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THE GEOSCIENTIFIC INFORMATION SYSTEM FOR THE NORTH MONTREAL REGION

M. KUGLER-GAGNON

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THE GEOSCIENTIFIC INFORMATION SYSTEM FOR THE NORTH MONTREAL REGION

Abstract

The geoscientific information system for the North Montreal Region was created to provide basic data for the design of a regional land-use plan. It consists of a data bank of geological, geotechnical, and geomorphological information; testing programs; mapping programs (SYMAP V); and combination programs. The system produces variable maps (raw data maps) or integrated maps. Integrated maps are produced by simple addition of several weighted variable maps or by the combination of variable maps with an intervariable weighting method.

Résumé

Le systeme d'information géoscientifique de la région nord de Montréal a été conçu pour fournir l'information de base pour l'élaboration du plan régional d'affectation des sols.

Il est constitue d'une banque de données géologiques, géotechniques et geomorphologiques, de programmes de tri, de cartographie (Symap V) et de combinaison. Le système produit des cartes de données brutes ou des cartes interprétées. Les cartes interprétées sont le résultat, soit de l'addition de cartes de variables pondérées, soit d'une méthode de combinaison qui fait intervenir une pondération entre les variables.

INTRODUCTION

Environmental impact surveys have become more common in North America (Barteli **et al.**, 1966; Bélanger, 1972; Dumper, 1972; Kiefer, 1967; Pepper, 1972; Turner and Coffman, 1973). The basic purpose of these multidisciplinary surveys is to provide data which will allow the construction of facilities without repeating the environmentally costly mistakes of the past. Because of the initially high cost of such multidisciplinary surveys, however, a simple compilation based upon data available from separate surveys of various aspects of the area is often utilized. Generally the data used in these compilations are out of date and so restricted in scope that their value in planning is limited.

To develop solutions to the problems of multisource, fragmented base data and complex data integration, the Geological Survey of Canada, Quebec Department of Mines, and Department of Regional Economic Expansion sponsored a geoscientific study of the area around the Montreal International Airport at Mirabel (North Montreal Region) (St-Onge and Scott, 1972). The region studied is 1290 km^2 (498 square miles) in area (Fig. 1). It is bounded in the north by the Precambrian Shield, in the west by Rivière du Nord, in the south by Lac des Deux Montagnes and Rivière des Mille Iles, and in the east by the county boundary.

The purpose of this study was to develop and demonstrate methods for gathering and integrating data on geological, geomorphological, and geotechnical problems. To maximize the use of all information gathered during the survey, a computer information system was developed which allowed the combination of various types of raw data for integration with respect to specific land uses. Other integrated environmental studies hopefully will follow the same pattern. Many of the ideas and techniques presented here are not individually new, but their integration and application to a problem of this nature represent a new approach.

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The ultimate objective of the geoscientific study was to provide data for the design of the regional land-use plan (Charles, 1972). The system was developed over two years (May 1971 to May 1973). The field data were gathered during the summers of 1971 and 1972. Most laboratory work was done in the field on a continuous basis during the time of the study (Morin, 1973). This paper presents the data processing and data presentation aspects of the study.

The paper summarizes parts of a Ph.D. thesis (Kugler-Gagnon, 1974) presented at the School of Graduate Studies (Geography), University of Ottawa, Ottawa, Ontario. Field work and thesis preparation were supported by the National Research Council of Canada (postgraduate bursary 1972-1973), Geological Survey of Canada, and Quebec Department of Mines.

Acknowledgments

The author is grateful to D.A. St-Onge, thesis supervisor, for his great help and useful comments. J.S. Scott of the Geological Survey of Canada, J.Y. Chagnon and R. Maranda of the Quebec Department of Mines were of assistance through their interesting discussions and the opportunity they provided for summer field work. Team work was essential to the project, and the author would like to thank everyone who was involved in the project, particularly F. Morin who supervised the laboratory analysis with meticulous care and competence. The author also would like to thank J.E. Harrison for his critical review of the paper.

