A GROUNDWATER MONITORING NETWORK

AND

PARTNERSHIP FOR ONTARIO

SUGGESTED GROUNDWATER MONITORING NETWORKS

FOR TEN BASINS IN SOUTHERN ONTARIO

PREPARED BY

ENVIRONMENTAL MONITORING AND REPORTING BRANCH
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CHAPTER ONE

INTRODUCTION

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1.1 GENERAL REMARKS

Groundwater is a major source of water supply for agricultural, commercial, industrial and municipal uses, and it is critical for the survival of fish and aquatic life in Ontario's watercourses. Decisions related to the use and management of groundwater are being made every day by various government agencies, conservation authorities, municipalities, and the general public. These decisions range from locating new groundwater supplies to assessing the potential impacts of proposed landfill sites, and from determining the effects of non-point sources of contamination on local aquifers to conducting studies on regional or watershed scales. The instances differ from location to location, but the need for good baseline data about groundwater persists unchanged.

In 1995, a review of existing groundwater monitoring programs within the Ministry of Environment (MOE) was undertaken by the Environmental Monitoring and Reporting Branch. The review, which involved the identification of MOE's monitoring needs and the provision of options on future directions, concluded that most groundwater monitoring in Ontario is being conducted as part of site specific assessments. The review also determined that a network of monitoring wells existed in Ontario between 1946 and 1979. These monitoring wells were used to measure the fluctuations of groundwater levels for detailed hydrogeologic studies as well as for assessing the impacts of water supply withdrawals and the resolution of interference complaints.

The 1995 review affirmed the need for a comprehensive groundwater database for Ontario to characterize the location, quality and sustainable yield of the resource and describe *where*, *how*, and *why* the resource is changing. A groundwater monitoring network strategically distributed throughout the province can provide such a database. The network would provide baseline data on ambient groundwater conditions throughout the province. The data could be used to prepare annual reports on future trends with special attention to existing and potential problems related to quality or quantity. Advisories could also be issued to specific municipalities where groundwater conditions indicate the need for action.

To be effective, the design of the groundwater monitoring network should be flexible and tailored to fit regional hydrogeologic and land use conditions, current and future water demands, and the specific needs of various users. The design should also recognize the dynamic nature of groundwater systems as affected by both natural phenomena and man-induced changes. Further, the success of an informative network will depend on a cooperative partnership among federal and provincial agencies, conservation authorities, municipalities, industry, academia, and the general public. Together these groups can implement mutually beneficial monitoring and data interpretation by sharing resources, identifying opportunities, and sponsoring technology transfer symposia.

1.2 THE PROVINCIAL GROUNDWATER MONITORING INFORMATION SYSTEM

An integral part of the proposed monitoring network is the design of an effective database management system capable of storing, verifying and retrieving information to facilitate interpretation and reporting and give direction to remedial actions. To this end, the data management system should allow users to select the monitoring wells within a geographic area of interest and to examine the information and data associated these wells.

The establishment of the database would involve the synthesis of past data as well as the collection of new data. Data related to local groundwater quality and quantity are available in various forms in both public and private sector databases such as:

S MOE Water Well Information System (WWIS),
S Dinking Water Surveillance Program (DWSP),
S Provincial Water Quality Monitoring Network (PWQMN),
S municipal water supply programs,
S site remediation works (Smithville, Elmira etc.),
S impact assessment studies (development of gravel pits or redevelopment of industrial land),
S Waste Management Master Plans,
S environmental assessments dealing with waste disposal sites,
S Permits to Take Water and Certificates of Approval that are issued to operate water supply wells or waste sites,
S results of bacteriologic and chemical analyses of samples collected from water wells by the Ministry of Health,
S test drilling and well surveys prior to road construction projects conducted by Ontario Ministry of Transportation,
S land development applications to the Ministry of Municipal Affairs and Housing, and
S special studies such as the Ontario Farm Well Survey in 1992.

