A Mined Underground Space Master Plan for Minneapolis, Minnesota—Part II

Subspace Associates

Abstract—*This second of a two-part article focuses on groundwater issues affecting the development of a mined underground space master plan for Minneapolis (Minnesota, U.S.A.). In the geologic formation underlying Minneapolis, there are generally two water tables: (1) a perched water table in the limestone that extends, at some locations, into the glacial drift; and (2) a water table in the sandstone. [Geology of the area is described in Part I of this article in* T&UST *5:3.] A specific mined underground space development in Minneapolis could require some dewatering of the underground formation, affect a perched water table above the project, or involve other groundwater impacts. The authors examine the groundwater issues and regulations, and make recommendations about them as they relate to possible future underground development of the area.*

Résumé—*La deuxième partie de l'article met l'accent sur la question de l'eau souterraine qui affecte le développement d'un plan d'ensemble détaillé de l'espace souterrain exploité dans la region de Minneapolis (Minnesota, USA). Dans la formation géologique au dessous de Minneapolis, il y a généralement deux nappes aquifères: (1) une, perchée dans le calcaire, qui s'étend, à certains endroits, dans le dépôt morainique; et (2) une nappe dans le grès. [La géologie de cette région est décrite dans la première partie de cet article à T&UST 5:3.]. Un développement spécifique de l'espace souterrain exploité à Minneapolis pourrait exiger un drainage des formations souterraines, affecter la nappe situé au dessus du projet, ou avoir d'autres répercutions sur l'eau souterraine. L'auteur examine la question de l'eau souterraine et des régulations, et fait plusieurs recommandations à ce sujet en tant qu'elles sont reliées au possibles développements souterrains futurs de cette région.*

Background Information on Mined Space Development in the Twin Cities

The Mined Space Resource

Use of mined underground space is becoming common in many parts of the world as a way to create attractive, and energy-efficient economic development opportunities in fully developed areas. In many major cities, such as Stockholm, New York, and Moscow, underground commercial and service activities have developed in conjunction with transit. Montreal's underground is famous for providing all-weather access to a broad range of uses, from hotels, restaurants, shopping, and entertainment to transcontinental rail access. In Kansas City, Missouri (U.S.A.), mined space is used for warehousing, freight handling, and high-technology services.

Mined underground space has many inherent characteristics that are attractive to potential users. Protection from surface temperature variation and climatic influences produces an environment that remains stable with relation to temperature, humidity, and atmospheric contaminants. Isolation from the surface and the nature of mined space also reduce vibration. Space created in the subsurface is more easily secured from unwanted intrusion.

The City of Minneapolis has a unique opportunity to develop such space due to its underlying geologic structure. A report prepared in 1982 estimated that approximately 6,000 acres of mined underground space could be created in Minneapolis with few complications resulting from the presence of water. Nearly 14,000 additional acres could be created using dewatering and other construction techniques.

The University of Minnesota is a leader in mined underground space technology and development. Construction and use of the new Civil and Mineral Engineering (CME) Building on the Minneapolis campus has demonstrated the technical feasibility of mined underground space in the geologic formation underlying Minneapolis. The CME Building extends 110 ft. beneath the surface and integrates new energy technologies and construction techniques. The University is currently considering the possibility of providing parking and laboratories in mined underground space.

Geology and Water Tables

A typical cross-section of the geological structure of the Minneapolis area is shown in Figure 1. Glacial till and unconsolidated soils extend from the soil to depths of 10 to 50 ft. below the surface. Beneath the soil and till lies a thin layer of Decorah shale, and a 30-ft.-thick layer of Platteville limestone. The Platteville limestone is underlain, in turn, by a thin layer of Glenwood shale, and a soft bedrock, the St. Peter sandstone.

Mined underground space would be created in the St. Peter sandstone, with the Platteville limestone forming a strong, self-supporting roof for the space. Thus, mined space in Minneapolis basically consists of man-made caverns surrounded completely by hard rock at a typical depth of 60 to 100 ft. below the surface depending, on the location (see Fig. 2).

