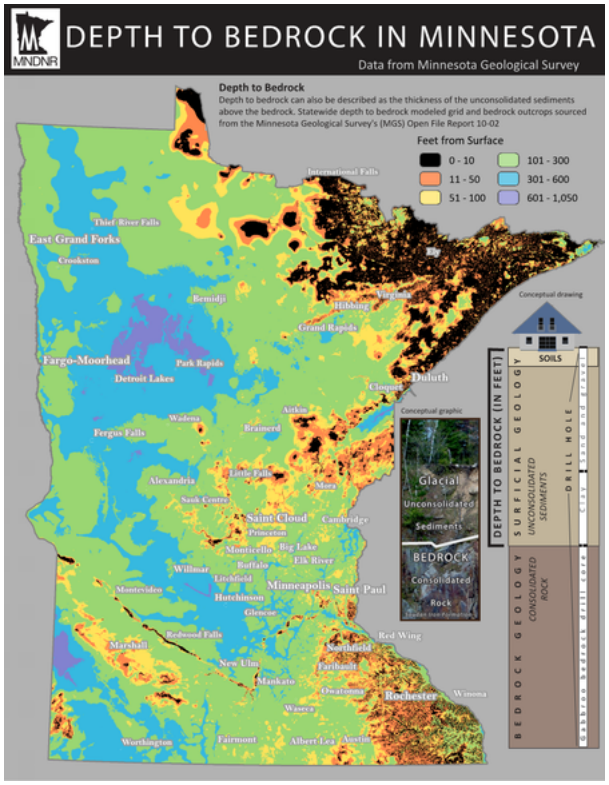
Shallow soils and shallow depth to bedrock

Sites with shallow bedrock are defined as having bedrock within 6 feet or less of the ground surface. Shallow bedrock is found in many portions of the state, but is a particular problem in the northeastern region. When installing an infiltration Best Management Practice (BMP), there must be at least 3 feet of separation between the base of the BMP and the bedrock per the Minnesota Construction General Permit (http://stormwater.pca.state.mn.us/index.php/Construction_stormwater_permit) (CGP). Bedrock at the 6 foot depth is a trigger to perform a geotechnical investigation to determine the location of the bedrock in the area in and around the proposed BMP to ensure the 3 foot separation can be achieved.

Contents



Bedrock Outcroppings Areas in Northern Minnesota (Source: MN DNR, with permission. Map is from the Minnesota DNR Lands and Minerals Division (http://www.dnr.state.mn.us/lands_minerals/index.html) and depth to bedrock grid data is from the Minnesota Geological Survey (http://www.mngs.umn.edu/))

Why is shallow depth to bedrock a concern?

Shallow bedrock limits the depth of BMPs, reduces the potential for subsurface infiltration, and reduces the depth over which treatment can occur. These sites present challenges to

stormwater management; however these challenges can be managed. General guidelines for investigation and management are presented below. Special caution for steep slopes and fractured bedrock is urged.