Data from the above sources will be examined and, when feasible, linked to or incorporated into the proposed groundwater database. To ensure that the necessary baseline data are being collected, a minimum level of monitoring has to be done. This will include the taking of water level readings in monitored wells and the collection of water samples for chemical analyses. A minimum requirement for the identification of water quality will be the determination of conventional chemical parameters and selected metals in all wells. In addition, selected pesticides will be analysed in areas of intensive agriculture and selected volatile organics will be analysed in urban and urban fringe.

Because the water samples will be collected by different partners and submitted to different laboratories for analysis, stringent quality assurance/quality control (QA/QC) protocols will be required for the proposed monitoring program. These protocols will be distributed to all partners in the form of a guidebook to ensure uniformity in sample quality. Further, to reduce data entry and QA/QC requirements, the data will be submitted electronically from the analytical laboratories to MOE.

1.3 SELECTED AREAS FOR GROUNDWATER MONITORING

Because the majority of Ontario's population lives in its southern parts where more than 90 percent of the water wells are located, it is logical to begin the implementation of the groundwater monitoring network in southern Ontario. Toward this end, nine basins and one area south of Georgian Bay (the Severn Sound drainage area) were selected to implement the initial phase of the monitoring network. If required, additional areas can be added to the network in the future. The selected areas for monitoring are:

- Big Otter Creek drainage basin,
- Bowmanville, Soper and Wilmot Creeks drainage basin,
- Credit River drainage basin,
- Grand River drainage basin,
- Holland and Black River drainage basins,
- Moira River drainage basin,
- Severn Sound drainage area,
- South Nation River drainage basin,
- Thames River drainage basin, and
- Upper Nottawasaga River drainage basin (Figure In-1).

The above areas include parts of most of the physiographic regions in southern Ontario as identified by Chapman and Putnam (1984). They also include parts of all the bedrock hydrogeologic units and parts of the most important overburden aquifers in southern Ontario as described by Singer et al. (1997). In addition, a variety of land uses including urban, intensive agriculture, row crops, specialty crops, pastures, woodlots, and wetlands are found within the selected areas.

Within the selected areas, groundwater is a major source of water supply for municipalities and agricultural, commercial, industrial, rural domestic, and recreation purposes, and the dependency on groundwater is increasing over time. This dependancy has resulted in severe water shortages and aquifer mining in some locations.

The natural quality of the groundwater within the selected areas is good, but it is also susceptible to contamination in certain locations.This is especially true in areas where bedrock or sand and gravel aquifers are near or at the surface. Numerous incidents of groundwater contamination by bacteria, nitrate, road salts, and volatile organics have been reported.

1.4 DESIGN METHODOLOGY

The design of the groundwater monitoring networks for the selected areas made extensive use of the MOE Water Well Information System. In addition, available technical reports and maps related to the physiography, geology, and hydrogeology of these areas provided indispensable information for the design of the networks. The reports provided background information about the hydrogeologic characteristics of the areas, while the maps served to define the areal extent of various physiographic and geologic features and as effective backgrounds to display the hydrogeologic information.

In designing the groundwater monitoring networks for the selected areas, the following factors were considered important:

- groundwater occurrence within various bedrock and overburden deposits,
- the water-yielding capabilities of the deposits,
- the susceptibility of groundwater to contamination, and
- groundwater use.

As part of the design process, the number of water wells that tap the various deposits, their designated uses (agricultural, commercial, domestic, industrial or municipal), and their water-yielding capabilities were considered important indicators that warranted special consideration.

The number of water wells and their designated uses are good indicators of the significance of groundwater as a source of water supply within an area. Further, the number of wells that tap a given bedrock or overburden formation is an indicator of the relative importance of the formation as a source of water supply. In areas where the overburden is thin or absent, as is the case in parts of the Canadian Shield, the bedrock could be the only source of water supplies. On the hand, in areas where the overburden is thick, as is the case within the Oak Ridges moraine, the overburden becomes the main source of water supplies. In many areas of Ontario both the bedrock and the overburden are important sources of water supplies.