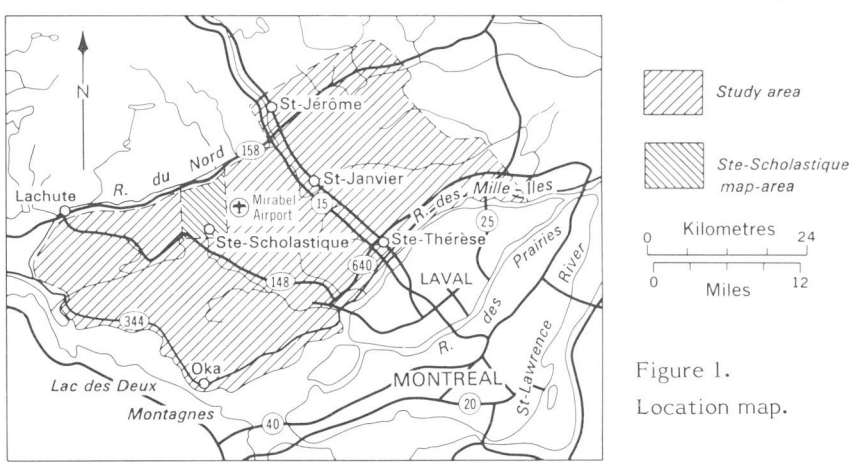


Figure 1.
Location map.

Table 1

Examples of criteria evaluation from the data collected

CRITERIA	FACTOR	DATA USED
Material stability	slopes	slopes
	nature of the material	grain size (Atterberg limits)
	relative position of different materials	stratigraphy
	drainage	minimal depth to water table (piezometric level)
Deformation	settlement	stratigraphy water content bulk density unit weight of solid constituents grain size Atterberg limits
	swelling	grain size Atterberg limits porosity water content
Excavation work	material	grain size thickness of the deposit

Table 2

Variable maps used for suitability mapping

SUITABILITY	SLOPES				SOILS*			THICKNESS OF SURFICIAL DEPOSITS (ft.)					DRAINAGE (Minimum depth to water table in ft.)			THICKNESS OF SAND (ft.)			THICKNESS OF CLAY (ft.)				CLAY CONTENT (%)		
	0.3%	3-8%	8-15%	15%	A	B	C	0-3.5	3.5-7	7-10.5	10.5-14	14	0-3	3-7.5	7.5	0-3	3-6	6	< 12	12-21	21-30	30	< 10	10-40	40
Low Density Residential Housing	X	X	1/ O	,	X	2/ O	,	,	4/ O	X	X	X	,	3/ O	X										
Light Industrial Park	X	O	1/ ,	,	X	4/ O	,	,	2/ O	X	X	O	O	5/ O	X				X	O	3/ ,	,			
Septic Tanks	X	X	4/ X	,				,	5/ O	X	X	X	,	2/ O	X	,	1/ O	X					X	3/ O	,
Sanitary Landfills	,	X	4/ X	,				,	3/ O	O	X	X	,	2/ O	X								,	1/ X	X
Landslide Susceptibility	,	,	2/ ,	X									X	3/ O	,				,	O	4/ O	X	,	1/ ,	X

1/ Intervariable weighting
X Variable weighting: Suitable (9)
O : Moderately suitable (5)
, : Unsuitable (1)

*Soils A: less than 50% fine particles
Soils B: more than 50% fine particles, liquid limit less than 50%
Soils C: more than 50% fine particles, liquid limit more than 50%

THE GEOSCIENTIFIC STUDY

The concept and methods of the geoscientific study have been described previously by St-Onge and Scott (1972). Figure 2 illustrates the different steps in the study.

