) states:

“If the Administrator, within sixty days after the date of submission of the revised or new standard, determines that such standard meets the requirements of this Act, such standard shall thereafter be the water-quality standard for the applicable waters of the state. If the Administrator determines that any such revised or new standard is not consistent with the applicable requirements of this Act, he shall not later than the ninetieth day after the date of submission of such standard notify the state and specify the changes to meet such requirements. If such Wetlands are “waters of the United States” and “waters of the state,” just like lakes and rivers. changes are not adopted by the state within ninety days after the date of notification, the Administrator shall promulgate such standard pursuant to paragraph (4) of this subsection.”

State authority arises from Minn. Stat. Chs. 115.03, 115.44 and 115.01:

Ch. 115.03, subd. 1: “To establish and alter such reasonable pollution standards for any waters of the state in relation to the public use to which they are or may be put as it shall deem necessary for the purposes of this chapter and, with respect to the pollution of the waters of the state, chapter 116."

Ch. 115.44, subd. 4. "The agency ... shall adopt and design standards of quality and purity for each such classification necessary for the public use or benefit contemplated by such classification. Such standards shall prescribe what qualities and properties of water shall indicate a polluted condition of the waters of the state which is actually or potentially deleterious, harmful, detrimental or injurious to the public health, safety or welfare, to terrestrial or aquatic life or to the growth and propagation thereof, or to the use of such waters for domestic, commercial and industrial, agricultural, recreational or other reasonable purposes, with respect to the various classes established ..."

Ch. 115.01 Definitions.

Subd. 22. "'Waters of the state' means all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, reservoirs, aquifers, irrigation systems, drainage systems and all other bodies or accumulations of water, surface or underground, natural or artificial, public or private, which are contained within, flow through, or border upon the state or any portion thereof."

Subd. 13. "'Pollution of water,' 'water pollution,' or 'pollute the water' means: (a) the discharge of any pollutant into any waters of the state or the contamination of any waters of the state so as to create a nuisance or render such waters unclean, or noxious, or impure so as to be actually or potentially harmful or detrimental or injurious to public health, safety or welfare, to domestic, agricultural, commercial, industrial, recreational or other legitimate uses, or to livestock, animals, birds, fish or other aquatic life; or (b) the alteration made or induced by human activity of the chemical, physical, biological, or radiological integrity of waters of the state."

Subd. 12. "'Pollutant' means any 'sewage,' 'industrial waste,' or 'other waste,' as defined in this chapter, discharged into a disposal system or to waters of the state.

Subd. 9. "'Other wastes' means garbage, municipal refuse, decayed wood, sawdust, shavings, bark, lime, sand, ashes, offal, oil, tar, chemicals, dredged spoils, solid waste, incinerator residue, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, cellar dirt or municipal or agriculture waste, and all other substances not included within the definitions of sewage and industrial waste set forth in this chapter which may pollute or tend to pollute the waters of the state."

7050.0130 Definitions.

APPENDICES

A. The terms “waters of the state,” “sewage,” “industrial wastes,” and “other wastes,” as well as any other terms for which definitions are given in the pollution control statutes, as used herein have the meanings ascribed to them in Minnesota Statutes, sections 115.01 and 115.41, with the exception that disposal systems or treatment works operated under permit or certificate of compliance of the agency shall not be construed to be “waters of the state.”

MDNR Authorities
Minn. Stat. 103G.101-315
Minn. Rules 6115.0150-0280

1991 Wetland Conservation Act

Article 6, 103G.005, sub. 19

> (a) “Wetlands” means lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this definition, wetlands must have the following three attributes:
>
> (1) have a predominance of hydric soils;
> (2) are inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions; and
> (3) under normal circumstances support a prevalence of such vegetation.
>
> (b) Wetlands does not include public waters wetlands as defined in subdivision 18.

APPENDICES

DEVELOPING THE PLAN[3]

The preparation of a plan follows a logical sequence:
1) Gathering information on existing resources and resource management programs (data collection) -- Find out what you have, and who's doing what.
2) Resource assessment -- Determine the condition and adequacy of existing resources and management programs.
3) Issue identification -- Identify problems and opportunities to address.
4) Issue prioritization -- Determine which issues are in the most critical need of attention.
5) Development of goals and objectives -- Determine the end result to achieve.
6) Formulation of actions -- Develop specific steps for solving problems and taking advantage of opportunities, while meeting goals and objectives.

A. Data Assembly

Data includes inventory information, descriptions of existing management programs, and other background information.

<u>The objectives of data assembly should be:</u>

1) To Help Identify Water Resource Issues: Relevant and existing data should be assembled to identify water resource issues.

2) To Measure the Scope and Severity of Water Resources Issues and Problems: As an example, if water quality is the issue, data that provides a direct measure of contamination in lakes, rivers and aquifers should be used, such as test well data. Data that measures related, contributing factors should also be used, such as information on the number and size of feedlots, runoff potential, distance from sensitive water resources, etc.

3) To Provide a Summary of Existing Conditions and an Indication of Future Trends: While individual data items provide a lot of useful information to the planner, when it is aggregated and summarized it can provide a better picture of what the issues and problems are, and if it can be compared to similar data from the past or projected into the future, it can be used to predict trends which should be planned for.

4) To Provide an Inventory of Water Resources Information: An inventory of water resources information will not only provide a catalog of available water resources information, but it will suggest areas where such information is lacking or inadequate. Water resource data sets should be briefly described and an indication of the utility of the data, or lack thereof, should be included.

Suggestions:

a. Use National Wetland Inventory map and DNR protected waters inventory as starting point.

