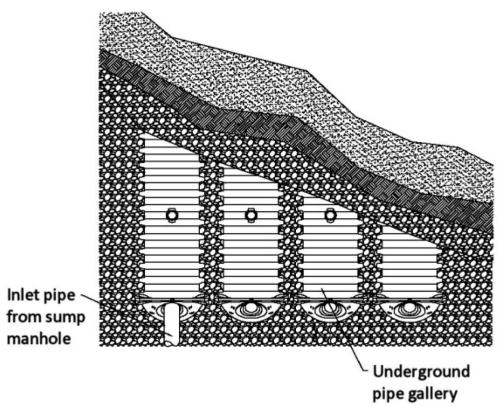
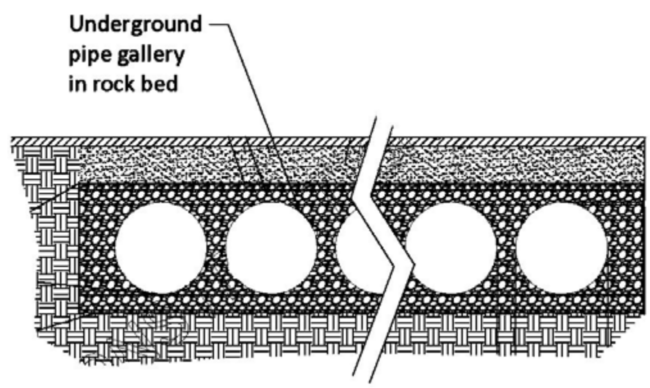
INTRODUCTION

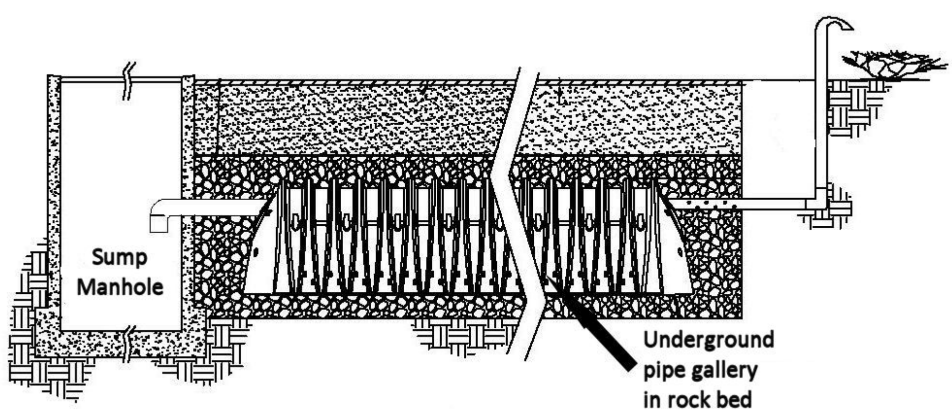
This Transportation Research Synthesis (TRS) provides an overview of relevant literature, regulations, guidance, and other information related to a specific stormwater Best Management Practice (BMP), underground infiltration systems with sump manhole pretreatment. This TRS is intended to serve as part of the justification to review this practice and related practices in the context of a revision to the Minnesota Stormwater Manual (MSWM).

Infiltration practices are addressed in Chapter 12-8: "*Infiltration*" of the MN Stormwater Manual. The practice in question is referred to in the MSWM as "underground infiltration systems". In particular, this TRS focuses on underground infiltration systems that receive stormwater runoff from roads and parking lots with high volumes of traffic and have only sump manholes as pretreatment. These systems have no biological treatment of the runoff, either in pretreatment or in the device itself.

An example of this type of system can be seen in the drawings below, from the MSWM (in plan view and two cross-sections):







In this example, the runoff enters the system through a sump manhole and is fed to a gallery of perforated pipes. In other examples, the pipe gallery can be replaced by concrete or plastic vaults or simply gravel beds.

The installation of these systems is frequently driven by compliance with new volume reduction permitting requirements by various regulatory authorities. These types of systems are most frequently seen on projects where space is significantly constrained. Examples of such projects include road reconstruction or expansion projects where space for other stormwater BMPs is not available in the right-of-way or commercial projects where land is either prohibitively expensive or not available. These underground systems can be relatively small or quite large (see picture at right).

