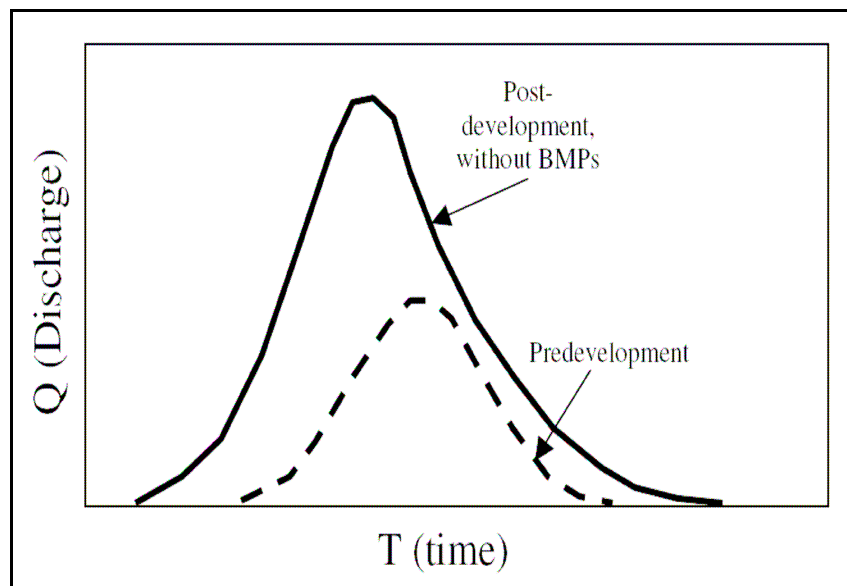

Staff Report on a Proposed Amendment to the *Dane County Water Quality Plan*, Adopting a Volume Control Standard for Urban Service Area Amendments

Impacts of Land Use Change on Hydrology

It is widely understood that land development without effective Best Management Practices (BMPs) results in changes to the rainfall-runoff process. Replacing vegetation with impervious surfaces (i.e., asphalt or concrete pavement and rooftops) results in increased runoff rates, longer runoff durations, increased runoff volumes, and decreased infiltration (Shaver *et. al.*, 2007). Figure 1 illustrates many of these changes. Increased runoff rates are shown by a higher discharge in the post development runoff curve. Longer runoff duration is shown by more time with a discharge in the post development runoff curve. Increased runoff volume is shown by a larger area under the post development runoff curve.

Figure 1: Runoff Hydrographs Pre- and Post- Development without BMPs



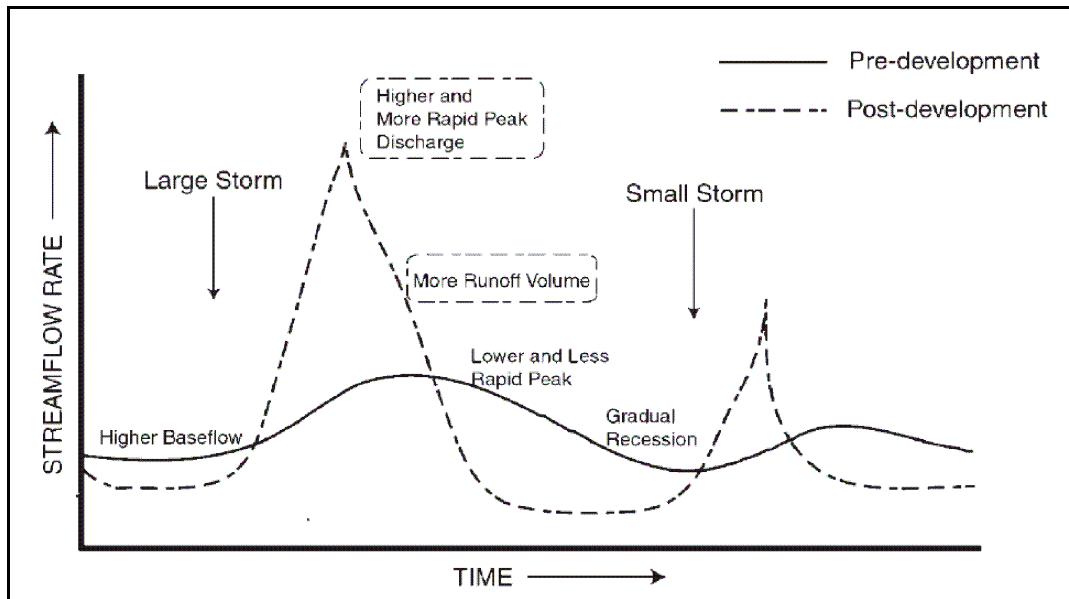
Source: Dane County Erosion Control and Stormwater Management Manual

