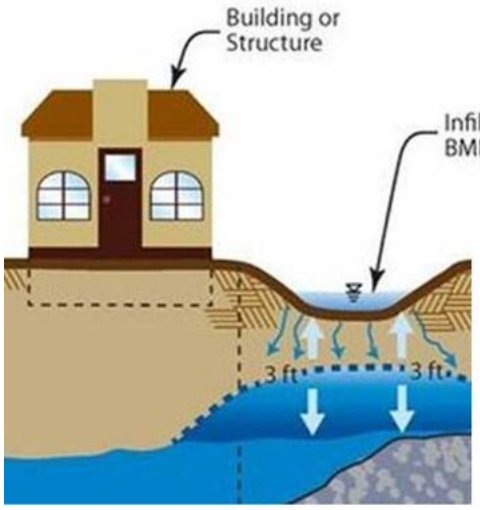
Shallow groundwater

Shallow groundwater is a condition where the seasonal high groundwater table, or saturated soil, is less than 3 feet from the land surface. There is a large portion of the state (more than 50 percent) where the seasonal high water table is located less than 3 feet from the surface. In these areas it may be impossible to get the 3 feet of separation from the bottom of an infiltration practice to the seasonal high water table REQUIRED under the NPDES Construction General Permit (http://stormwater.pca.state.mn.us/index.php/III._STORMWATER_DISCHARGE_DESIGN_REQUIREMENTS#III.D._PERMANENT_STORMWATER_MANAGEMENT_SYSTEM) (CGP). Non-infiltration BMPs, such as lined filtration or settling practices, should be considered in areas with shallow groundwater.



Schematic illustrating how depth to water is calculated. Note that a temporary mound formed as a result of infiltration is not included in the determination of depth to water. (Source: CDM Smith)

Contents

Why is shallow groundwater a concern?

Removal of some pollutants (e.g., bacteria) can occur in the vadose zone beneath the base of the BMP. Pollutant removal in the vadose zone is attained via biological activity, chemical degradation, adsorption of pollutants to soil, and plant uptake. Shallow groundwater reduces the depth of the unsaturated soil available for treatment, leading to an increased likelihood of groundwater contamination. The vadose zone is further reduced when a groundwater mound (http://stormwater.pca.state.mn.us/index.php/Stormwater_infiltration_and_groundwater_mounding) forms. These sites present challenges to stormwater management, however these challenges can be managed. General guidelines for investigation and management are presented in the following sections.

How to investigate for shallow groundwater

Investigations are recommended for all proposed stormwater facilities located on sites with a suspected shallow groundwater table. The investigation should be two-fold. First, appropriate screening tools such as soil surveys (http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=MN), geologic atlases (http://www.dnr.state.mn.us/waters/groundwater_section/mapping/index.html), or well records (http://www.health.state.mn.us/divs/eh/cwi/) should be used to determine the likelihood that the groundwater table is shallow. If a shallow groundwater table is present, a geotechnical investigation should be conducted.

Geotechnical investigations are recommended for all proposed stormwater facilities located on sites where it is suspected that the 3 foot vertical separation between the base of the BMP and the groundwater table might not be achievable. This is needed to show that requirements of the CGP have been met. The guidelines for how to investigate for shallow groundwater are summarized below. Guidelines for investigating all potential physical constraints to infiltration on a site are presented in a table at this link (http://stormwater.pca.state.mn.us/index.php/Procedures_for_investigating_sites_with_potential_constraints_on_stormwater_infiltration). These guidelines should not be interpreted as all-inclusive. The size and complexity of the project will drive the extent of any subsurface investigation. Regardless of the results of the initial site screening, soils borings and infiltration tests should be performed to verify site soil conditions.

Subsurface material investigation

The investigation is designed to determine the nature and thickness of subsurface materials, including depth to bedrock and to the water table. Subsurface data for depth to groundwater may be acquired by soil boring or studying existing wells on the site, if present. These field data should be supplemented by geophysical investigation techniques deemed appropriate by a qualified professional, which will show the location of the groundwater formations under the surface. The data listed below should be acquired under the direct supervision of a qualified geologist, geotechnical engineer, or soil scientist who is experienced in conducting such studies. Pertinent site information should include the following:

- Known groundwater depth or bedrock characteristics (type, geologic contacts, faults, geologic structure, rock surface configuration)
- Soil characteristics (type, thickness, mapped unit)
- Bedrock outcrop areas

Location of soil borings

Borings should be located in order to provide representative area coverage of the proposed BMP facilities. The location of borings should be:

- within each distinct major soil type present, as mapped in soil surveys (http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=MN);
- next to bedrock outcrop areas and/or in areas with known shallow groundwater if present;
- near the edges and center of the proposed practice and spaced at equal distances from one another; and

- near any areas identified as anomalies from any existing geophysical studies.

Number of soil borings

The number of recommended borings is described below.

- Infiltration trenches, bioretention, and filters - a minimum of 2 per practice. Note that more borings are recommended for infiltration BMPs greater than 5000 square feet in area. See here (http://stormwater.pca.state.mn.us/index.php/Recommended_number_of_soil_boring,_pits,_and_permeameter_tests_for_bioretention_design) for recommendations on number of borings for infiltration BMPs as a function of BMP size.
- Ponds/wetlands - a minimum of 3 per practice, or 3 per acre, whichever is greater.
- Additional borings – as needed to define lateral extent of limiting horizons, or site specific conditions, where applicable.