Some of the regulated parties responsible for these systems are concerned about a range of issues that will be discussed in this TRS. There are reasons to believe that these systems may have higher potential for groundwater contamination than other types of infiltration systems. Additional site evaluation screening and design protocols may be appropriate and necessary. It is thought that the best approach to resolving these concerns is a comprehensive review of the issues, in the context of revising the MSWM, to provide improved guidance and controls on the installation, operation, and management of these BMPs. All appropriate agencies should participate in this review, including MPCA, MDH, MnDOT, MN Geological Survey, USEPA, MN Duty Officer Program, and local regulating authorities (such as watershed districts and cities). A review of State and local permitting requirements, guidelines, and practices should be conducted to determine whether the recommendations of the MSWM are being followed and implemented by design professionals and permitting authorities. The need for additional research should also be considered.

If these types of infiltration systems have a higher potential for groundwater contamination, the reasons for reviewing the issues and provisions of the MSWM are compelling. The numbers of these installed systems is growing rapidly. Potential groundwater contamination caused by these systems may be difficult to perceive or detect for a long period of time. Such groundwater contamination may be extraordinarily difficult and expensive to remediate.

Issues of Concern

Class V Underground Injection Control Program Regulations

There is a possibility that many of these underground infiltration systems meet the USEPA definition of a Class V injection well. This is listed as a “concern” in the MSWM. A 1999 study by the USEPA Underground Injection Control Program included the following reported data from Minnesota in an *Inventory of Storm Water Drainage Wells in the U.S.*:

Documented Number of Wells	*0*
Estimated Number of Wells	*No estimate provided, but state suspects some wells exist*

If these types of BMPs do meet the USEPA definition, the regulatory requirements are not trivial. Please see the text box below for relevant text excerpts from the USEPA Web site on this subject. It appears that it is appropriate for this concern to be addressed in more definitive manner in the MSWM.

The State of Minnesota does not have authority to implement the USEPA Class V Underground Injection Control Program.

Excerpts from USEPA Class V Underground Injection Control Program Web Site

Answer the following questions to determine if you have a Class V storm water drainage well.

Questions:	If Your Answer is Yes...	If Your Answer is No...
1. Do you operate a storm water collection system that relies on infiltration to collect and dispose of storm water runoff?	Go to question 2.	You do not have a Class V storm water drainage well. *Stop here.*
2. Does your infiltration system discharge to the subsurface?	Go to question 3.	You do not have a Class V storm water drainage well. *Stop here.*
3. Does your storm water infiltration system consist of a drilled or driven shaft, or dug hole that is deeper than it is wide? Does it rely on a naturally occurring sinkhole? Does it include any subsurface piping?	*You have a Class V storm water drainage well* and are subject to Class V requirements.	You do not have a Class V storm water drainage well. *Stop here.*

What are the minimum federal requirements for storm water drainage wells?
This section outlines the minimum federal requirements for storm water drainage wells. Some states have applied for and been granted authority to implement the Class V UIC Program in their state, including oversight of storm water drainage wells, and may have more stringent requirements. Visit the permitting authority page to find out what agency oversees Class V wells in your state. *It is your responsibility to find out what the specific requirements are in your state.*

Class V storm water drainage wells are “authorized by rule,” which means they may be operated without an individual permit so long as the injection does not endanger a USDW, and the owner or operator of the well submits basic inventory information about the well to their permitting authority.

Inventory submission requirements vary by state, but the required inventory information typically includes the facility name and location, name and address of a legal contact, ownership of property, nature and type of injection well(s), and operating status of the well(s). For more information, visit the page on minimum requirements, or contact your permitting authority.

- If you have a new storm water drainage well, you must contact your permitting authority before you begin construction.
- For existing storm water drainage wells, you must stop using the well immediately and contact your permitting authority to find out what you must do. In most cases, you will need to submit an inventory form and you may have to wait 90 days to allow the UIC program to authorize your well, after which you may continue using it (unless you are told otherwise).