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[3] Modified from: Minnesota Board of Soil and Water Resources, Minnesota Department of Natural Resources, July, 1990, "Summary of the Comprehensive Local Water Planning Process"

b. Locate each wetland on a base map, a computerized Geographic Information System (GIS) can be useful.

c. Indicate size (acres).

d. Determine hydrologic flow routing of present and future development condition.

e. Determine sensitivity of vegetation by site surveys and sensitivity classification

f. Determine the small storm and flood storm hydrology of the sensitive and problem areas, including analysis of flooding, erosion control, pollutant loading, wetland water level fluctuation and inundation concerns.

g. Regulatory framework including, Federal: 404 and Section 10 Clean Water Act, State: Safe Drinking Water Act, NPDES Programs, Wetland Conservation Act, DNR work in water permits, Shoreland Act, Local: zoning, building code, nuisance requirement. Appendix I.A. and I.B. contain summaries of plan requirements and applicable laws.

B. Resource Assessment

Assessment is a critical link between the data assembled in Step A above and issue identification, discussed in Step C below. The data, and especially the summaries of the data as discussed above, provides the raw facts about a particular problem or issue. An assessment, however, analyzes the data to provide an understanding of the problem and can lead to possible solutions.

The present condition of water and related land sources, as evidenced by the data, as well as the adequacy of existing management and regulatory programs, will form the basis of many of the issues to be addressed in the plan. Assessment will also help determine the severity of the problems identified, thus helping in the setting of priorities in the action planning and implementation phases of the planning process.

Note that the rules require a discussion of the implications of many of the information items. This should include an analysis of how existing resource conditions and management programs will impact the attainment of goals and what challenges will be faced in dealing with the identified problems.

Assessments and discussions of implications need not be lengthy, but should be detailed enough to facilitate the development of issues and goals, objectives and actions.

Suggestions:

a. Choose a useful and consistent method to assess functions and values:

(1) Rapid assessment (qualitative) evaluation method, on a first step and overall assessment on temporary basis. A rapid assessment method such as that developed by the Wisconsin Department of Natural Resources (1992) can be employed until funds become available for more complete assessment.

(2) Long-term, research-type quantitative method for critical sites and long term on a priority basis.

CAUTION: Most wetlands are of high value for some functions, moderate value for other functions and low value for still others; thus, it is difficult to arrive at an aggregate value of high, medium of low. Ranking a wetland as "low value" for one function does not necessarily mean that wetland is expendable for all functions. Even severely degraded wetlands can be important for functions such as storm-water retention.

b. Define proposed watershed changes:

(1) Proposed zoning and development descriptions.
(2) Proposed physical alterations.
(3) Resultant changes in pollutant concentration and loading.
(4) Check for compliance with all federal, state and local requirements.

c. Analyze the hydraulic changes related to development and the sensitivity of the wetland to impacts. Determine the need for avoidance, pretreatment, or other management options.

C. Issue Identification

A good plan rests on a foundation of clear issue identification. The issue identification process should be open to all water-related resources issues, including not only direct water issues such as water quality and supply, but related issues which affect water such as land use practices, and "dependent" uses such as fish and wildlife. The Handbook for Comprehensive Local Water Planning should be consulted for additional information; the first portion of Chapter 6, titled Identifying Problems and Opportunities, provides guidance in this area.

1) Ground-Water Quality: sub-issues include abandoned wells, leaking storage tanks, chemical use, nonpoint source pollution, etc.

2) Surface-Water Quality: Sub-issues include sedimentation, erosion, wetland protection, nonpoint source pollution, poorly functioning on-site sewer systems, chemical use, stream bank erosion, etc.

3) Ground-Water Quantity: Sub-issues include water allocation, well interference problems, etc.

4) Surface-Water Quantity: Sub-issues include flooding, structural water control measures, wetland protection, drought contingency planning, etc.

5) Water-based Recreation: Sub-issues include providing public access to lakes and rivers, surface water crowding, shoreland development problems, promotional opportunities, etc.

6) Fish and Wildlife: Sub-issues include loss of critical habitat and species, developing additional fish and wildlife habitat, wetlands protection, etc.

7) Related Land Use: Sub-issues include agricultural and urban land use.

D. Goals and Objectives Development

APPENDICES

Goals and Objectives form the linkage between issues and the actions. Since issues change over time, the primary goals and objectives focus should be on high-priority issues -- those to address in the near future.

Suggestions:

a. Explicitly state the existing community and public values - this means defining what functions the critical areas perform for the local regional and statewide public interest. Recreation, water quality, flood control, wildlife habitat and other functions should all be described in as detailed a manner as possible.

b. Examples of goals include:

(1) Preserve wetlands
(2) Improve water quality
(3) Enhance wildlife habitat
(4) Maximize recreational/educational opportunities
(5) Mitigate unavoidable adverse impacts

E. Action Plan

Actions should be specific projects, programs or activities which have a good likelihood of being achievable in the short term. That is, they are likely to be funded and/or to be achieved within the existing programs of any agency or organization. Identifying realistic actions increases the chances that a plan will bring results. Towards the end of developing a meaningful plan, counties should state actions that require accomplishment as a measure of success. The actions should use proactive language, require effective activities, or propose specific programs to deal with the issues. Actions such as encourage, promote and facilitate often will not go very far in addressing complex water resource problems, and allow no measure of accomplishment. Such actions may have less chance of receiving state or federal funding support. There are a number of issues where consideration should be given to teaming educational efforts with immediate and direct action such as regulation, and enforcing existing regulations. *Suggestions:*

a. Ensure coordination between cities, counties, watershed districts, state agencies and federal agencies and their respective programs (e.g., local ordinances, Wetlands Conservation Act, Section 404 permits)

b. Implement management techniques needed to protect priority wetlands and provide enhanced benefits, such as:

(1) Avoidance of Impacts

(2) Use of finger printing or pretreatment ponds before discharging urban storm water to wetlands.

(3) Plantings/landscaping using desirable vegetation.

(4) Control of noxious weeds (e.g., purple loosestrife, buckthorn)

(5) Placement of nesting boxes, nesting island.

(6) Buffers (e.g., no grading or mowing of adjacent uplands).

(7) Incorporate wetlands into "green corridors" that link them with lakes, streams, upland habitats, wildlife travel corridors, etc.

(8) Acquire in public ownership higher-quality wetlands and associated uplands if feasible.