Laboratory analysis of surficial materials (Fig. 3) was conducted on 800 samples obtained from 734 auger holes (Fig. 4). During the deep drilling program 211 boreholes (Fig. 5) were drilled which provided another 800 samples as well as additional information on the bedrock in the area. Laboratory analysis provided the following information: grain size, pH, Atterberg limits, water content, bulk density, and unit weight of solids. Additional information on the lithology and stratigraphy of the subsurface was gathered from the drilling logs of the Department of Transport (C.A.I.M., Construction de l'aéroport international de Montréal); E.Z.A.I.M. (Ecologie de la zone de l'aéroport international de Montréal) provided noise value and slope information (Dansereau, 1971); the Quebec Department of Mines provided hydrogeological data; and the B.A.N.A.I.M. (Bureau d'aménagement de l'aéroport international de Montréal) provided the noise values (B.A.N.A.I.M., 1972).

DATA PROCESSING

The internal structure of the data bank is simple and allows the addition of various types of information such as physical environmental – microclimate, frost penetration; biological – vegetation, sensitive zones; or historical and sociological – existing land-use regulations, historical sites, building, and political constraints. All geoscientific data gathered during various phases of the project were stored on magnetic tape (Fig. 6) under a fixed format. The format, however, changes from one type of information to another. The use of variable format would have maximized the use of tape space but would have required a far more sophisticated level of programming. The final file is about 40 000 lines long. The data bank contains information associated with points (auger holes and boreholes) or with areal surfaces (data already mapped: distribution of till, gravel, slopes, noise zones).

Initially the data were processed in two different ways to produce either tables giving the physical properties of soils in a given area of basic data maps (raw data maps) (Fig. 7).