I have a Class V well, but didn’t know about the UIC requirements. What should I do?
Contact your local UIC program representative right away to find out about requirements you must meet. In most cases, you will need to stop using the well and submit an inventory form. Within 90 days, the permitting authority will either tell you that you may resume injection or let you know of any additional requirements.

What if I want to construct a new Class V well?
Contact your permitting authority before you begin construction. At a minimum, you will need to submit inventory information (e.g., the name and location of the facility, a legal contact, the property owner, and information on the nature and type of injection well). The permitting authority will let you know what else (if anything) you must do.

Whom do I contact or send information to about my Class V well?
Information about your well, including information you may need to provide while operating the well, should be submitted to your permitting authority, which may be either a state agency or an EPA Regional Office. To find out what agency you should contact you should visit the page below.

Pollutant Fate

The MSWM includes the following language:

> *Infiltration practices can remove a wide variety of stormwater pollutants through chemical and bacterial degradation, sorption, and filtering. Surface water load reductions are also realized by virtue of the reduction in runoff volume.*
>
> *There are few data available demonstrating the load reductions or outflow concentrations of larger-scale infiltration practices such as infiltration trenches. Similarly, few sampling programs collect infiltrating water that flows through an infiltration system.*
>
> *For properly designed, operated, and maintained infiltration systems, all water routed into them should be "removed" from stormwater flow, resulting in 100% efficiency relative to volume and pollutant reduction. For this reason, any infiltration BMP performance table should show all 100% entries (see page 1 of Ch. 12-INF). This logic assumes that stormwater is the beneficiary of any infiltration system, but ignores the fact that pollution, if any remains after the internal workings of the infiltration BMP itself (see later discussion in this chapter), is being transferred into the shallow groundwater system. Good monitoring data on the groundwater impact of infiltrating stormwater are rare, but there are efforts underway today to document this, so future Manual revisions should be able to include some data updates.*

A 1995 study from the Washington State Transportation Center included the following text:

> *In our quest to find the balance between environmental and economic demands, we can become confused about the means to this end. In particular, infiltration practice is considered a "treatment" technology. However, this point of view is mistaken, because over the lifetime of a basin the attenuated metals would accumulate. Any changes in the water quality infiltrating a site can potentially change the geochemical conditions, leading to the possible release of the sorbed mass on the soil. Therefore, it is stressed here that infiltration is merely a mass storage technology when considering metals and should be thought of as such. Serious consideration of this point should be made before any long term management decisions concerning land disposal of runoff are made.*

A 2008 literature review from the University of Minnesota included this text:

> *An increasing proportion of modern stormwater management practices rely upon infiltration as a method of controlling runoff. The purpose of this literature review is to examine the current state of research regarding possible soil and groundwater pollution caused from stormwater infiltration practices. Research has shown that many of the priority pollutants in urban stormwater runoff have some potential to compromise groundwater supplies. Furthermore, concentrations of the pollutants in the receiving soil may become elevated above acceptable levels. Further research is necessary to determine important management and risk analysis decisions, such as heavy metal*

breakthrough times or establishment of a media exchange regime. Most important, optimizing pollutant minimization to protect the human and environmental healthy requires consideration of the ultimate fate of stormwater pollutants. Certain pollution risks are associated with infiltration, but many pollution risks are also associated with the status quo methods (i.e. discharging to surface water bodies). This review provides an informative reference regarding infiltration practices and the consequential possibilities of pollution, as well as a cornerstone for future and much-needed research in this growing field.

The issues addressed in the excerpts above are directly related to pollutants commonly found in runoff from roads and parking lots with high traffic volumes. In light of relatively new technical work in this field, they help justify a comprehensive review of these issues.

POLLUTANTS IN RUNOFF FROM ROADS AND PARKING LOTS WITH HIGH TRAFFIC VOLUMES

The MSWM includes recommendations and prohibitions regarding infiltration features that might receive runoff from potential stormwater hotspots. It also calls for additional geotechnical testing when infiltration BMPs are used in active Karst formations.

The MSWM does not call for additional screening or design measures when an infiltration BMP receives runoff from roads or parking lots with high traffic volumes and/or significant applications of road salt.

There are a number of references in the literature indicating that roads and parking lots with high traffic volumes have higher pollutant loads than many other land uses, especially for heavy metals and PAHs. A revision of the MSWM is appropriate, in light of this information.