The water-yielding capabilities of wells and the aquifers they tap are usually determined through long-term pumping tests which are intended to calculate the coefficients of permeability (hydraulic conductivity), transmissivity, and storage. Often, however, the only available data for wells are the final drawdowns associated with pumping tests of short durations. These data can be used to calculate the specific capacity values for the wells. In general, high specific capacities are indicative of high transmissivities and, consequently, high water-yielding capabilities.

In designing the monitoring networks for the selected areas, the specific capacity values for various wells served as useful indexes to describe the water-yielding characteristics of the wells and the formation(s) they tap.

1.4.1 Design Considerations Related to the Susceptibility of Groundwater to Contamination.

The susceptibility of groundwater to contamination is another major factor that has to be addressed when designing a monitoring network. Groundwater is susceptible to contamination from many types of pollutants that can travel rapidly downward from the surface to the water table. Pollutants originate either from point or non-point sources.

Potential point sources of pollution include municipal sanitary landfill sites, industrial waste storage and disposal sites, municipal and industrial liquid waste impoundments, major spills, underground gasoline storage tanks, mine tailings, radioactive wastes, coal tar sites, coal and coal ash from thermal power plants, PCB storage areas, deep well injection from industrial waste and brine disposal lagoons. Non-point sources that can impact the groundwater quality include industrial and municipal operations (pipelines, minor spills, and road de-icing salts), agricultural activities (fertilizer and pesticide use, animal manure, and irrigation), urban drainage, septic systems, unprotected domestic and abandoned wells, acid rain and atmospheric fallout.

In 1981 MOE initiated the Groundwater Susceptibility to Contamination Map Series Program. As part of this program, twenty-six maps for various areas in southern Ontario were published. When evaluating the potential susceptibility of groundwater to contamination within each of these twenty-six areas, the following factors were considered:

- permeability of near surface materials,
- direction of groundwater movement,
- presence of shallow aquifers, and
- groundwater use in the area.

As part of the above program, seven different hydrogeologic environments were identified in Ontario. These environments are: areas of carbonate bedrock that are at or close to the surface; the Canadian Shield; areas of surficial sand and gravel associated with kame deposits; areas of surficial sand with a minor amount of gravel; areas of surficial clay deposits; areas of surficial silt, clay and till; and areas of surficial sand and gravel among till.

A high, low, and variable rating system was used to determine the susceptibility of groundwater to contamination within each hydrogeologic environment. The rating system was based on the presence or absence of shallow aquifers, the permeability of surface materials, and groundwater use.

A slightly modified methodology to that used by the MOE program was used for the design of the monitoring networks in the selected areas. As described further, the modified methodology considered the presence and thickness of protective clay material.

1.4.2 Designing a Groundwater Monitoring Network in the Bedrock

As part of designing the monitoring network within the bedrock of a selected area, the following steps were taken.

- **S** The bedrock wells were plotted on a bedrock geology map.
- **S** The number and percentage of wells within each bedrock formation were identified.
- **S** Formations with less than 5% of the wells were considered as currently not significant.
- **S** The specific capacity values for the bedrock wells were calculated.
- **S** Maps were prepared to show bedrock wells with the following ranges of specific capacities in l/min/m:

    - **S** < 5 (minimal producing wells),
    - **S** 5-25 (below average producing wells),
    - **S** 25-50 (average producing wells), and
    - **S** > 50 (above average producing wells).

- **S** Areas containing bedrock wells with specific capacities of 25-50 and >50 l/min/m were delineated to identify average and above average water producing areas.
- **S** A sufficient number of geologic-cross sections and panel diagrams were prepared (Figure In-2).
- **S** All the available information was used to delineate areas within the bedrock that have _high_, _variable_ (_medium_), and _low_ susceptibility to groundwater contamination.