Impacts of Hydrologic Change on Natural Resources

It is also widely understood that without effective BMPs, the hydrologic changes due to increased impervious surfaces result in negative effects on aquatic resources. Increased runoff rates, longer runoff durations, increased runoff volumes, and decreased infiltration can adversely impact waterways and their aquatic inhabitants through flashier stream flows (sudden higher peaks), increased frequency and duration of bankfull flows, channel enlargement, bank undercutting, aquatic habitat destruction, increased sediment loadings, and increased water temperatures (Shaver *et. al.*, 2007). Figure 2 illustrates many of these changes. The altered hydrology can also lead to more frequent and severe flooding; and

decreased infiltration can lower the shallow groundwater aquifer, leading to a decrease in dry weather baseflow in streams and springs (Lathrop *et. al.*, 2005).

Figure 2: Stream Hydrographs Pre- and Post- Development without BMPs



Source: Fundamentals of Urban Runoff Management

Existing Stormwater Regulations in the Region

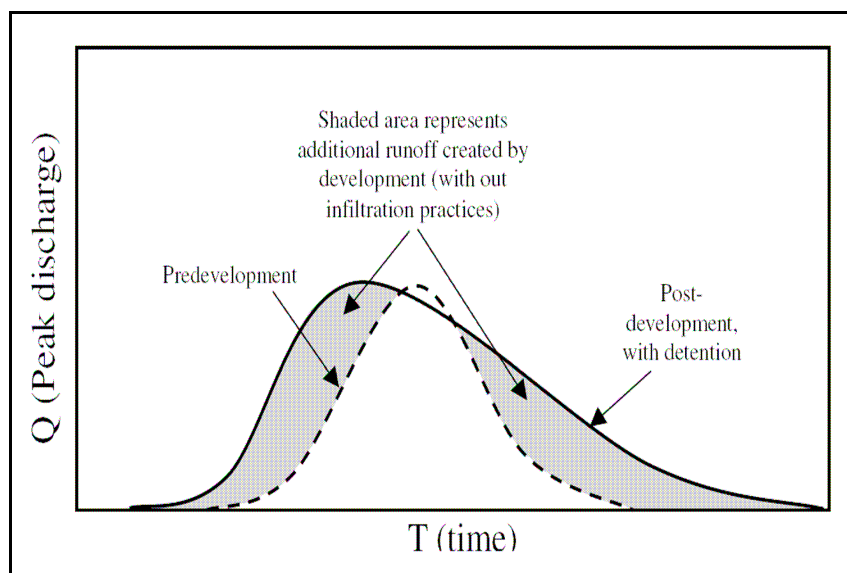
Chapter NR 151 of the Wisconsin Administrative Code and Chapter 14 of the Dane County Code of Ordinances establish the *minimum* standards for stormwater management in the State of Wisconsin and Dane County, respectively.

Peak Flow Rate Control

The first attempt to mitigate the impacts of runoff due to development was peak flow rate control with detention basins. While a few communities have used detention basins since the 1970s and the RPC has required them since the 1980s, they were not required throughout the region until the passage of NR 151 and the amended Dane County Chapter 14 in 2002. As Figure 3 illustrates, detention basins can be effective in controlling the increased peak runoff rates due to development, but they do not mitigate the longer runoff durations, increased runoff volumes, or decreased infiltration.

Detention basins are designed for peak flow rate control of relatively large, infrequent storms, generally the 2-year and 10-year, 24-hour storms. As a result, flow rates from smaller, frequently-occurring storms typically exceed those that existed onsite before development occurred and these increases in runoff rates, volumes, and durations typically result in flows erosive to stream channel stability (Shaver *et. al.*, 2007).

Figure 3: Runoff Hydrographs Pre- and Post- Development with Detention



Source: Dane County Erosion Control and Stormwater Management Manual

Volume Control

Volume control is needed to mitigate the impacts of longer runoff durations and increased runoff volumes. Volume control will only mitigate the impacts of decreased infiltration if the BMP(s) used result in groundwater recharge. Therefore it is desirable to have a separate groundwater recharge standard in addition to a volume control standard.