(9) Limit upland development in areas with unacceptable hydrologic impacts.

c. Develop a plan for mitigation of unavoidable impacts from development.

(1) Identify previously drained or converted wetlands that possess high potential for restoration then take measures to implement (e.g., blocking drainage ditches, breaking drain tile, removing fill) to meet mitigation, banking needs, water quality and other goals.

Establishing Priorities

The actions should be prioritized to reflect the urgency of the problems they are intended to address, as well as the resources which can be expected to be available for addressing them. Priorities should reflect the rankings established in the Issue Identification step discussed previously. By incorporating estimates of costs and time and money available, priorities can be established using the same methods used for the issue rankings.

F. Implementation Program

The purpose of the Implementation Program is to state how and when the plan will be carried out to meet the objectives and achieve the actions identified. It will identify the agency or organization that will perform each action, provide a cost estimate for each, and lay out a schedule of when each will be undertaken. A brief description of these steps follows:

1) Who will perform the action? Actions may be accomplished either by the county or by other agencies or organizations. The amount of staff and financial resources necessary (and available) must be considered. Please note that the Handbook states that if actions require the cooperation of other agencies or local units of governments, the plan must indicate whether commitments for that assistance have been obtained.

2) What will it cost? While detailed cost estimates may not be possible or practical at this state, “ballpark” estimates should be made so that a realistic implementation schedule can be developed. Grandiose plans may look impressive, but if they can’t be funded, goals will not be achieved.

3) When will it be initiated? Based on project costs and funds and staff available, you should develop an implementation schedule that accomplishes the most important objectives first.

APPENDICES

(Sec.2)

Laws Relating to Hydroperiod of Storm Water[4]

There are a number of laws, rules and guidelines relate to the issue of changing the hydrology of a given site.

1. **Minnesota Statutes Section 103B.3365.** Passed in 1991, this law requires local governments to require water-retention devices or areas for all developments creating more than one acre of new impervious surface. The Board of Water and Soil Resources developed guidelines for local governments to use in achieving compliance with this law. They are entitled "Guidelines on Water Retention," dated August 1993. Copies of this document can be acquired from the Minnesota Board of Water and Soil Resources. **(REPEALLED and no longer applicable)**

2. **Local comprehensive water management plans and standards. (MR - 8410)** Almost all areas of the state are affected by comprehensive water management plans developed by cities, townships, counties, watershed districts and water management organizations. In the seven-county metro area, the planning was mandated in 1982 by the Minnesota Legislature and is done on a watershed basis. Many of these plans contain policies and standards for specific design requirements for managing changes in water quality and quantity from developments. After 1995, both metro and non-metro plans will be required to adopt standards specific to their areas of jurisdiction relating to runoff from developments if their existing plans do not already contain them.

3. **Flood Plain Management Standards.** Minnesota law and rule allow local governments administering flood plain regulations to permit up to a 0.5 foot increase in flood elevation over the existing 100-year flood elevation for areas mapped as flood-prone. Higher increases may be authorized in very few circumstances and only after substantial documented justification and review. The Minnesota Department of Natural Resources provides oversight to the administration of local flood plain controls. Many local governmental units have adopted more restrictive flood-plain management ordinances than state and federal laws may allow. Local governments and land developers must be certain that all land rights are secured either through flowage easements or fee title when ever natural hydrologic conditions are altered.

4. **Water Quality Standards**. Minn. Rules Ch. 7050 establishes water-quality standards for waters of the state. The rules may affect a project if it requires an individual "Section 404" permit from the U.S. Army Corps of Engineers. If an individual permit is required, a "Section 401" certification from the Minnesota Pollution Control Agency is required. MPCA 401 certifications assess project proposals for compliance with Ch. 7050 rules. Projects covered under USCE nationwide and general permits do not require individual 401 certification from the MPCA.

[4] Bruce Sandstrom (March 14, 1994), Board of Water and Soil Resources, office memorandum.

APPENDICES

5. **Department of Natural Resources Regulation of Public Waters.** Natural "bounce" from runoff events on ponds, lakes and wetlands varies considerably, even in watersheds with limited development. A common water-management problem in Minnesota has been flooding on landlocked lakes. State rules allow a man-made outlet to be installed no lower than 1.5 feet below the ordinary high-water level of a landlocked lake when the solution to a flooding problem is to install an outlet.

6. **Common Law Considerations.** Under the riparian water law concept that prevails in Minnesota, numerous common law precedents provide protection to landowners who might be impacted by the hydrology changes resulting from development. This law is always evolving and usually lags behind technology and our base of knowledge of the environmental impacts of changing hydrology. The basic concept of common water law will not change, however. And that is that an upstream landowner cannot alter the flow of water to the detriment of downstream interests. This concept may be the most compelling aspect of trying to design developments so that post-development hydrology closely replicates pre-development conditions.

7. **Wetland Conservation Act.** Minn. Rules Ch. 8420 allow credit for replacement of altered wetlands if a "created" wetland contains two cells and the downstream cell has no more than one foot of bounce for a 10-year runoff event.

Analysis of Documented Naturally Occurring Water-Level Variance

Data from the Minnesota Department of Natural Resources, Division of Waters reflect the natural variance for the 100 or so natural, free-flowing water bodies where the DNR has valid data. It should reflect the variance that might be expected on wetlands. Factors strongly influencing "bounce" are likely related to outlet configuration, capacity of the outlet stream, watershed to water basin surface area, and relative position of the basin in the watershed.

Recorded Fluctuation Above Runout Elevation For Natural Lakes

	Ordinary High WL	**10-yr Flood Elev.**	**100-yr Flood Elev.**
Average	1.41 ft.	2.86 ft.	4.60 ft.
Range	-.45 to 4.90 ft.	.02 to 7.00 ft.	.60 to 9.26 ft.

When the Department of Natural Resources restores wetlands for wildlife management purposes, it uses criteria which limit the "bounce" for 10-year and 100-year runoff events to one foot and two feet, respectively, above the runout elevation.