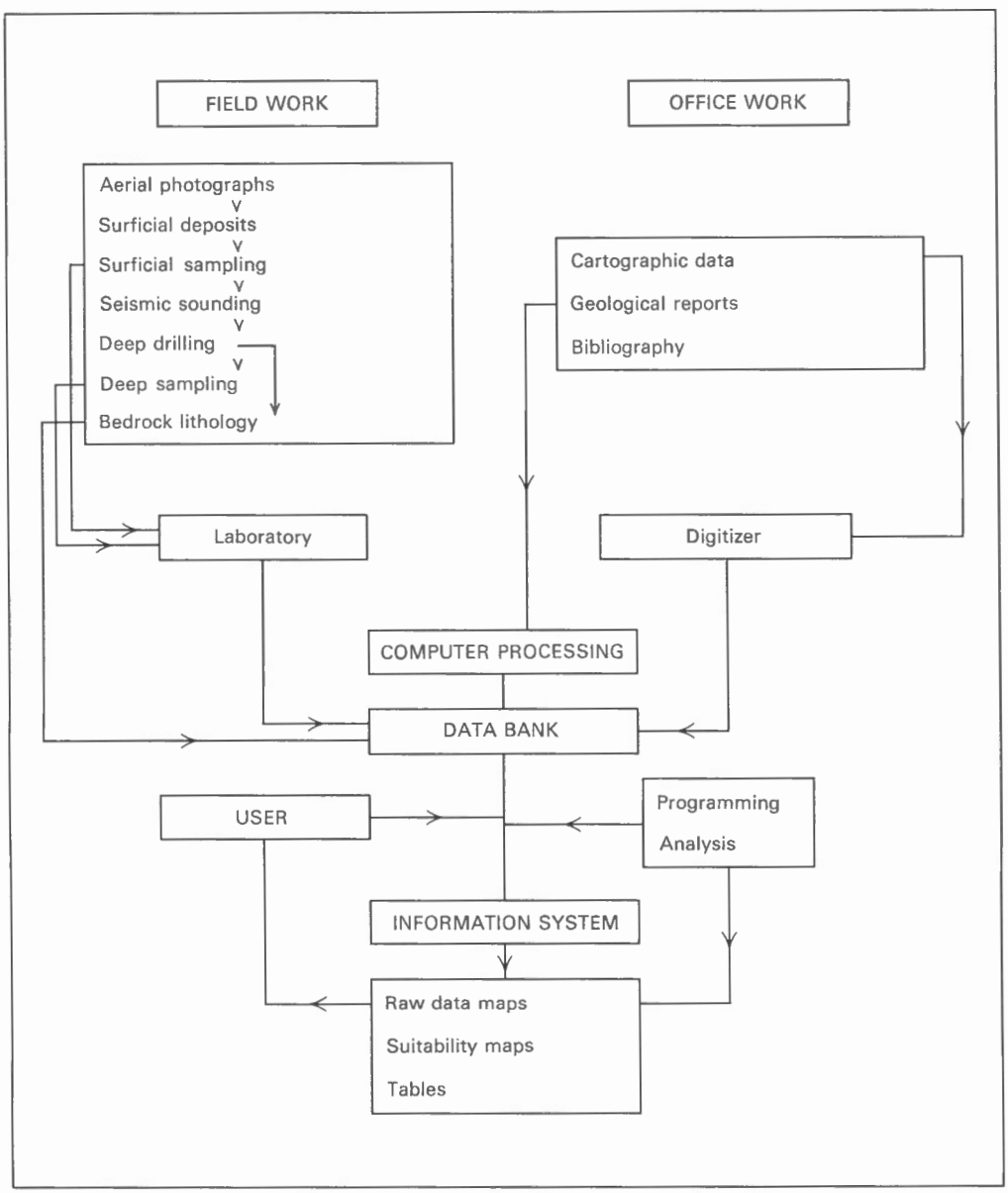


Figure 2. Flow chart for the geoscientific study of the North Montreal Region.