The volume control standard in NR 151 has been in effect since October 2004. It requires residential developments to maintain 90% of annual pre-development stay-on volumes with a 1% cap on the site area required for infiltration BMPs and commercial developments to maintain 60% of annual pre-development stay-on volumes with a 2% cap on the site area required for infiltration BMPs. This standard is often referred to as an infiltration standard, however, it is more accurately called a volume control or stay-on standard, because best management practices that utilize evapotranspiration or infiltration can be used to meet the standard. The site area caps can have the effect of reducing the stay-on requirements in the standard and increasing runoff volumes above the target levels in the standard.

A graphic comparison of the current 60% and 90% standards and pre-development conditions is shown in Attachment A. The runoff curve numbers for hydrologic soil group B are used in this example, since it is the most common hydrologic soil group in Dane County. NR 151.12(1)(b) defines the average annual rainfall in our region as the rainfall in Madison in 1981 from March 12th through December 2nd. This is a total rainfall of 28.81 inches. RECARGA modeling shows that with a pre-development runoff curve number of 68 for hydrologic group B soils, 27.01 inches infiltrates or evapotranspirates (stays on) and 1.80 inches runs off. By definition a 60% pre-development stay-on standard requires 16.21 inches of infiltration or evapotranspiration (60% of 27.01) and allows 12.60 inches of runoff (28.81 minus 16.21) under post-development conditions. This standard results in a 10.8-inch (12.60 minus 1.80) or 600% increase in annual runoff (runoff during the design year). By definition a 90% pre-development stay-on standard requires 24.31 inches of infiltration or evapotranspiration (90% of 27.01) and

allows 4.50 inches of runoff (28.81 minus 24.31) under post-development conditions. This standard results in a 2.7-inch (4.50 minus 1.80) or 150% increase in annual runoff (runoff during the design year).

The maximum pre-development runoff curve number of 68 allowed for agricultural land use in hydrologic group B soils is conservative by design. Typical, “real world” agricultural runoff curve numbers range from 61 to 85 depending on soil type, crop type, and farm management practices (NRCS, 1986). A runoff curve number of 75 is near the middle of this range and represents straight row crops with crop residue in good condition, a typical predevelopment condition in our region. A 60% pre-development stay-on standard results in a 9.35-inch (12.60 minus 3.25) or 287% increase in annual runoff compared to this condition. A 90% pre-development stay-on standard results in a 1.25-inch (4.50 minus 3.25) or 38% increase in annual runoff compared to this condition.

Municipal Ordinances

There are many examples where communities have adopted more protective standards for stormwater management in their local ordinances than the state or county standards. At least ten municipalities in Dane County require peak flow rate control for the 100-year, 24-hour design storm. The Cities of Verona and Middleton require the use of *pre-settlement* (instead of pre-development) curve numbers for calculating allowable peak flow rates. The City of Middleton has a specific groundwater recharge requirement. The Town of Westport requires infiltration of the increase in runoff volume for the 100-year 24-hour design storm.

Other Volume Control Standards

There are several examples of other approaches to volume control standards. The Capital Region Watershed District in Minnesota requires that the first 1-inch of runoff from impervious areas be controlled (CRWD, 2006). It is estimated from the 1981 rainfall data that this is equivalent to 24.40 inches of average annual stay-on, about the same as the 90% standard.

The Pennsylvania Department of Environmental Protection (PDEP, 2006) has two volume control guidelines. The first, recommended where site conditions allow, is no increase in the post-development total runoff volume for all storms equal to or less than the 2-year, 24-hour event. It is estimated from the 1981 rainfall data that this is equivalent to a 100% standard, since all of the 1981 rainfall events were less than the 2-year, 24-hour event for our region (2.9 inches). The second, if the first cannot be met, is at least the first 1-inch of runoff from new impervious surfaces shall be permanently removed from the runoff flow. It is estimated that this is about the same as the 90% standard.

Most new federal facilities are required to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow (US EPA, 2009). This requirement can be met by two options. The first is to manage onsite all storms up to the 95th percentile rainfall event by infiltrating, evapotranspiring, or collecting and reusing the runoff. The second option is to preserve predevelopment hydrology (rate, volume, duration & temperature) for the 1, 2, 10 and 100-year 24-hour storm events. This is a 100% standard on an event basis, which given the range of design storms should be similar to a 100% standard on an average annual basis.