APPENDICES

MnRAM Appendix A - User Guidance supplement

Comparison of the U.S. Fish and Wildlife Service's Circular 39[1] wetland classification system to that of Cowardin et al. (1979)[2] used on National Wetland Inventory maps and of Eggers and Reed (1987)[3].

	Circular 39	Cowardin et al. 1979	Eggers and Reed 1987
TYPE 1	Seasonally flooded basin or flat	PEMA PFOA PUS	Floodplain Forest Seasonally flooded basin Fresh (wet) meadow Low prairie
TYPE 2	Wet meadow	PEMB	Fresh (wet) meadow Low prairie Calcareous fen Sedge meadow
TYPE 3	Shallow marsh	PEMC *and* F PSSH PUBA *and* C	Shallow marsh
TYPE 4	Deep marsh	L2ABF L2EMF *and* G L2US PABF *and* G PEMG *and* H; PUBB *and* F	Deep marsh
TYPE 5	Shallow open water	L1[4] L2ABG *and* H L2EMA, B, *and* H L2RS L2UB PABH PUBG *and* H	Shallow, open water
TYPE 6	Shrub swamp	PSSA, C, F, *and* G PSS1, 5, *and* 6B	Alder thicket Shrub-carr
TYPE 7	Wooded swamp	PFO1, 5, *and* 6 B PFOC *and* F	Coniferous swamp Lowland hardwood swamp
TYPE 8	Bogs	PFO2, 4, *and* 7B PSS2, 3, 4, *and* 7B	Coniferous bog Open bog

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1 Shaw, S.P. and C.G. Fredine. 1956. Wetlands of the United States. U.S. Fish and Wildlife Service, Circular 39. 67 pages.

2 Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, FWS/OBS-79/31. 131 pages.

3 Eggers, S.D. and D.M. Reed. 1987. Wetland plants and plant communities of Minnesota & Wisconsin. U.S. Army Corps of Engineers, St. Paul District. 201 pages.

4 The Cowardin habitats of L1, PUBG, and PUBH are often considered as deep water habitats.

APPENDICES

Minnesota Statutes and Definitions of BMPs[5]

MS 103F.711 Minnesota Clean Water Partnership Act

> "Best Management Practices" means practices, techniques, and measures that prevent or reduce water pollution from nonpoint sources by using the most effective and practicable means of achieving water quality goals. Best management practices include, but are not limited to, official controls, structural and nonstructural controls, and operation and maintenance procedures.
>
> "Official controls" means ordinances and regulations that control the physical development of the whole or part of a local government unit or that implement the general objectives of the government unit.

MS 103h Ground Water Act

> "Best Management Practices" means practicable voluntary practices that are capable of preventing and minimizing degradation of ground water, considering economic factors, availability, technical feasibility, implementability, effectiveness and environmental effects. Best management practices apply to schedules of activities; design and operation standards; restrictions of practices; maintenance procedures; management plan practices to prevent site releases, spillage, or leaks; application and use of chemicals; drainage from raw material storage; operating procedures; treatment requirements; and other activities causing ground water degradation.
>
> See attached flow chart.

MS 103G.2241 Wetland Conservation Act

> "Best Management Practices" means state-approved and published practices associated with draining, filling, or replacement wetlands that are capable of preventing and minimizing degradation of surface water and ground water.
>
> This act sets the guidelines for the avoid, minimize and mitigate policy for protection of wetlands. This also states in order to qualify for the exemptions provided for by the act you must use BMPs.

MS 17.498 Rules; Financial Assurance. (aquaculture) no definition.

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[5] Klang, Jim, June 1994, Minnesota Pollution Control Agency office memorandum

APPENDICES

MS 17.115 Shared Savings and Loan Program.

MS 17.116 Sustainable Agriculture Demonstration Grants

> Both statutes use the term BMP without a definition, yet meaning practices which are not water quality related.

MS 18B.04 Pesticide Impact on Environment. No definition given

MS 18C.005 Fertilizers, Soil Amendments Refers to MS Ch. 103H.

MS Section 103B.3365 (Reding Bill)

> Best Management Practices means any design criteria or land use management technique (or combination) to limit nonpoint pollution from land uses that is either advocated by a formal publication of a state or federal agency publication or a public research institution.

(note: Repealled and no longer applicable)

Federal and State Delegations of Authority

MS 103F.751 Nonpoint Source Pollution Control Plan and Program Evaluation

> For the purpose of coordinating the programs and activities used to control nonpoint sources of pollution to achieve Minnesota's water quality goals, the agency (MPCA) shall:
>
> 1) develop a state plan for the control of nonpoint source water pollution in order to meet the requirements of the federal Clean Water Act;
> 2) work through the environmental quality board to coordinate the activities and programs of federal, state and local agencies involved in nonpoint source pollution control, and where appropriate, develop agreements with federal and state agencies to accomplish the purposes and objectives of the state nonpoint source pollution control plan; and
> 3) evaluate the effectiveness of programs in achieving water quality goals and recommend to the legislature under sections 103F.701 to 103F.761.

MS 103h Provides for the Department of Agriculture and MPCA Authority

Clean Water Act authority has been delegated to the MPCA by EPA and MS 115 and 116 for:

> NPDES Programs
> Construction Grants Program
> Section 319 Nonpoint Source Pollution coordination

APPENDICES

History of MPCA Programs and Objectives

Two-pronged approach

1) categorical state-wide
2) specific targeted

CWA Section 208, 208 Agriculture Report August 1979,. the report laid out many of the BMPs and management practices in use today.

CWA Section 319 Management Plan, 1988 (see attachment)

LCMR project in 1987 to 1989 which developed BMPs without a specific program application in mind.

MS Chapter 103H, 1989-1990

1) doesn't alter any pre-existing statute
2) defines who can develop ground water BMPs
3) voluntary before regulatory flow path

The variety of statutes have created confusion between definitions, procedures and authority.