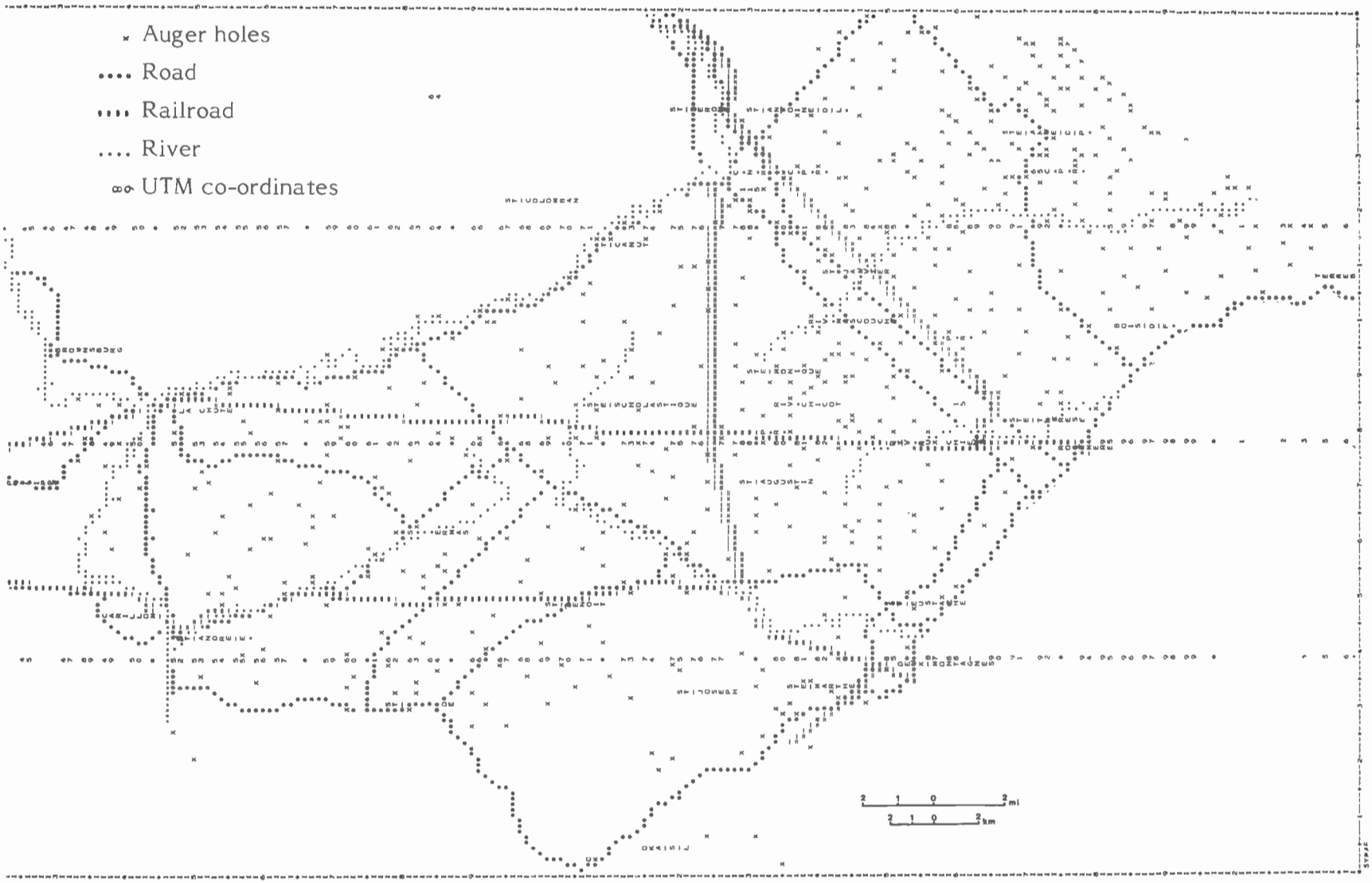


Figure 4. Computer drawn map showing density of auger holes.