Generally, there are two water tables in this geologic formation:

1. A perched water table in the limestone and, at some locations, extending above the limestone into the glacial drift; and
2. A water table in the sandstone.

The perched water table is mainly held above the Glenwood shale, al-

---

Subspace Associates is a consortium of the following consultant groups: BRW, Inc.; CNA Consulting Engineers; Faegre & Benson; Nelson Associates, Inc.; and the Underground Space Center (University of Minnesota). All of these groups are based in Minneapolis, Minnesota U.S.A.

This article is derived from a report, "Minneapolis Mined Underground Space Master Plan," prepared by Subspace Associates for the Minneapolis City Council.

Tunnelling and Underground Space Technology, Vol. 5, No. 4, pp. 375–377, 1990. 0886-7798/90 $3.00 + .00
Printed in Great Britain. Pergamon Press plc

though some water penetrates through cracks in the rock to the sandstone layer below. The lower water table in the sandstone begins at river level and rises gradually as the distance from the river increases. In areas adjacent to the Mississippi River, this leaves a 10- to 30-ft. "dry zone" immediately beneath the limestone, where mined space development can take place without de-watering. Beyond the dry zone, the water table can be regulated and lowered, if necessary, by dewatering techniques using pumps.

Regulation of Groundwater

Groundwater appropriation, use, and quality are all subject to regulation by the Minnesota Department of Natural Resources (MDNR) and the Minnesota Pollution Control Agency (MPCA).

The Mined Underground Space Development Act passed in 1985 specifically gives the MDNR certain authority with respect to groundwater impacts of mined space development. Minnesota Statute 469.141, Subd. 1, requires that MDNR review all mined space project plans that involve dewatering of underground formations. Minnesota Statute 469.141, Subd. 2, requires that any mined underground space project involving or affecting the quality or quantity of underground waters obtain an MDNR Groundwater Appropriation Permit.

Wells in mined underground space are regulated by the Minnesota Department of Health (MDH) under its Water Well Construction Code, Minnesota Rules, Parts 4725.0100-.7600 (1987). These regulations govern the construction, use, maintenance, and abandonment of water wells.

Groundwater Use and Protection

Discussion

Initial mined underground space development in the Study Area will involve little dewatering because the space will be created above the water table in the St. Peter sandstone. Further, the mining process and subsequent occupancy of the space do not present inherent threats to groundwater quality.

Because of the growing concern over groundwater protection and the potential for limited dewatering of underground formations, both the MDNR and the MDH will review mined space development plans and issue permits for certain activities. Consequently, any plan for mined underground space development must deal with the use and protection of groundwater.

Recommendations

Subspace Associates recommends that:

1. Groundwater use and protection should be addressed in any plan for mined underground space development presented to the City.
2. Regulations for groundwater protection in mined underground space should be referenced in City ordinances regulating mined space developent.

Dewatering Wells and Protection of the St. Peter Aquifer

Discussion

Dewatering wells are subject to a number of regulations that fail to recognize the unique requirements of mined underground space. Minnesota Rules Part 4725.2100 requires that a well be located at least 3 ft. horizontally from a building. Minnesota Rules Parts 4725.1900-.2000 sets various distance requirements from preparation and storage areas for spray materials, commercial fertilizers, chemicals, and buried sewers. Minnesota Rules, Part 4725.3400, Subp. 8, requires that well casings extend vertically at least 12 in. above ground surface. Minnesota Rules, Part 4725.2200, Subp. 1, requires that casings of wells located in areas subject to flooding extend at least 2 ft. above the level of the highest known flood of record; or that such casings be otherwise protected as prescribed in writing by the MDH.

Because the initial construction of mined space in the Study Area will involve minimal or no dewatering, these rules do not present an obstacle at the outset of mined space development. Nevertheless, to resolve the conflict between these requirements and the need to place dewatering wells in mined underground space, the Underground Space Center, other parties interested in mined underground space development, and the MDH should study the use and construction of dewatering wells in mined space and develop standards for their construction.