Who has authority to identify BMPs

Why is this authority important

WCA decisions are based on BMP implementation
Publications and reproduction of information
Public vs. private interests
Local vs. state interests
Regulation vs. voluntary

The language is not precise and this causes problems.

the word BMP
the words "developing" versus "identifying"

APPENDICES

Local Jurisdiction

In the past, MPCA programs have encouraged the locals to choose when to enforce BMPs rather than encourage volunteer use, ordinance or incentive promotional paths, for BMP adoption. However, recently Renville District Court has issued a finding which states the local governments can no longer require stricter feedlot controls (BMPs) by ordinance, that the state permit program requires.

Upcoming changes in Federal Clean Water Act

Both the Baucus and Oberstar reauthorization of the CWA versions include mandatory BMP language for some categories.

Coastal Zone Management

This program is still being negotiated, however, EPA is suggesting for MPCA to adopt the management measures as a minimum. There is also discussion about 100 percent adoption of Management Measures in the watershed and a legal means for the state to have authority to require adoption.

Where should we go from here?

Continue to identify BMPs and their efficiencies, limits and costs.

Create a new term to clarify the confusion due to the lack of precise language.

Identify a process for “state approved” or define the authorities and their limits.

APPENDICES

Appendix II

Erosive Flow Control

STORMWATER DETENTION PERFORMANCE BASED ON DOMINANT DISCHARGE

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March 15, 1990

Introduction

The physical characteristics of fish spawning and rearing habitat in small streams can be protected by preserving the channels dominant discharge. Dominant discharge is that flow which is most effective in performing work on the channel, in terms of its magnitude, frequency of occurrence and duration. The frequency of occurrence is generally accepted as the 2-year flood. When a drainage basin is developed, the change in the hydrologic regime is most significant for frequent floods, such as the 2-year. Past stormwater management policies have only considered peak release rates for conveyance of flood waters for the higher magnitude less frequent storms. As a result, the frequency of dominant discharge events for many stream channels has increased causing significant channel widening and degradation of physical habitat. Preservation of the channel dominant discharge requires a significant increase in detention volume over existing standards. This will allow the frequent storms to be metered out at a magnitude and duration which will not result in a increase in work to the channel. Rainfall-runoff relationships should be analyzed using a watershed model such as the Hydrologic Simulation Program - Fortran (HSPF), which is a continuous simulation model that computes the complex interactions of the hydrologic cycle. Detention volumes should be calculated for several design storms using a storage routing process for each storm frequency, so that preexisting magnitudes and durations are maintained. In many cases, watershed modeling is not available. In this case run-off based on an event model can be used. The recommended event for Western Washington is the 24-hour, Type 1A design storm. Using this storm in a Soil Conservation Service (SCS)-based hydrograph method for calculating run-off and a storage routing process for detention volume has been shown to give reasonable results. An event model can only be used to approximate the design theory of dominant discharge. It is recommended here that the two-year preexisting peak release rate be reduced by fifty percent to account for the inadequacies in event based models overpredicting preexisting run-off, and the extended duration of release which occurs after the 24-hour design storm event. These recommended methods for computing stormwater run-off and detention were compared to past methods. As a baseline for past methods the 10-year Rational, Yrjanainen and Warren method was chosen. Twelve case studies (URS, 1989) were compared and the results showed a 4-fold increase in detention volume. The increase in cost for the required detention volume may be offset by the benefits gained from reduced bank erosion, increased flood protection and enhanced stormwater quality.

Dominant Discharge for Habitat Protection

The discharge regime from a drainage area forms a fundamental independent control of channel cross-section morphology (area, shape and bedforms). Maintaining this channel morphology has many benefits, including preservation of fisheries habitat, minimizing bank erosion and bank protection demands, reducing fine sediment loads to the stream, and aesthetics. The channel morphology does not adjust with every short term variation of discharge, but depends on a discharge measure which typifies the range and frequency of competent discharges experienced over a long time. The channel dominant discharge can then be defined as that discharge that has been most effective in performing work on the channel; a measure of this work is the product of its magnitude and frequency of occurrence. Richards (1982), notes that the flow which just fills the section of an alluvial channel without overtopping the banks "the bankfull discharge", is the dominant event controlling channel form. Wolman and Leopold (1957) suggest a frequency of occurrence for bankfull discharge of 1 to 2 years. Frequency studies and other channel geometry studies indicate that the most effective flow, defined here as the channel dominant discharge, can be approximated by the bankfull discharge and the annual flood equals or exceeds this discharge once every 1.5 years or on an average of twice in 3 years (Wolman and Miller, 1960; Shen, 1971).