The following method was used to delineate the areas with various susceptibility to groundwater contamination:

- *high susceptibility* areas are those where the bedrock is at or near the surface or covered with sand and/or gravel materials with no impermeable layers,
- *variable susceptibility* areas are those where the overburden mantle over the bedrock consists of sandy till and/or very fine sand and silt with up to 3 m of clay material, and
- *low susceptibility* areas are those where the overburden mantle over the bedrock contains over 3 m of clay material.

The recommended areas for groundwater monitoring within the bedrock were delineated using the following method.

- Areas that are *highly recommended* for monitoring are those where groundwater in the bedrock is highly susceptible to contamination and where the wells have average or above average yields.
- Areas that are *recommended* for monitoring are those where groundwater in the bedrock has a variable susceptibility to contamination and where the wells have average or above average yields.
- Areas that are *optional* for monitoring are those where groundwater in the bedrock has a variable susceptibility to contamination and where the wells have below average yields.

1.4.3 Designing a Groundwater Monitoring Network in the Overburden

As part of designing a groundwater monitoring network within the overburden of a selected area, the following steps were taken.

- The overburden wells were plotted on a surficial geology map.
- The number and percentage of wells within each type of overburden deposits (glacial, glaciofluvial, glaciolacustrine or glaciomarine) were identified.
- Deposits with less than 5% of the wells were considered as currently not significant.
- The specific capacity values for the overburden wells were calculated.
- Maps were prepared to show overburden wells with the following ranges of specific capacities in l/min/m:

    - < 5 (minimal producing wells),
    - 5-25 (below average producing wells),
    - 25-50 (average producing wells), and

- S > 50 (above average producing wells).

- S Areas containing overburden wells with specific capacities of 25-50 l/min/m and >50 l/min/m were delineated to identify average and above average water producing areas.
- S A sufficient number of geologic-cross sections and panel diagrams were prepared.
- S All the available information was used to delineate areas within the overburden that have *high*, *variable* (*medium*), and *low* susceptibility to groundwater contamination.

The following method was used to delineate the areas with various susceptibility to groundwater contamination:

- S *high susceptibility* areas are those where the overburden consists of thick sand and gravel deposits which form a surficial aquifer,
- S *variable susceptibility* areas are those where the overburden consists of sandy till and/or very fine sands and silts with up to 3 m of clay material, and
- S *low susceptibility* areas are those where the overburden mantle consists of clay till or over 3 m of clay material.

The recommended areas for groundwater monitoring within the overburden were delineated using the following method.

- S Areas that are *highly recommended* for monitoring are those where groundwater in the overburden is highly susceptible to contamination and where wells have average or above average yields.
- S Areas that are *recommended* for monitoring are those where groundwater in the overburden has a variable susceptibility to contamination and where wells have average or above average yields.
- S Areas that are *optional* for monitoring are those where groundwater in the overburden has a variable susceptibility to contamination and where wells have below average yields.

1.5 POTENTIAL PARTNERS

A key component of this program is partnerships between MOE and other groups who are interested in groundwater. The program will be delivered in cooperation with these groups. This cooperative approach would ensure that the program covers a wide range of interests and utilizes current resources that are already being used for groundwater monitoring.

Potential partners who are already conducting monitoring program will be encouraged to make their data available for inclusion into the Provincial Groundwater Monitoring Information System. Those potential partners will also be encouraged to enter into individual arrangements with MOE. Such arrangements could include specific technical assistance to the partners such as the development of detailed hydrogeologic maps for local groundwater resources or training in the use of the electronic MOE water well database. In addition to individual arrangements made with the partners to serve specific local needs, MOE, as custodian of the database, will use its hydrogeologic expertise and knowledge of provincial environmental issues to provide:

S annual reports on environmental trends in groundwater conditions, with special attention to emerging potential problems related to quality or quantity, and

S advisories to specific municipalities or regions where observations indicate the need for attention.

In exchange, the partners will be asked to provide assistance regarding the implementation of the monitoring network and the collection and analyses of samples.