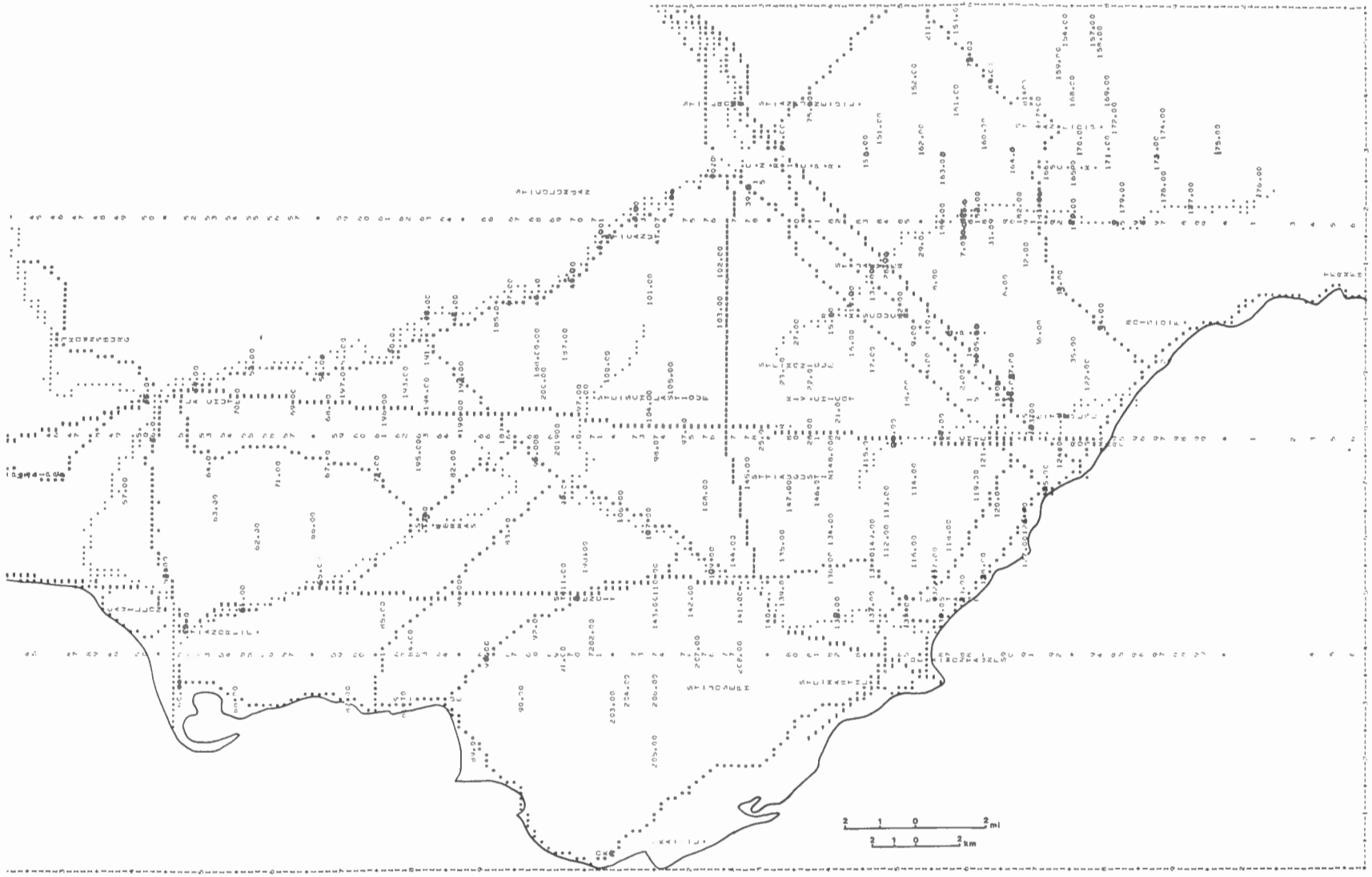
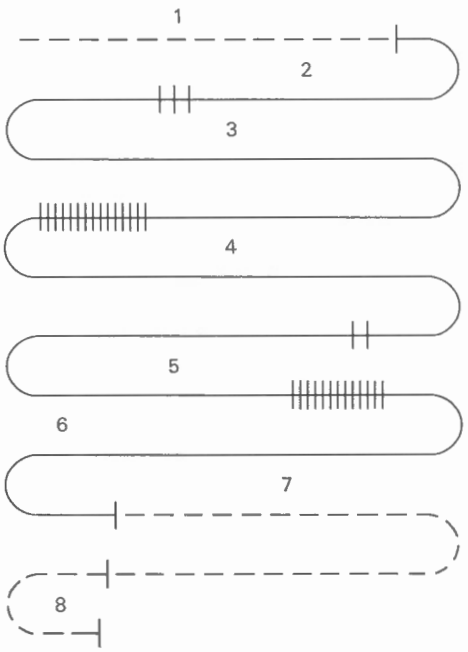


Figure 5. Computer drawn map showing location of boreholes. See Figure 4 for complete legend.

Maps derived from point information required interpolation from measured values (control points) (Figs. 8 and 9). Most users found maps more feasible than tabular listings; therefore, a series of raw data maps were produced. These allowed the user to obtain an overview of the data as well as simultaneously to consider the application of several types of data in a planning decision. Tables are used, when required, to provide detailed information at specific locations.

The raw data maps (variable maps), developed as part of the geoscience base for planning purposes for the area around Mirabel airport, include: slope, lithology, anticipated background noise level, distribution of till, gravel, and outcrops, and a map for each property determined in the laboratory (grain size; sand, silt, clay ratio; Atterberg limits; plasticity; bulk density; water content; unit weight of solid constituents; porosity). These variable maps can be drawn for any depth below the surface at which the user requires information.