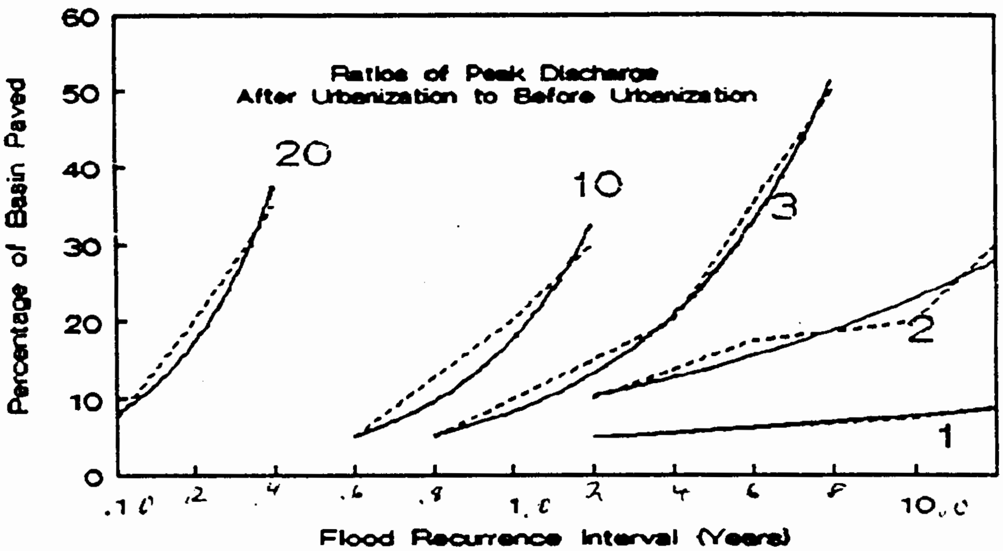
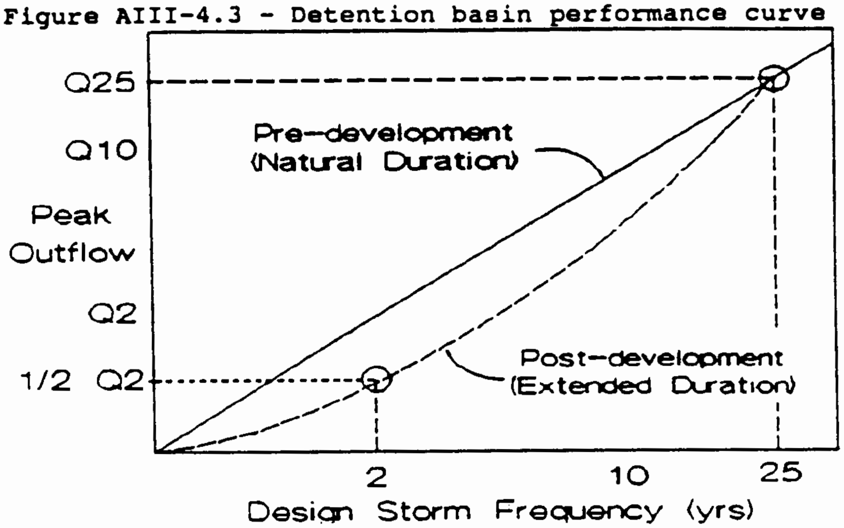


Figure AIII-4.2 - Increases in floods of varying recurrence in relation to percentage of basin paved (Hollis, 1975)

Increases in Frequent Floods From Development

Impervious surfaces on developed land reduce depression storage and infiltration so a higher percentage of the rainfall becomes run-off. Overland flow velocities become faster on smoother surfaces resulting in run-off entering the channel system more quickly. Thus, the run-off regime is flashier with shorter lag times and time bases, and with higher peaks. Flood peaks from urbanization increase with varying degrees according to their return periods. Hollis (1975) shows that smaller frequent floods increase up to 10 times after 20 percent urbanization, while extreme events are barely increased at all (Figure AIII-4.2). This is because extreme floods in natural basins are generated by high magnitude storms onto fully saturated soils, and they have a hydrological response similar to that of an urban basin.Past stormwater management policies have not considered frequent floods to protect channel form. Design methods have dealt mainly with conveyance of flood waters. These smaller floods however, are the ones which have the greatest impact on channel form. Bates (1983), summarizing impacts to fisheries habitat from stormwater run-off notes the importance of attenuating the channel dominant discharge in stormwater management, and that current stormwater ordinances can be expected to cause a trend in channel enlargements in the range of 50 percent. This is a result of the increase in "work" done on the stream channel from a increased occurrence of more channel forming flows. Also, under existing policies design of stormwater detention basins are based on metering run-off to preexisting peak rates, without regard to the duration of the release.

Figure AIII-4.3 - Detention basin performance curve



Methods such as the Rational-Yrjanainen and Warren (YW) method apply too many simplifications in an attempt to model the hydrologic response of a drainage basin, and should only be used for sizing conveyance facilities. Recent research (King Co, 1990) has resulted in major changes in the design of stormwater facilities in the Puget Sound area. Revised design methods in the 1990 King County Stormwater Manual utilize SCS-based hydrograph methods for calculating run-off, and storage routing for detention basin sizing. The detention basin design must meet a performance curve so pre-existing peaks are maintained at the 2 and 10 year storms. The manual uses event-based models with a theoretical design storm distribution and duration. The 24-hour, type 1A design storm was selected as best representing storms in Western Washington. Detention basin design is still based on releasing flows at preexisting peak rates without considering the extended duration of release caused by the increased volume of run-off. To design using the theory of dominant discharge, preexisting peaks for the more frequent storms should be reduced by some amount to account for the extended duration of release. As a guideline, it is recommended that the 2-year release be reduced by 50 percent, and that this reduction taper off to the pre-existing peak at the 25-year event. In general, storms above the 25-year event have very little impact on channel form, because of how infrequent they occur. The detention basin performance curve for these two design storms (i.e. 2 and 25-year) is shown in Figure AIII-4.3 The reasoning for this is discussed below.

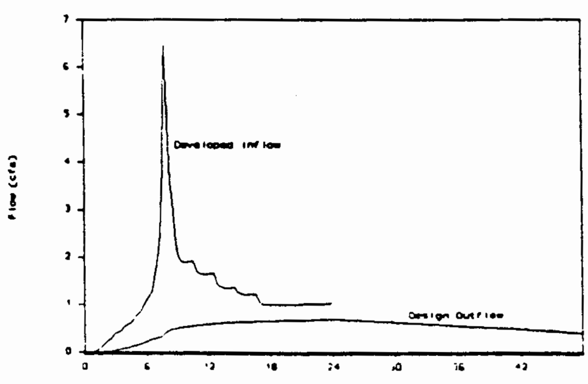


Figure AIII-4.4 - Detention basin inflow-outflow hydrograph for 2-year frequency (case study 12)

Peak Reduction - Extended Duration

Under some existing stormwater policies detention basin releases are metered to match pre-existing peak rates. Because of the significant increase in run-off volume from the developed state, the duration of the peak release rate cannot be matched to the pre-existing state unless a significant amount of run-off is infiltrated. When the pre-existing peak release rates are used to design a detention facility, calculations show that actual metering of stormwater run-off from a 24-hour storm can last for several days. Figure AIII-4.4, shows how the stormwater would be metered for a 2-year peak release rate. The hydrograph data was derived from case study 12 (URS, 1989). The developed inflow hydrograph in Figure AIII-4.4 is only a theoretical storm. Actual conditions in the Western Washington could extend the peak release rate even longer as rainfall before and after the storm could partially fill the basin. It is recommended that the peak release rate for the 2-year event be reduced by 50 percent for the following reasons.