1.6 ACKNOWLEDGMENTS

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FIGURES

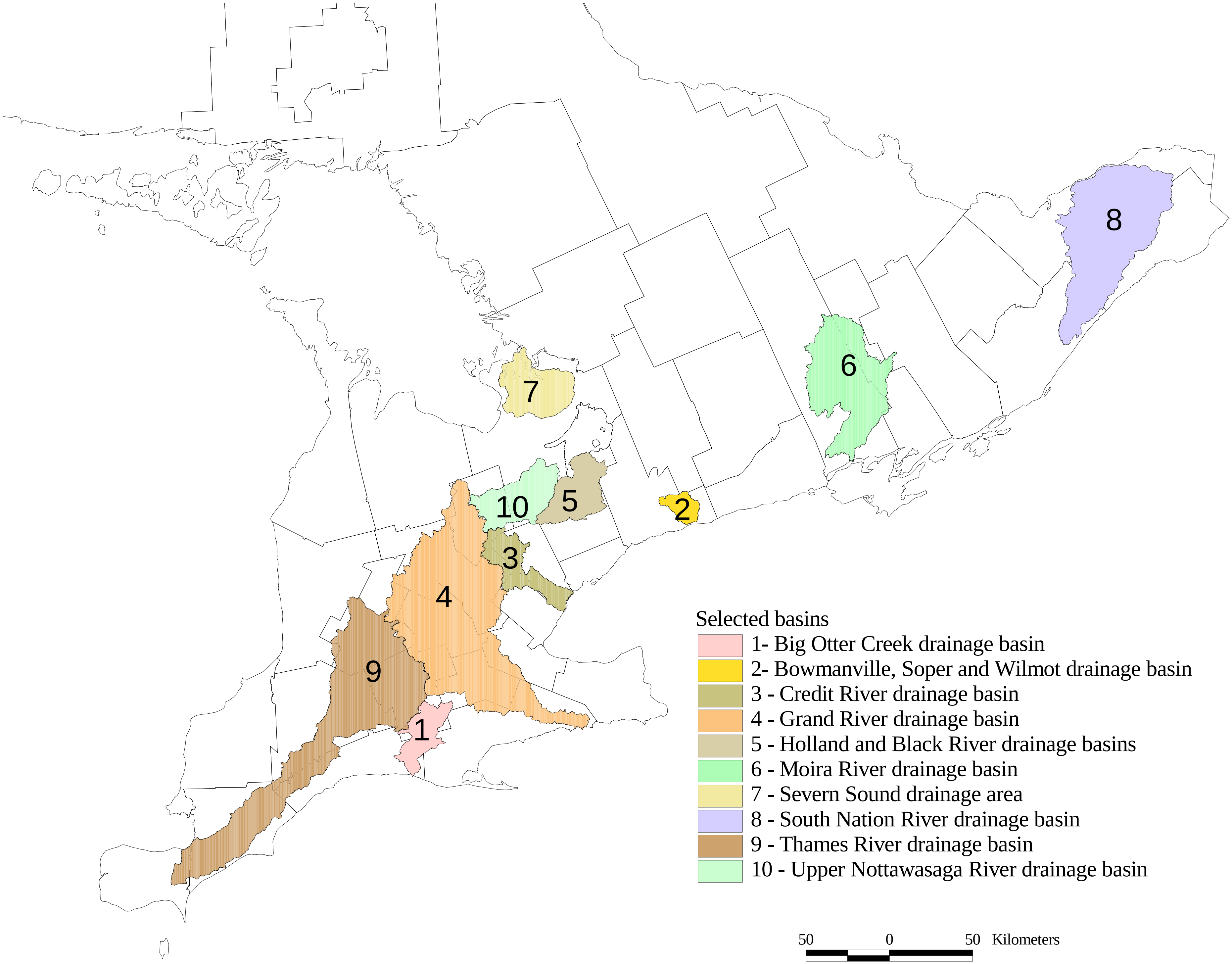

Figure ln-1. Selected basins for groundwater monitoring in southern Ontario.