Building design features that could be affected include:

1. Protection of the adjacent aquifers from pollution sources and spills on the slab floor of mined space.
2. Provisions for the design and protection of wellheads in the mined space.

Recommendations

The Subspace Associates consulting team recommends that:

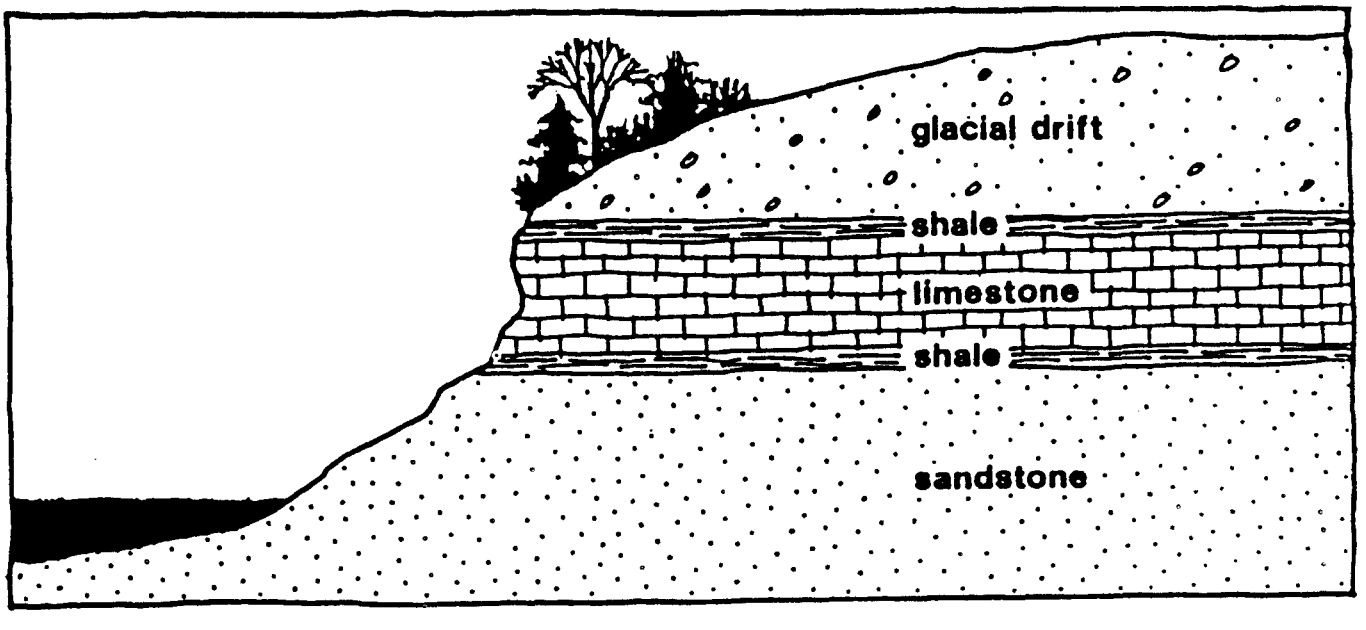

Figure 1. Geological section in the Minneapolis Study Area.