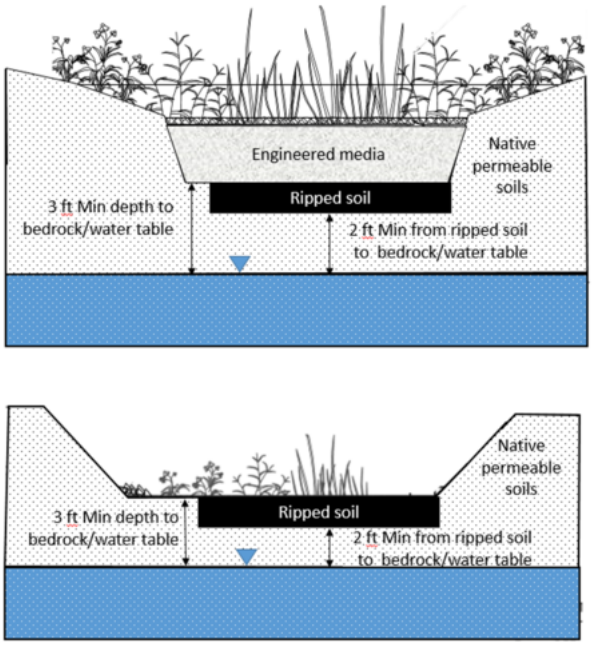
How to investigate for shallow bedrock

It is important to understand the general depth to bedrock over the entire site, but more specifically it is important to know the depth to bedrock in and around the area of the proposed BMP. Geotechnical investigations are recommended for all proposed stormwater facilities located in regions with shallow bedrock. The purpose of the investigation is to identify subsurface conditions which can pose an environmental concern or a construction hazard to a proposed stormwater management practice. 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.

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 backhoe investigation. These field data should be supplemented by geophysical investigation techniques deemed appropriate by a qualified professional, which will show the location of the geologic and 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



Schematic illustrating separation distance from bottom of infiltration BMP to water table or top of bedrock. This diagram includes a modified subsoil zone in which the subsoil has been ripped to alleviate compaction.

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 bedrock?

The following investigations and guidelines are HIGHLY RECOMMENDED for infiltration and other BMPs proposed to be located in areas with shallow depth to bedrock.

- Conduct thorough geotechnical investigations in areas with suspected or documented shallow bedrock. Perform site geotechnical analysis similar to karst.
- Consider a non-infiltration BMP or moving the BMP to a location on site with sufficient depth to bedrock if the required 3-foot separation cannot be achieved. It may be possible to move the infiltration BMP to another location in order to achieve this separation.
- Consider shallow ponding depths up to 12 inches for filters, swales, and bioretention.
- Conclude that infiltration of stormwater runoff from stormwater hotspots (http://stormwater.pca.state.mn.us/index.php/Potential_stormwater_hotspots) is not feasible due to potential for connections with bedrock fracture zones.
- Consider stormwater wetlands which have shallower ponding depths than stormwater ponds. The disadvantage is that the shallow depths result in basins with large footprints which may not be feasible on small sites.

The following table provides an overview of shallow bedrock and soil related design considerations for different structural practice groups. Guidelines for investigating all potential physical constraints to infiltration on a site are presented in the table at the bottom of this page.

Recommendations for structural BMP use in settings with shallow soils and shallow depth to bedrock.
Link to this table

BMP	Shallow soil and shallow depth to bedrock considerations
Bioretention	Should be constructed with an underdrain or liner if minimum separation distance of three (3) feet is not present between practice bottom and bedrock.[1]
Media filter	▪ Recommended practice in areas of shallow bedrock and soil ▪ Can be located in bedrock, but will be expensive due to blasting
Vegetative filter	▪ Recommended practice in areas of shallow bedrock and soil. ▪ Dry swales with engineered soil media will need an underdrain if minimum separation distance of three (3) feet is not present between bottom of practice and bedrock
Infiltration trench or basin	▪ Will be limited due to minimum separation requirement. Surface area to depth ratios of practices may need to be larger. Arch pipe and other perforated storage "vault" practices can help increase treatment volumes within limited spaces. ▪ If used, should have supporting geotechnical investigations and calculations ▪ Use with PSHs (http://stormwater.pca.state.mn.us/index.php/Potential_stormwater_hotspots) should be carefully considered. Pre-treatment should be extensive to limit risk of groundwater contamination if groundwater is close to the land surface. ▪ Local review authority should be consulted for approval

BMP	Shallow soil and shallow depth to bedrock considerations
Stormwater ponds	▪ Will have depth limitation to consider, making surface areas larger for a given storage volume. ▪ Shallower depths may be undesirable from an aesthetic standpoint, particularly if wide fluctuations in water level are expected. ▪ Bedrock should act like a liner and help to maintain a permanent pool, unless fracture zone is present
Constructed wetlands	▪ Applied more easily than ponds, but will also require larger surface area to drainage area ratios. ▪ Bedrock should act like a liner and help to maintain a permanent pool, unless fracture zone is present

[1]A liner is required under the Construction Stormwater General Permit (http://stormwater.pca.state.mn.us/index.php/Construction_stormwater_permit).

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