Underground Injection Wells for Stormwater, Oregon Assoc. of Clean Water Agencies, January 2003

Potential areas where groundwater contamination may exist include

a. *Industrial areas and commercial developments where activities involve petroleum products, herbicides, pesticides, or solvents*
b. *Areas where "reportable quantities" of hazardous materials are expected to be present*
c. *Areas with a high risk for spills of toxic materials, such as gas stations and vehicle maintenance facilities*
d. *Locations where deicing using salts or other chemicals occurs in the winter*
e. *Designated truck routes and high vehicle traffic roads*

Table 4-1
Common Stormwater Pollutants of Concern Associated with Various Land Use Types[1]

Land Use Types (Potential Pollutant Sources)	Potential Pollutants of Concern
PARKING LOT/DRIVEWAY	
High Use Sites (>1,000 trips/day)	High Oil and Grease, Total Suspended Solids, Copper, Zinc, Polycyclic Aromatic Hydrocarbons
Non High Use Sites (<1,000 trips/day)	Oil and Grease, Total Suspended Solids
STREETS/HIGHWAYS	
Arterials, Highways and High Use Intersections	High Oil and Grease, Total Suspended Solids, Copper, Zinc, Polycyclic Aromatic Hydrocarbons
Residential Collectors	Low Oil and Grease, Total Suspended Solids, Copper, Zinc
OTHER SOURCES	
Industrial/Commercial Development	Oil and Grease, Total Suspended Solids, Copper, Zinc
Residential Development	Total Suspended Solids, Pesticides/Herbicides, Nutrients, Bacteria
Landscaped areas	Total Suspended Solids, Pesticides/Herbicides, Nutrients
Fueling Stations	High Oil and Grease
Industrial Yards/Maintenance Areas	High Oil and Grease, Total Suspended Solids, Metals, Polycyclic Aromatic Hydrocarbons

[1] Table based on literature review and stormwater management manuals from Pacific Northwest jurisdictions, including Table 2.1 of Volume V of Stormater Management Manual for Western Washington (Washington Department of Ecology, August 2001).

Stormwater Management for Highway Projects, Pitt, March 2001

> *Highway runoff has been shown to be similar in many ways to typical urban stormwater. However, it has higher concentrations of many pollutants, especially for the heavy metals and petroleum hydrocarbons (receiving waters are therefore similar, or worse, compared to the extensive problems associated with urban stormwater). Highway runoff seems to have a higher fraction of dissolved pollutants compared to most runoff (making it harder to control).*

In light of the information above, it is appropriate to reevaluate the MSWM to determine whether it should recommend additional screening or design measures when an infiltration BMPs receives runoff from roads or parking lots with high traffic volumes and/or significant applications of road salt.

REGULATION OF UNDERGROUND INFILTRATION SYSTEMS IN OTHER STATES

In some of the states that have delegated authority from the USEPA UIC Program, regulation of and guidance for underground infiltration systems is much more extensive. Oregon, for example, has a document titled "*Underground Injection Wells for Stormwater: Best Management Practices Manual*". This document is 125 pages long. The table of contents is as follows:

The difference between this manual and the information regarding underground infiltration systems provided in the MSWM is striking. In light of the fact that underground infiltration systems are being used widely, revisions to the MSWM are appropriate and necessary.

PRETREATMENT & TREATMENT

Robert Pitt, a leading stormwater researcher, has great respect for surficial infiltration BMPs and pretreatment devices. In his view, much of the water quality treatment that occurs in such devices is due to biological activity, in the vegetation above the ground and the root zone below the ground. Underground infiltration systems with sump manholes offer no such biological activity.