Technical Advisory Committee Recommendations

The Environmental Resources Technical Advisory Committee (TAC) is a group of twenty-five people who are recognized as experts in their respective fields. The committee membership is multi-disciplinary with a wide range of scientific skills and specialties in both the public and private sectors. The TAC members were appointed at the February 8, 2008 Commission meeting. A list of TAC members is in Attachment B.

On October 8, 2009, the Capital Area Regional Planning Commission requested that the TAC convene to provide technical recommendations on a more protective stormwater runoff volume control standard than the one currently required under NR 151 and Dane County Chapter 14. A working group of TAC members who were interested in this topic met four times between November 2009 and February 2010 to discuss this issue and develop recommendations to the Commission. The names of those members who participated, or designated a representative to participate, in the volume control recommendations are highlighted in Attachment B. The committees' work included a review of recent literature on volume control and the habitat impacts of volume increases, including excerpts from *Volume-Based Hydrology* (Reese, 2009), *Urban Stormwater Management in the United States* (National Research Council, 2008), and *Fundamentals of Urban Runoff Management: Technical and Institutional Issues* (Shaver et. al., 2007). It also included a review of the volume control approaches discussed previously in this report.

Neither CARPC staff nor the TAC are aware of any published research that establishes a quantitative threshold for runoff volume as it relates to water resource or habitat impacts. The TAC noted that the existing 60% standard for nonresidential development was so low that it did not require any volume control practices in many cases. The complete recommendations of the TAC are included in Attachment C. The TAC recommendations state:

"The TAC recognizes the potential benefits of a runoff volume control standard to 100% of pre-development volumes, however it has several concerns related to the achievability and the cost versus benefit of adopting a standard of no increase in pre-development runoff volumes."

Therefore the TAC proposed that the Commission adopt a runoff volume control standard for all new Urban Service Area Amendments in which both residential and nonresidential developments control sufficient runoff volume so that post-development stay-on volume shall be at least 90% of the pre-development stay-on volume.

The TAC also identified additional research efforts, data collection, and model improvements that should be conducted to provide the information needed to further evaluate this issue and set a 5-year time frame for reevaluation of the proposed standard. Implementation of these efforts will require collaboration among and funding by the many agencies involved in water resource management in our region.

Eleven TAC members were in support of the final recommendations that were developed and one member was not in support of the recommendations.

Conclusions and Staff Recommendations

The hydrologic effects of urban land use on receiving streams have been studied since the late 1960s (Leopold, 1968). Recommendations that developments be required to incorporate measures to limit increases in volume and peak flows of stormwater runoff have been made since the first Urban Nonpoint Source Analysis (Technical Appendix D) in the *Dane County Water Quality Plan* (Dane County Regional Planning Commission, 1979). The use of detention basins steadily increased through the 1980s and 1990s, and infiltration requirements have been in effect since 2004. This history reflects a system that requires compromise and encourages incremental improvements. While a 100% volume control standard is intuitively more protective, the TAC recommendation represents a significant improvement in the volume control standard for non-residential development. Since potential adverse impacts due to the difference between a 90% and a 100% volume standard are likely to be cumulative and occur in the future, the TAC's proposal to reevaluate the standard in 5 years should address this concern.

Staff recommends that the Commission adopt the TAC recommendations for a 90% pre-development volume control standard as the *minimum* standard for new urban service areas. Staff also recommends that the 90% pre-development volume control standard be used as a *condition of approval* for urban service areas amendments and that the goal of attempting to achieve a 100% pre-development volume control standard be used as a *recommendation*. This approach is consistent with the TAC's recognition of the potential benefits of a 100% volume control standard as well as their concerns related to the universal achievability and cost versus benefit of such a standard at this time. Adoption of this minimum standard would not preclude the Commission from using a 100% pre-development volume control standard as a *condition of approval* for an urban service area amendment where it was determined necessary to mitigate the impacts on water resources.

