Construction and interpretation of a hydrogeological data base for the Seoul groundwater system

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ABSTRACT: This paper presents a GIS-based study of the urban hydrogeology of the Seoul area. The groundwater relationship between the Han River and adjacent aquifer has been analyzed. Line type fluctuations of groundwater level are decreased along the Han River from Inchun to Chamsil Low Dam. The pumping rate are difficult to extrapolate to the past, since seepage of groundwater into the subway system has increased in recent years, and the amount of increase is unknown. A groundwater flow model is developed to simulate the flow characteristics of groundwater in and around the subway lines. Water-level changes associated with the subway pumping station are estimated. The water budget of the groundwater system in the Seoul area and the movement of groundwater flow are estimated. The amount of groundwater available for use from an aquifer of Seoul area is not supplied from the natural recharge only. The additional sources are expected to be the increase in recharge or leakage from urban activity induced by well development and subway line, along with the reduction in discharge.

Key words: line type fluctuations, GIS, subway pumping station, water budget, subway line

1. INTRODUCTION

GIS (Geographic Information System) is a computerized database in which spatial data are linked to a set of specially designed software tools. Using GIS, geographic data can be to automate, manage, query, display, manipulate and analyze. GIS could be need for manipulating properties of the urban aquifer system. Over-extraction of groundwater in Seoul has produced a fall in groundwater levels (Kim et al., 2001). Urban storm-water runoff and infiltration of sewage have resulted in deterioration of the groundwater quality. This study for Seoul groundwater system is to assemble a database of urban hydrogeological data, including topographic data, precipitation, groundwater hydrochemical data, geology, aquifer properties, and urban landuse. The database is intended to support the development and application of a hydrogeological model of the aquifer system in Seoul.

GIS software is used for storing, processing and presenting geographical data. The requirements of GIS are:

(1) Data model flexibility, to allow system and database developments

(2) Outward open architecture, and the possibility of accepting and transmitting data in different formats

(3) Interactive and multimedia interface between user and system

(4) Integrated management of vector, raster, geographic data, and texts (Burrough, 1986).

Point data are used to represent measured elevation of land surface, monitoring wells, and gas stations and water levels recorded at the Han River monitoring stations. Line data show the network of rivers, the route of the Seoul subway lines and roads. Line coverage containing a route system is used to establish stages along the outer boundary of the model. The model grids are represented by polygon coverage with numerous region subclasses depicting certain model parameters. Land uses are included in the database with polygon coverage.

For urban hydrogeological studies, GIS enhances the opportunity for visualization and processing of data. The spatial database of this research is completely designed as a set of point, line and polygon coverages and Triangulated Irregular Networks (TIN). This is illustrated with a description of urban hydrogeological model input data and the assessment of the uncertainty in such input data. This study includes an analysis of hydrogeological conditions and a simulation of the subway groundwater flow system. The UHDS (Urban Hydrogeological Database System) uses GIS technology to analyze regional hydrogeological data. Concurrently, UHDS is involved in the development of systems (Fig. 1).

GIS is a useful tool for managing and modeling spatial data. Douglas (1995) lists GIS applications in four categories: (1) government management and planning, (2) environmental safety and health applications, (3) resource planning, and (4) commercial planning. Environmental safety and health applications include wastewater management and monitoring of air emissions.

Applications of GIS for industrial facilities include automated mapping and facilities management (AM/FM). Berry (1993) describes AM/FM applications as “descriptive,” in contrast with “prescriptive” applications that involve spatial statistics and modeling. Prescriptive applications are iden-
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tified by the term decision support systems (DSS). Addition-
ally, Nobel (1998) investigated the application of GIS to
Eco-Industrial Parks. Nobels work incorporates optimiza-
tion models and the ArcView GIS. There are three main
benefits of GIS as a tool for resource management.

ARC/INFO is used to digitize hardcopy maps. Data in the
tabular format are converted to standard ASCII files suit-
able for ARC/INFO map design. An AML (Arc Macro
Language) menu interface can simplify the most frequently
performed tasks.

At First, GIS allows a user to view maps, design maps
and assign data to map features. Each map layer has a fea-
ture attribute table, and each feature of the map has a
unique entry and identification number. This link between
maps and attribute tables enables the display of attributes on
the map. ArcView is the primary GIS software used in this
research, and maps are displayed from Arc View for windows.

Secondly, GIS can establish the connectivity of polygon
or line map features. Sewer networks are best represented
as a series of lines and points. Reaches are described as
lines. Drains, manholes, and junctions are represented by
points. Point and line are numbered, and lines are assigned
a “from node” and a “to node”. These nodes depict location
as well as direction. This feature allows the connectivity of
the sewer network to be established without manual effort.

In the third, GIS software can be customized to suit spe-
cific applications. These programs eliminate the require-
ment of user expertise in GIS. In ArcView, the user can be
prompted for input, input can be processed, and files can be
manipulated to read and write necessary information with-
out demands on the user.

2. URBAN HYDROGEOLOGICAL DATA BASE

GIS is used to manage large amount of data analyzed in
this project, including data from geophysical investigations,
boreholes, topographical and geological maps, water eleva-
tion, and chemical and biological analysis. The following
data has been incorporated into ARC/INFO; rivers and pro-
file boundaries (Line data); Well and borehole locations
(Point data); Bedrock unit; Hydraulic conductivity; ground
surface and landuse; pumping test data; transmissivity of
the aquifer; storage coefficient; hydraulic conductivity of
the confining beds and aquifer boundary conditions (Poly-
gon data).

The detail of borehole data varies from detailed descrip-
tions of lithological logs, accumulative yield and pumping
test data to old boreholes with minimal description of log-
ging data. The hydrogeological data includes well number,
depth to water, pumping rate, drawdown, specific capacity,
urban landuse, transmissivity and hydraulic conductivity.

This paper describes the urban hydrogeological applica-
tion of GIS in the Seoul area. This involves the construction
of an urban hydrogeological database composed of ground-
water-level fluctuation, topographic data, water chemistry
data, subway pumping station data, tidal effects of the Han
River, and hydrogeological parameters such as hydraulic
conductivity. A hydrogeological model imports data from
the database and the model output is stored again for the
manipulation and display in GIS (Kim and Lee, 1999).

3. COLLECTION OF URBAN HYDROGEOLOGICAL
DATA

The temporal and spatial characteristics of groundwater is
the basis of the urban groundwater impact assessment
project. Loading spatial data into GIS and building the spa-
tial database were critical but time-consuming parts of the
research. Data, either spatial data (map, graphical data) or
descriptive data (attribute, tabular data), are linked by spa-
tial location (coordinates) in GIS (Goodchild, 1992). Each
map, or coverage layer, represents the thematic spatial data
of groundwater characteristics. The maps contain vector data,
which are digitized into GIS to represent the spatial loca-
tions, and raster data, which are used to present the land use
type, surface elevation and similar features. The following
are the coverages and their related features, which are the
components of the GIS spatial database: All coverages were

![Image]

**Fig. 1.** Application of GIS for evaluation of groundwater suscep-
tibility of Seoul area.