> *Incorporation of the pollutants onto soil with subsequent biodegradation, with minimal resultant leaching to the groundwater, is desired. Volatilization, photolysis, biotransformation, and bioconcentration may also be significant in grass filter strips and grass swales. Underground French drains and porous pavements offer little biological activity to reduce toxicants.*
>
> *The use of surface percolation devices (such as grass swales and percolation ponds) that have a substantial depth of underlying soils above the groundwater, is preferable to using subsurface infiltration devices (such as dry wells, trenches or French drains, and especially injection wells), unless the runoff water is known to be relatively free of pollutants. Surface devices are able to take greater advantage of natural soil pollutant removal processes.*

In Pitt's paper titled "*Protection of Groundwater from Intentional and Nonintentional Stormwater Infiltration*", he offers a table titled "*Groundwater Contamination Potential for Stormwater Pollutants*". He provides a rating for the potential for contamination in three categories of infiltration BMPs:

- *Surface infiltration and no pretreatment*
- *Surface infiltration with sedimentation, and*
- *Sub-surface injection with minimal pretreatment.*

For every type of pollutant, the sub-surface injection devices with minimal pretreatment have the highest potential for groundwater contamination.

This paper also includes this text:

> *The use of surface percolation devices (such as grass swales and percolation ponds) that have a substantial depth of underlying soils above the groundwater, is preferable to using subsurface infiltration devices (such as dry wells, trenches or French drains, and especially injection wells), unless the runoff water is known to be relatively free of pollutants. Surface devices are able to take greater advantage of natural soil pollutant removal processes.*
>
> *Very little treatment of residential area stormwater runoff should be needed before infiltration, especially if surface infiltration is through the use of grass swales. If subsurface infiltration (French drains, infiltration trenches, dry wells, etc.) is used, then some*

pretreatment may be needed, such as by using grass filter strips, or other surface filtration devices.

The MSWM includes the following text regarding pretreatment for infiltration BMPs:

> ***Pre-treatment 2. 3.***
> *It is REQUIRED that some form of pre-treatment, such as a plunge pool, sump pit, filter strip, sedimentation basin, grass channel, or a combination of these practices be installed upstream of the infiltration practice. It is HIGHLY RECOMMENDED that the following pre-treatment sizing guidelines be followed:*
>
> *Before entering an infiltration practice, stormwater should first enter a pre-treatment practice sized to treat a minimum volume of 25% of the* V_{WQ}
>
> *If the infiltration rate of the native soils exceeds 2 inches per hour, a pre-treatment practice capable of treating a minimum volume of 50% of the* V_{WQ} *should be installed.*
>
> *If the infiltration rate of the native soils exceeds 5 inches per hour a pre-treatment practice capable of treating a minimum volume of 100% of the* V_{WQ} *should be installed.*

With this guidance in place, underground infiltration systems have been designed and built with only sump manholes for pretreatment.

There are a number of potential problems with this configuration. First it is inconceivable that the sump portion of the manhole (the volume below the outlet pipe) can be sufficient to meet the V_{WQ} recommendations listed above, for anything larger than an extremely small drainage area.

Second, sump manholes have been widely thought to be largely ineffective in controlling sediment. The small volume of the manhole is easily overwhelmed by a significant storm. If the manhole is not cleaned frequently, the little available treatment volume is lost due to accumulated sediment at the bottom of the manhole. It is also thought that the sediment stored at the bottom of the manhole can be easily resuspended and discharged during a significant storm.

The University of Minnesota is currently assessing standard sump manholes for their stormwater treatment capacity:

> *Standard manholes have been a staple in stormwater infrastructure for their use as maintenance access and pipe junctions. Including a sump within a standard manhole allows for the removal of some particulate pollutants by settling, but very little data exists on both the ability of sump manholes to remove particles and how much scour occurs during high flows. A project funded by the Minnesota Department of Transportation at St. Anthony Falls Laboratory is seeking to fill this knowledge gap by testing full-scale standard sump manholes in the laboratory.*

The guidance provided by the MSWM appears to be insufficient in multiple regards. It makes no distinction between pretreatment with biological activity and those without. It does not specifically recommend using pretreatment with biological activity in situations where the infiltration BMP has no biological activity of its own (such as underground infiltration systems). It also appears to encourage the use of sump manholes without regard to their small capacity or widely perceived ineffectiveness. When the U of M research is complete, the MSWM should be revised.