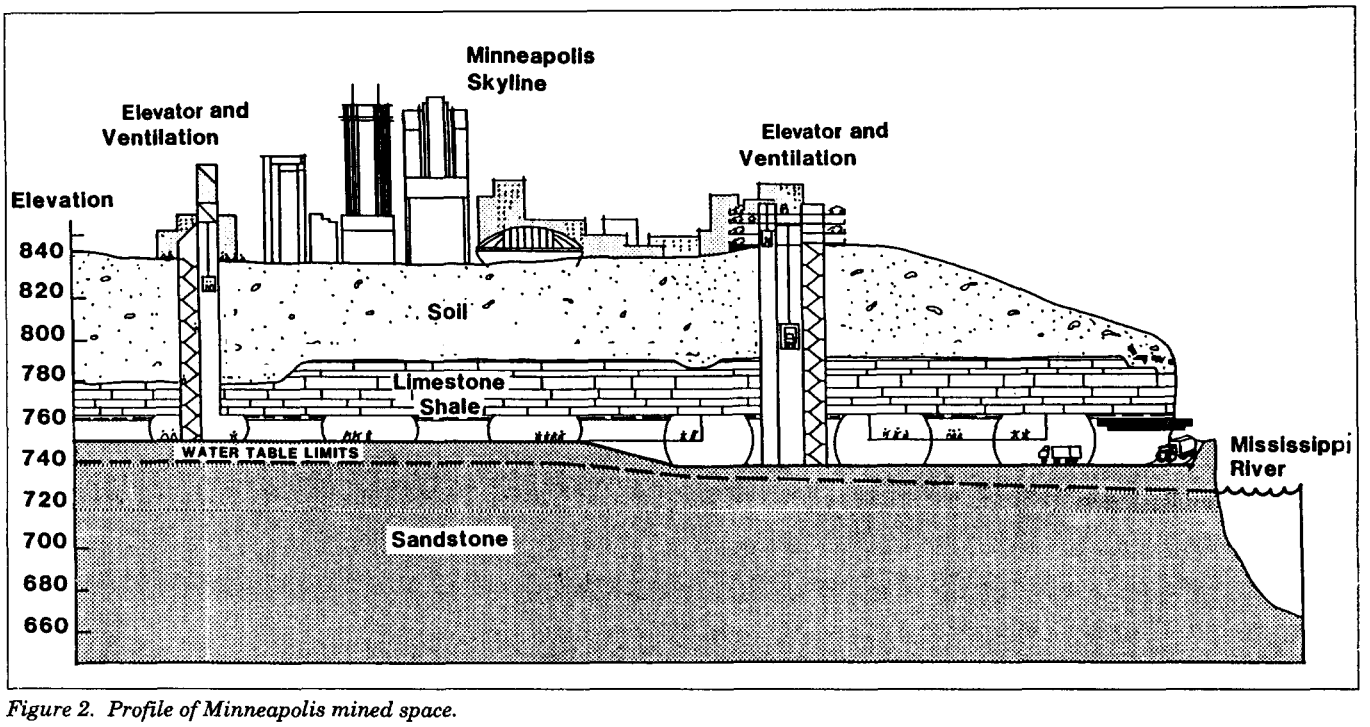

Figure 2. Profile of Minneapolis mined space.

1. The Underground Space Center, other parties interested in mined space development, and the MDH study the use and construction of dewatering wells in mined space and develop standards for their installation.

2. The MDH amend its Well Water Construction Code to permit water well construction in mined underground space, subject to the agreed-upon standards.

3. Requirements for water well construction in mined underground space be referenced in City ordinances regulating mined space development.

Impact of Mined Space on the Perched Water Table

Discussion

Under certain circumstances, mined underground space development could drain water tables perched above the Platteville limestone in the glacial drift. Leakage through the limestone roof or around shafts or deep underground buildings could cause such drainage. In moisture-sensitive soils below the water table, dewatering has the potential to cause surface settling. Thus, monitoring is need to detect changes in the perched water table where the soil above the Platteville limestone is sensitive to dewatering. Because such soils are not present in the Study Area, initial mined space development will not face these monitoring requirements.

Recommendations

The Subspace Associates consulting team recommends that:

1. In areas where soils are sensitive to dewatering, a set of monitoring locations should be chosen to record any changes in perched water tables. The spacing of the monitoring points should be determined according to the sensitivity of the soil to moisture-related movements and other factors of engineering or environmental significance. The water levels should be read monthly in the first two years of operation and yearly thereafter.

2. A report recording the measurements and describing their significance, if any, should be prepared and presented to the City yearly. □

References

Minnesota Department of Health. 1987. Water Well Construction Code, Minnesota Rules, Parts 4725.0100-.7600. St. Paul: Minnesota Department of Health.

Subspace Associates. 1984. The Legal and Economic Feasibility of Mined Underground space, Legislative Policy Discussion Document, p. 5 and Appendix G.