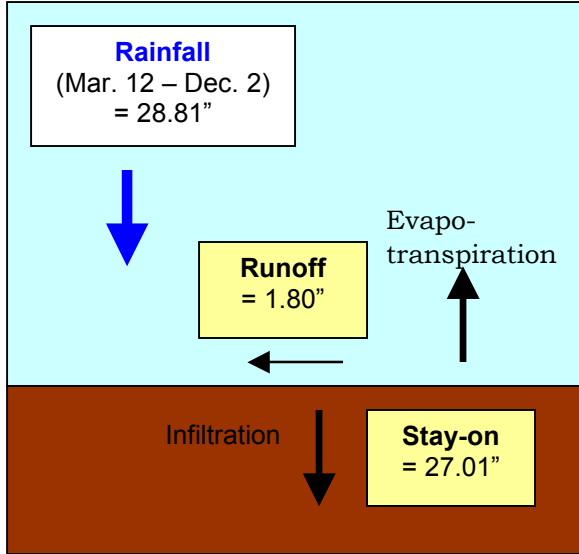
The extent that municipalities are willing and able to meet a runoff volume control standard to 100% of pre-development volumes will provide valuable information to be considered regarding the universal achievability and the cost versus benefit of adopting a standard of no increase in pre-development runoff volumes in the future.

Staff also recommends that the Commission follow the TAC's recommendation to request that the Dane County Board also adopt this volume control standard, so that it is applied to all new development within Dane County and not only to new urban service areas. This should be brought about by a recommendation to the Dane County Lakes and Watershed Commission that the Dane County Ordinance be changed to incorporate the 90% pre-development volume control standard.

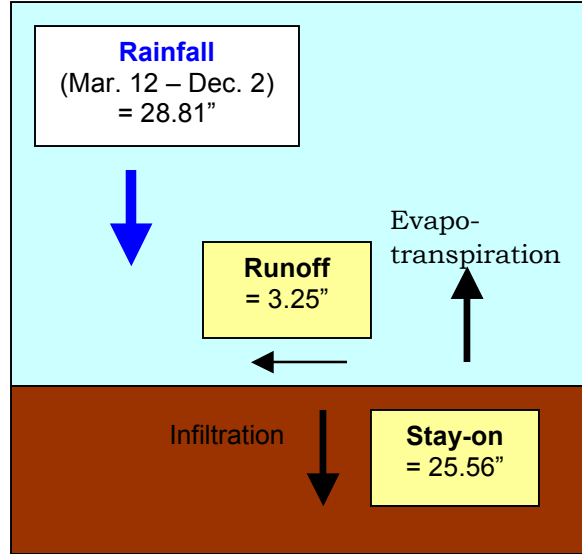
The full flow regime should be taken into consideration when assessing the impacts of stormwater on water resources. Increased stormwater volume is only one aspect of an urban-altered storm hydrograph. Other hydrologic changes include changes in the sequence and frequency of high flows, the rate of rise and fall of the hydrograph, and the season of the year in which high flows can occur. These can all affect both the physical and biological conditions of streams, lakes, and wetlands (National Research Council, 2008). Watershed level studies that incorporate the Hydroecological Integrity Assessment Process (USGS, 2008) and research from the emerging interdisciplinary field of Ecohydrology may increase our knowledge regarding what is necessary for the effective mitigation of the hydrologic impacts of development.

Technical Appendix D (Urban Nonpoint Source Analysis) and B (Water Quality Conditions) of the *Dane County Water Quality Plan* are currently being updated. Both of these appendixes will identify needs and include recommendations for additional monitoring and research. These measures should also provide new information to further guide the continued assessment and evolution of stormwater management in the region.

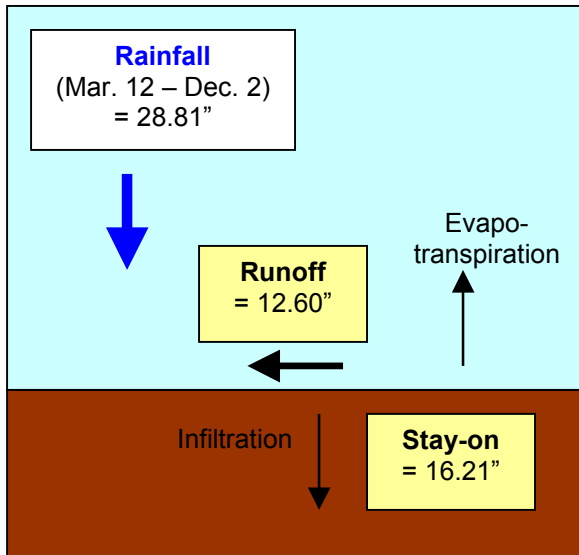
Attachment A
Water Balance Comparison of Pre-Development and Post-Development Conditions
 Modeled with RECARGA
 Runoff = Rainfall - Stay-on¹