SEPARATION BETWEEN THE BOTTOM OF THE INFILTRATION PRACTICE & SEASONALLY SATURATED SOILS

The MSWM includes the following language:

> *Ground water mounding, the process by which a mound of water forms on the water table as a result of recharge at the surface, can be a limiting factor in the design and performance of infiltration practices. A minimum of 3 feet of separation between the bottom of the infiltration practice and* ***seasonally saturated soils*** *(or from bedrock) is REQUIRED (5 feet RECOMMENDED) to maintain the hydraulic capacity of the practice and provide adequate water quality treatment. A ground water mounding analysis is RECOMMENDED to verify this separation for infiltration practices.*

The required 3 feet of separation should be revisited. This standard is a remnant of standards developed for siting septic systems. Based on conversations with MPCA staff, this standard was a compromise to allow septic systems to be built in the large portion of the state with relatively shallow groundwater. This standard should be reevaluated to determine whether it is appropriate for stormwater infiltration systems.

This separation standard does not vary according to either the type of soil under the infiltration system or the pollutant loading of the stormwater runoff entering the system. The Oregon guidance document "*Underground Injection Wells for Stormwater*" includes the following text:

> *DEQ recommends a minimum separation distance of between four to 10 feet between the bottom of the stormwater injection system and the seasonal high groundwater level (see Figure 2-2 in Section 2.2 for a diagram of a typical dry well). Generally, a greater minimum separation distance (seven to 10 feet) is recommended for injection systems underlain by coarse-grained soils (sand and gravel) which have a lower capacity for removing pollutants through soil adsorption. A minimum separation distance of four to seven feet is recommended for injection systems underlain by fine-grained soils (clay and silt) that have a higher capacity for removing pollutants through adsorption onto soil particles. The type of surrounding land uses and associated expected pollutant loading to an injection system may affect best professional judgment regarding necessary vertical separation between an injections system and groundwater.*
>
> *Besides the vertical separation from the high groundwater table, the extent to which potential pollutants are removed by subsurface soils depends in part on the geologic components of the subsurface soils. Clay content in the soil is usually desirable for removing pollutants, particularly metals, from the stormwater. Sand or gravel has a much lower capacity for removing certain types of pollutants.*

The MSWM separation standard should be reevaluated to determine whether it is appropriate to add varying standards depending on the type of underlying soil, the nature of the pretreatment, and the pollutant loading of the runoff entering the system.

MAINTENANCE CHALLENGES

The MSWM provides many recommendations for the long-term maintenance of infiltration devices. This is appropriate because maintenance is critically important to maintain the function of the devices. These recommendations include:

- *Debris removal*
- *Sediment removal*
- *Inspection*
- *Scrape basin bottom and remove sediment (every 5 years for infiltration trenches)*

All these procedures are impossible to do or prohibitively expensive in the case of underground infiltration systems. This should be clearly stated in the MSWM. Alternative maintenance protocols should be developed. Pretreatment standards specifically developed for underground infiltration systems should be provided, in light of these maintenance challenges. Maintenance protocols, especially the cleaning frequencies for sump manholes, should also be specified in the MSWM.

RECENT LITERATURE

The widespread interest and concern regarding stormwater infiltration and potential groundwater contamination is reflected in numerous recent publications and papers on the subject. This new research and information should inform the revision of the MSWM. These new publications include:

- *Contamination of Soil & Groundwater Due to Stormwater Infiltration Practices: A Literature Review*, Peter T. Weiss, Greg LeFevre, and John Gulliver, University of Minnesota Stormwater Assessment Project, June 23, 2008
- *Infiltration vs. Surface Water Discharge: Guidance for Stormwater Managers*, Shirley E. Clark, Katherine Baker, J. Bradley Mikula, and Catherine S. Burkhardt, Water environment Research Foundation, 2006

In addition, a revision of the MSWM should also be based the following text:

- *Groundwater Contamination from Stormwater Infiltration*, Robert Pitt, Ann Arbor Press, 1996

COUNTY GEOLOGIC ATLAS MAPS

Many counties in Minnesota have geologic atlas maps. For Ramsey County, for example, these maps include:

- Sensitivity of the Water-Table System to Pollution, and
- Sensitivity of the Prairie Du Chen-Jordan Aquifer to Pollution.