1. In an attempt to establish a guideline for peak flow reduction at the 2-year frequency the author conducted the following study. USGS stream flow data for 13 small streams with undeveloped drainages were selected (Table AIII-4.1 from the Puget Sound area. Each station had at least 10 years of record. Flows for the 2-year frequency highest mean flow based on a log-Pearson Type III analyses for various consecutive days of occurrence were analyzed. The highest mean flow at the 2-year frequency was recorded for the annual peak and the 1, 3 and 7 day consecutive occurrence. Each of these values were then divided by the peak flow, averaged and plotted according to their corresponding durations (Figure AIII-4.5). This curve shows that as the duration of the 2-year event approaches 3 days, the reduction in peak flow is approximately 50 percent. The standard deviation for the 3 duration points on the curve in Figure AIII-4.5 was 0.1, which is a measure of the degree to which these values vary from the mean.

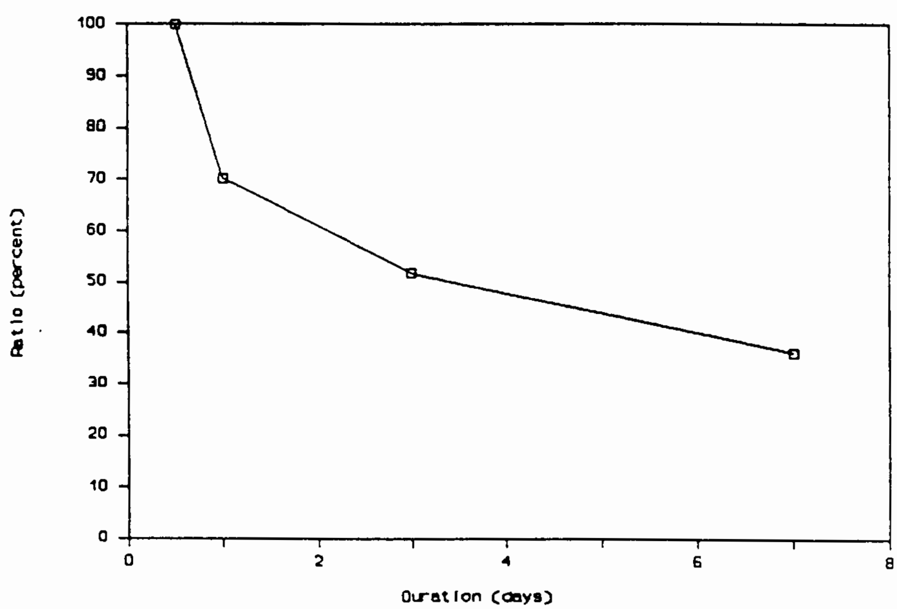


Figure AIII-4.5 - Ratio (percent) of 2-year peak and duration for natural catchments. Data from Table AIII-4.1

USGS Station	Drainage Area(sq.mi)	Consecutive Days of Peak	Occurrence 1	3	7
12047500	15.5	430	249	169	111
12050500	11.2	208	151	113	83
12063000	3.2	290	194	140	95
12063500	19.8	920	567	411	278
12065500	1.5	118	74	52	35
12066000	6.0	330	294	220	151
12067500	15.0	708	632	494	352
12068500	18.4	1034	792	579	398
12070000	5.0	130	77	57	40
12072000	15.3	475	366	293	222
12073500	6.5	120	98	75	55
12078400	17.4	762	563	438	347
12081000	24.6	91	71	63	57

Table AIII-4.1. 2-year frequency stream flow data for sleected Puget Sound streams from USGS, 1985

2. SCS-based hydrograph methods over-predict run-off in the pre-existing state. It assumes rainfall intensity exceeds infiltration. Justification for the accuracy of models such as the Santa Barbara Urban Hydrograph (SBUH) is that much of the drainage is impervious and the infiltration component is negligible. This is not true for frequent storm events, as the infiltration is a significant factor in the run-off regime. Also, event based models do not account for antecedent conditions prior to the simulation.

3. The actual run-off from a 24-hour storm event lasts more than 48 hours (Figure AIII-4.4). If rainfall occurs before and after the theoretical 24-hour storm, the actual pre-existing rates could occur for a duration of 3 to 4 days. The theoretical model for the pre-existing state shows the peak release only lasting for a short period, less than 6 hours. Therefore, there could be a 12 to 16-fold increase in the duration of the pre-existing peak.

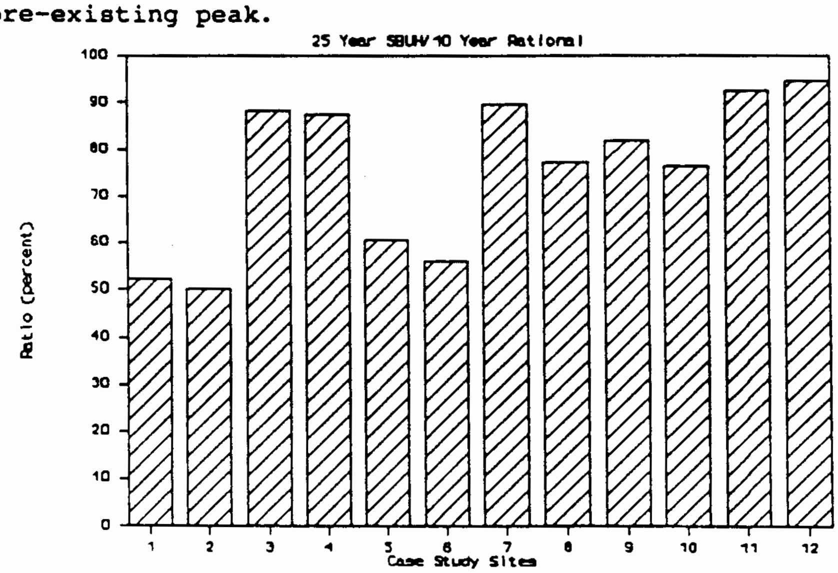


Figure AIII-4.6 - Comparison of peak flow rates for developed conditions between 25-yr. SBUH, and 10-yr. Rational