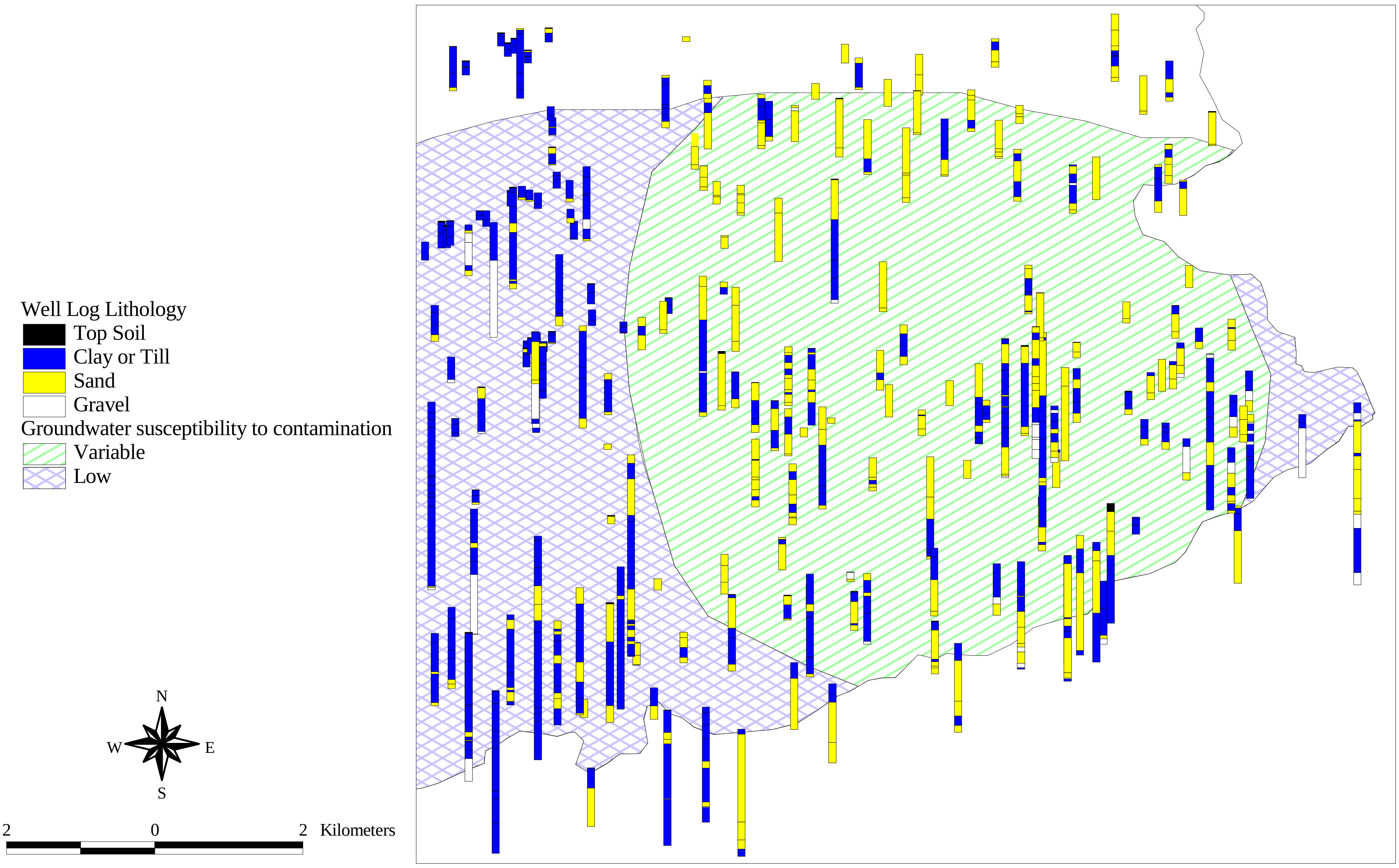

Figure In -2. A panel diagram showing the overburden subsurface geology in the southeastern part of the Holland and Black River drainage basins.