The sensitivity ratings on these maps are as follows:

	Type of Map & Estimated Travel Time	
Sensitivity Ratings	Shallow Water Table	Drinking Water Aquifer
Very High	Hours to months	
High	Weeks to years	Weeks to years
Moderate	Years to decades	Years to decades
Low	Decades to a century	Decades to a century
Very Low		More than a century
Not rated		

In informal conversations, staff with the MN Geological Survey have stated that these geologic atlas maps should be used to trigger additional site screening, testing and/or review in areas where the groundwater sensitivity is very high or high. These maps are general and limited in their specificity and detail, but they are appropriate if used as a screening tool.

This opinion has been directly contradicted by the staff of multiple surface water regulatory authorities. Their opinion was that these maps are not appropriate for this use. They felt that the indication of very high or high groundwater sensitivity shown on these maps should not trigger any additional site screening, testing and/or review.

This is a fundamental difference of opinion that should be resolved through a comprehensive review of these issues, leading to recommendations on this subject in the revised MSWM.

OTHER ISSUES

The following is a brief list of additional issues that should be addressed in the course of a comprehensive review

- **Hazardous materials spills –** Should there be mapping and management requirements for underground infiltration systems that receive runoff from arterial roads and/or transportation corridors?

- **Terminology –** Should we develop a common terminology for various types of underground infiltration systems to facilitate easy and clear discussion of related issues and concerns?

- **Changes to maximum drawdown times over time –** Clogging is widely recognized as a potential problem with all infiltration systems. Should there be maintenance and inspection protocols developed to assure that underground infiltration systems retain sufficient infiltration capacity over time to meet drawdown time recommendations?

- **Groundwater mounding –** Should the MSWM recommendations for groundwater mounding analysis for underground infiltration systems be reviewed and strengthened to assure that this analysis is performed in all appropriate situations?

- **Pesticides –** Should siting and design recommendations for underground infiltration systems be reviewed and revised to include information about pesticide application rates in the drainage areas for such systems?

- **Hydrocarbons and PAHs –** Should siting and design recommendations for underground infiltration systems be reviewed and revised in light of increased concern about runoff with hydrocarbons and PAHs?

- **Urban land –** Should soils classified as "urban land" in soil surveys be considered to be fill soils and addressed by the following recommendation in the MSWM? *It is HIGHLY RECOMMENDED that native soils have silt/clay contents less than 40% and clay content less than 20%, and that infiltration practices not be situated in fill soils.*

CONCLUSIONS

There appear to be compelling reasons for a comprehensive review of the issues, in the context of revising the Minnesota Stormwater Manual, to provide improved guidance and controls on the installation. operation, and management of these BMPs. This review should address, at a minimum, all the issues listed above. All appropriate agencies should participate in this review, including MPCA, MDH, MnDOT, MN Geological Survey, USEPA, MN Duty Officer Program, and local regulating authorities (such as watershed districts and cities). A review of State and local permitting requirements, guidelines, and practices should be conducted to determine whether the recommendations of the MSWM are being followed and implemented by design professionals and permitting authorities. The need for additional research should also be considered.

These reasons include:

- Lack of clarity regarding regulation of underground infiltration systems as Class V injection wells.
- Concerns and lack of knowledge about the long-term fate of pollutants captured in underground infiltration systems.
- Higher pollutant loadings from roads and parking lots with high traffic volumes, especially for hydrocarbons and salt.
- Higher levels of regulation, management, guidance, and regulation for these systems in other states, such as Oregon.
- Distinctions between surficial pretreatment and treatment BMPs (with biological activity) and subsurface BMPs (with no biological activity).
- Possibly inadequate separation between the bottom of underground infiltration systems and the seasonally saturated soils.
- Maintenance challenges.
- Including recent literature and research.
- Including county geological atlas map data.
- Other issues.

The issues of concern and potential risks are significant. The literature and information from other states indicates that alternative approaches to the siting, design, and management of these systems are used in other places.

If these types of infiltration systems have a higher potential for groundwater contamination, the reasons for reviewing the issues and provisions of the MSWM are compelling. The numbers of these installed systems is growing rapidly. Potential groundwater contamination caused by these systems may be difficult to perceive or detect for a long period of time. Such groundwater contamination may be extraordinarily difficult and expensive to remediate.