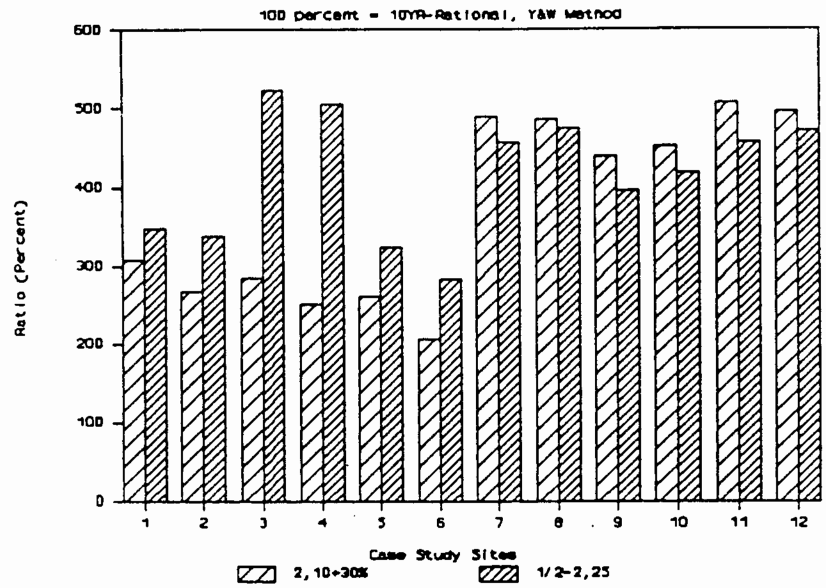


Figure AIII-4.7 - Comparison of detention volume for 2 and 10-year events plus 30 percent, and 1/2-2,25-year events

4. An assumption in using a event model is that the frequency of a rainfall event results is the same frequency run-off event. This is rarely true within a drainage basin, and with the limitations of a event based model it cannot be analyzed. Therefore, to protect stream channels against a potential increase in the critical channel forming flows a factor of safety should be applied to the release rate. Reducing the 2-year peak by 50 percent is a reasonable reduction given the uncertainty of the drainage characteristics.

Impacts From Suggested Guidelines

The basic criteria for stormwater detention design recommended in this paper for protecting physical habitat features in streams is as follows:

1. Fifty percent of the pre-existing 2-year peak release rate for the 2-year design storm.

2. The pre-existing 25-year peak relea*se rate for the 25-year design storm, and

3. Storage routing for determination of detention volume.

Overall costs for construction of stormwater facilities are expected to increase due to the increase in required detention storage. To estimate the impact of this increase, the suggested criteria were applied to 12 case studies. Data for the case studies were taken from (URS,1989), where an analysis was conducted to determine the impacts of the proposed King County Surface Water Design Manual. In the King County impacts analysis, detention volumes were calculated using storage routing for pre-existing peak release rates at the 2, 10 and 100-year frequencies and compared to the 10-year Rational-Y&W method. Run-off was calculated using the SCS-based Santa

Barbara Urban Hydrograph (SBUH). For a comparison, design standards suggested in this paper where compared to the proposed King County standards and the ten-year Rational-Y&W method. Detention volumes were calculated for the 2-year and 25-year frequencies, with the 2-year being released at 50 percent of the pre-existing peak, and the 25-year at the pre-existing peak. Figure AIII-4.6 is a comparison of how peak flow rates calculated using the SCS-based SBUH for the 25-year storm compare to the ten-year Rational method. Figure AIII-4.6 shows that increasing the high design' storm from the 10 to the 25-year event will not result in a increase in the size of conveyance facilities. Figure AIII-4.7 shows the increase in detention volume for the 12 case studies. The larger detention facility translates into a greater capital cost and some potential increase in maintenance. The following is a summary of results from applying the suggested criteria to the 12 case studies:

1. Detention storage increases an average of 4.2 times over that which is required using the ~~18~~ 10-year Rational, Y&W methods. For residential units this results in a average capital cost increase for detention facilities from $362 to $1,585 dollars per dwelling unit.

2. Detention storage increases an average of 1.2 times over the accepted King County standards for the 2 and 10-year

3. Average peak discharge/acre for the 3-year frequency in the pre-existing state was 0.046 cfs/acre.

4. Average detention volume per impervious acre was 11,073 cubic feet/acre. This includes the standard error with a one-sided 80 percent confidence interval.

While storage volume costs will increase, it is expected that reduced downstream erosion, increased flood protection and enhanced water quality will offset these costs. These benefits are difficult to quantify in monetary terms, but are substantial when considering the fisheries and other natural resource values from streams.

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Editors Note Regarding Detention Design for Fisheries Habitat Management

The previous papers prepared by P.D. Powers of the Washington Department of Fisheries compared their proposed design with those used by King County. The standards in this manual (following advice from the Technical Advisory Group) differ slightly from those of Fisheries. The standard in this manual is release of the 2-year storm at 50 percent of the pre-developed rate and the 10 and 100-year storms at 100 percent of the pre-developed rate (2-½, 10, 100). Fisheries standards require the same release rate for the 2-year storm and release of the 25-year storm at 100 percent of the predeveloped rate (2-½, 25).

Pat Powers prepared the tables and figures to compare all proposed standards using the case studies prepared by King County. Note that the 2-½, 10, 100 standard in this manual results in an average increase of 26 percent in detention volume compared with the Fisheries standard (2-½, 25) and an increase of 43 percent compared with the current King County standard (2, 10 + 30%). All of these standards require considerably more volume (400-500%) than the old King County standard that used the Rational/Y&W method and only controlled 10-year storm.