Depth of soil borings

Borings should be extended to a minimum depth of 5 feet below the lowest proposed grade within the practice unless auger/backhoe refusal is encountered.

Identification of material

All material penetrated by the boring should be identified, as follows.

- Provide descriptions, logging, and sampling for the entire depth of the boring.
- Note any stains, odors, or other indications of environmental degradation.
- Perform a laboratory analysis of a minimum of 2 soil samples, representative of the material penetrated including potential limiting horizons, with the results compared to the field descriptions.
- Identify soil characteristics including, at a minimum: color; mineral composition; grain size, shape, and sorting; and saturation.
- Log any indications of water saturation to include both perched and ground water table levels, and descriptions of soils that are mottled or gleyed (sticky clay soils typically found in waterlogged soils).
- Measure water levels in all borings at the time of completion and again 24 hours after completion. The boring should remain fully open to total depth of these measurements.
- Estimate soil engineering characteristics, including “N” or estimated unconfined compressive strength (http://www.uta.edu/ce/geotech/lab/Main/Soil%20Lab/09_UCS/UCS.pdf), when conducting a standard penetration test (http://teaching.ust.hk/~civl607d/Standard%20penetration%20test.pdf) (SPT).

Evaluation of findings

At least one (1) figure showing the subsurface soil profile cross section through the proposed practice should be provided, showing confining layers, depth to bedrock, and water table (if encountered). It should extend through a central portion of the proposed practice, using the actual or projected boring data. A sketch map or formal construction plan indicating the location and dimension of the proposed practice and line of cross section should be included for reference, or as a base map for presentation of subsurface data.

References for conducting geotechnical investigations

Information: A section providing information on soil borings is being developed for the Manual and should be available in early 2016

The following references provide useful information for conducting geotechnical investigations. Note that some of these documents were written for investigations at contaminated sites.

- Guidelines for Consultants Performing Geotechnical Investigations (http://www.eng.hctx.net/pdf/guidelines_for_geotech_investigations.pdf)
- Drilling, Logging, and Sampling at Contaminated Sites (https://www.dtsc.ca.gov/PublicationsForms/upload/Drilling_Logging_Sampling_Cont_Sites.pdf)
- Understanding the Geotechnical Report as an Engineering and Construction Reference (http://www.pdhonline.org/courses/g106/g106.htm)

What are general stormwater management guidelines for areas with shallow groundwater?

The following investigations and design variants are HIGHLY RECOMMENDED for infiltration BMPs proposed to be located in areas of shallow groundwater:

- Conduct thorough geotechnical investigations with geotechnical analyses similar to those recommended for karst regions.
- Conclude the site to be infeasible for infiltration BMPs where a minimum 3 foot separation between the bottom of the BMP and groundwater cannot be achieved. The CGP prohibits infiltration BMPs when the separation distance is less than 3 feet.
- Consider stormwater wetlands which require a shallower ponding depth than stormwater ponds. The disadvantage of stormwater wetlands is that the shallow depth of the wetlands often creates footprints that are larger than ponds.
- Consider a stormwater pond that will intercept the groundwater table. This approach requires close examination of the land uses to assess the potential for stormwater hotspot or other highly concentrated runoff sources that would contribute excess pollutants to the groundwater. If the area is a potential stormwater hotspot and there is less than 3 feet of separation from the seaonally high water table, or if the area is a confirmed stormwater hotspot, a Level 1 liner (http://stormwater.pca.state.mn.us/index.php/Liners_for_stormwater_management#Liner_specifications) is recommended to protect against groundwater contamination.

MPCA is often asked why it allows a sedimentation pond (no liner) to be constructed that may intercept the water table, but require a minimum of 3 feet of separation from the bottom of any constructed infiltration practice and the water table. The treatment processes for these two practices are very different and may help to explain the requirements. A stormwater pond achieves pollutant removal through the process of settling of suspended solids. If the basin is large enough, contains vegetation, and has a long detention time, additional treatment through biological uptake and microbial action can also occur. An infiltration practice removes pollutants through filtering that occurs in the minimum 3 foot unsaturated soil layer beneath the practice along with the biologic and microbial activity that takes place in the layer under aerobic conditions.

Related pages

- Overview of stormwater infiltration
- Pre-treatment considerations for stormwater infiltration
- BMPs for stormwater infiltration
- Pollutant fate and transport in stormwater infiltration systems
- Surface water and groundwater quality impacts from stormwater infiltration
- Stormwater infiltration and groundwater mounding
- Stormwater infiltration and setback (separation) distances
- Karst
- Shallow soils and shallow depth to bedrock
- Shallow groundwater
- Soils with low infiltration capacity
- Potential stormwater hotspots

- Stormwater and wellhead protection
- Stormwater infiltration and contaminated soils and groundwater
- Decision tools for stormwater infiltration
- Stormwater infiltration research needs
- References for stormwater infiltration