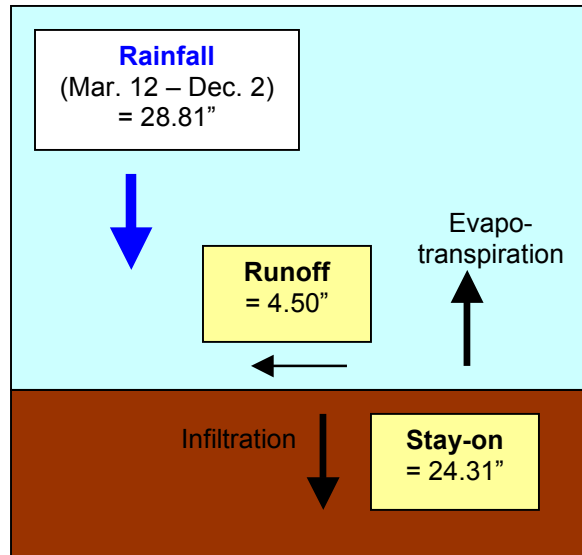
“Ordinance” Pre-Development
(Max. allowed CN=68)²



“Typical Real” Pre-Development
(Typical Ag. CN=75)³



**Post-Development w/
60% Pre-Development (CN=68) Stay-on
Standard**



**Post-Development w/
90% Pre-Development (CN=68) Stay-on
Standard**

¹ Stay-on = Evapo-transpiration + Infiltration

² For Hydrologic Soil Group B

³ Agricultural curve numbers (CN) range from 61 to 85 depending on soil type, crop type, and farm practices

Attachment B
Capital Area Regional Planning Commission
Environmental Resources Technical Advisory Committee

Agency	Area of Expertise	Contact
UW	Water Chemistry	D. Armstrong – Professor Emeritus, Civil and Environmental Engineering
UW	Wastewater	W. Boyle – Professor Emeritus, Civil and Environmental Engineering
MMSD	Wastewater Treatment	J. Schellpfeffer – Director, Madison Metropolitan Sewerage District
DNR	Water Resource Planning	L. Helmuth – Water Resource Management Specialist, Watershed Management
DNR	Regional Watershed Management	K. Johnson – Regional Water Leader, South Central Region
Dane Co.	Land and Water Resources Management	K. Connors – Director, Land and Water Resources Division
USGS	Geology/Hydrology	C. Peters – Director, USGS Wisconsin Water Science Center
UW	Hydrology	K. Potter – Professor, Civil & Environmental Engineering
Private firm	Hydrology	R. Montgomery – Principle Professional Engineer, Montgomery and Associates
WGNHS	Groundwater	K. Bradbury – Professor, Wisconsin Geological and Natural History Survey
UW	Wetlands	J. Zedler, UW – Professor, College of Letters and Science
UW	Wetlands	C. DeWitt – UW – Professor, Gaylord Nelson Institute for Environmental Studies
DNR	Wetlands	T. Bernthal –Watershed Management Lakes and Wetlands
Private firm	Wetlands	S. Storlid –Senior Principle Scientist, Natural Resources Consulting, Inc.
UW	Wildlife	D. Drake – Professor, Natural Resources Wildlife and Forest Ecology/Management
DNR	Wildlife	D. Rusch – Former Wildlife Management Supervisor, South Central Region
Private firm	Soils	D. Roberts – Former NRCS Southeast Area Resource Soil Scientist, retired
Dane Co	Public Works	P. Dunphy – Assist. Commissioner, Dane Co. Public Works, Highway, and Transp.
C. Madison	Public Works	L. Nelson – Chief Engineer, City of Madison ¹
C. Fitchburg	Public Works	P. Woodard – Director of Public Works, City of Fitchburg
C. Madison	Municipal Water Supply	T. Heikkinen – G.M., Madison Water Utility
Private firm	Community Planning	M. Slavney – Director of Planning, Vandewalle and Associates
Dane Co	On-Site Wastewater Systems	J. Clark – Former Director, Dane Co. Department of Environmental Health, retired
Dane Co. UW-Ex	Education and Outreach	M. Habecker – Natural Resource/Community Resource Development Educator
DATCP	Ex-Officio Member, Dane Co. RPC	J. Vanden Brook – Water Quality Section Chief, DATCP

¹ Larry Nelson retired after appointment to the TAC. Greg Fries also participated as a representative of the City of Madison Public Works Department.

Attachment C
Environmental Resources Technical Advisory Committee
Recommendations to the
Capital Area Regional Planning Commission

Background

On October 8, 2009, the Capital Area Regional Planning Commission (CARPC) requested that its Environmental Resources Technical Advisory Committee (TAC) convene to provide technical recommendations on a more stringent stormwater runoff volume control standard than the one currently required under NR 151 and Dane County Chapter 14.

The TAC met on November 12, 2009 to review and discuss some of the relevant literature on stormwater volume control as well as some of the volume control standards currently in use around the country. On December 16, 2009 the TAC met to review and discuss modeling results of the runoff volumes resulting from different volume control standards. On January 25, 2010 the TAC met to review and discuss the analysis approach used by Montgomery Associates for the standards recommended in the Badger Mill Creek – Sugar River Study and prepare draft recommendations. On February 22, 2010 the TAC met to finalize their volume control standard recommendations.

Discussion

The TAC agrees that without controls, increased volumes of stormwater runoff from impervious surfaces have an adverse effect on receiving waters. The TAC further agrees that the current infiltration (stay-on) standards in NR 151 and Dane County Chapter 14 do not completely mitigate the impacts of increased volumes of stormwater runoff in all cases. The TAC recognizes the potential benefits of a runoff volume control standard to 100% of pre-development volumes, however it has several concerns related to the achievability and the cost versus benefit of adopting a standard of no increase in pre-development runoff volumes. Therefore, the TAC proposes that the CARPC adopt the following volume control standard and that the standard be reevaluated 5 years from the date of adopting this standard.

Recommendations

The TAC proposes that the CARPC adopt a runoff volume control standard for all new Urban Service Area Amendments based on the infiltration standard in Chapter 14 of the Dane County Ordinances [14.51(2)(e)], including prohibitions, with the following revisions:

1. For both residential and nonresidential developments, design practices to control sufficient runoff volume so that post-development stay-on volume shall be at least 90% of the pre-development stay-on volume, based upon average annual rainfall.
2. The runoff curve numbers used in calculating pre-development conditions shall be based on the pre-development land uses. For agricultural land, the maximum runoff curve number (RCN) used in calculating pre-development conditions shall be 51 for hydrologic soil group (HSG) A, 68 for HSG B, 78 for HSG C, and 83 for HSG D.
3. If when designing appropriate volume control systems, more than two percent (2%) of the site is required to be used as effective infiltration area, the applicant may alternately design infiltration systems and pervious surfaces to meet or exceed the annual pre-development recharge rate. The annual pre-development recharge rate shall be

determined from the Wisconsin Geological and Natural History Survey's 2009 report, *Groundwater Recharge in Dane County, Wisconsin, Estimated by a GIS-Based Water-Balance Model* or subsequent updates to this report, or by a site specific analysis using other appropriate techniques. If this alternative design approach is taken, at least two percent (2%) of the site must be used for infiltration.

4. The standard should be applied on a subwatershed basis and allow credit for best management practices (BMPs) located within the subwatershed of concern and upstream of the point of discharge, including the option of retrofit practices in existing developed areas. The standard can be met with a combination of infiltration, evapotranspiration, and/or reuse BMPs.

The TAC also recommends that CARPC include a public hearing process as part of the adoption of this standard.

The TAC also recommends that the Dane County Board also adopt this volume control standard, so that it is applied to all new development within Dane County and not only to new urban service areas.

The TAC also recommends that CARPC encourage watershed wide standards and inter-municipal cooperation in meeting the standards.

The TAC also recommends that the following additional research efforts, data collection, and modeling be conducted to provide the information needed to further evaluate this issue:

- Use of the SWAT (Soil and Water Assessment Tool) model or other continuous hydraulic/hydrologic/water quality model to evaluate the impacts of runoff volume on the Yahara Lakes watershed This should be a high priority
- Improvements to the SLAMM model to better account for the split between recharge and evapotranspiration that occurs in infiltration / biofiltration practices
- Improvements to RECARGA, SLAMM, or other models to better predict performance during early season and late season infiltration, including frozen ground conditions.
- Information on the performance and life expectancy of infiltration practices currently in place and an assessment of contributing factors if failures occur
- Case studies demonstrating that volume control to 100% of predevelopment volumes can be met by constructed best management practices
- Biological monitoring, such as pre-development and post-development Indexes of Biotic Integrity (IBI)
- An economic analysis of the costs and water quality benefits of runoff volume control

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