The maps were produced using the SYMAP V program (Douglas and Fleming, 1969). The SYMAP V mapping program, however, is not exactly suited to deal with earth science data. Interpolation formulas of the program do not take into account the trend and discontinuity of the variables. The SYMAP V interpolation algorithm is based upon a linear interpolation with a weighting factor related to distance from a control point and to a shadow effect behind a control point. Careful field work and a large number of control points make this mapping program an extremely useful tool yielding reliable results. The maps produced cannot be used for a specific site study but are useful as a planning tool in providing information of regional nature.



Index line of no. 9 . . . . . |
Graphic data subfile . . . . . — — —
Data subfile . . . . . ———
Boundaries of study area and map-sheets 1
Surficial drilling data 2
Deep drilling data 3
Seismic data 4
Hydrogeology 5
C.A.I.M. data (Construction l'Aéroport International de Montréal) 6
Cartographic data 7
Slopes 8

Figure 6. Geoscientific information system: data bank structure.

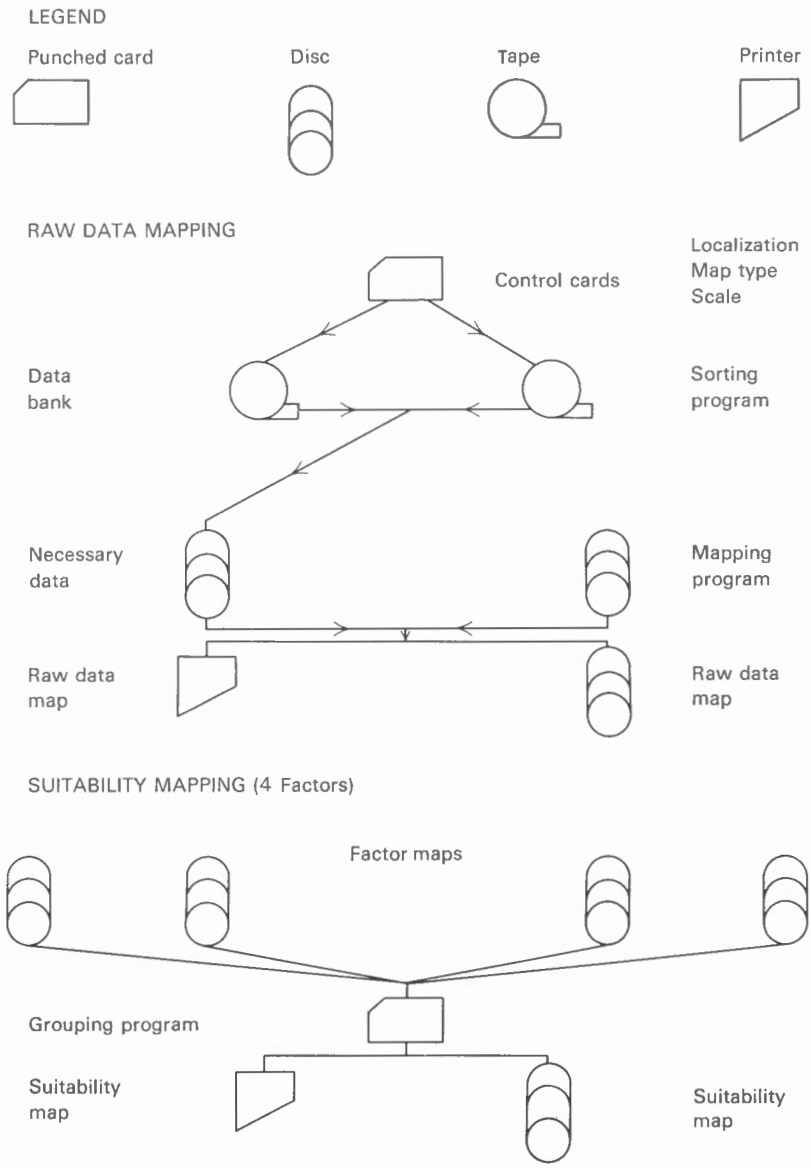


Figure 7. Geoscientific information system: flow chart.

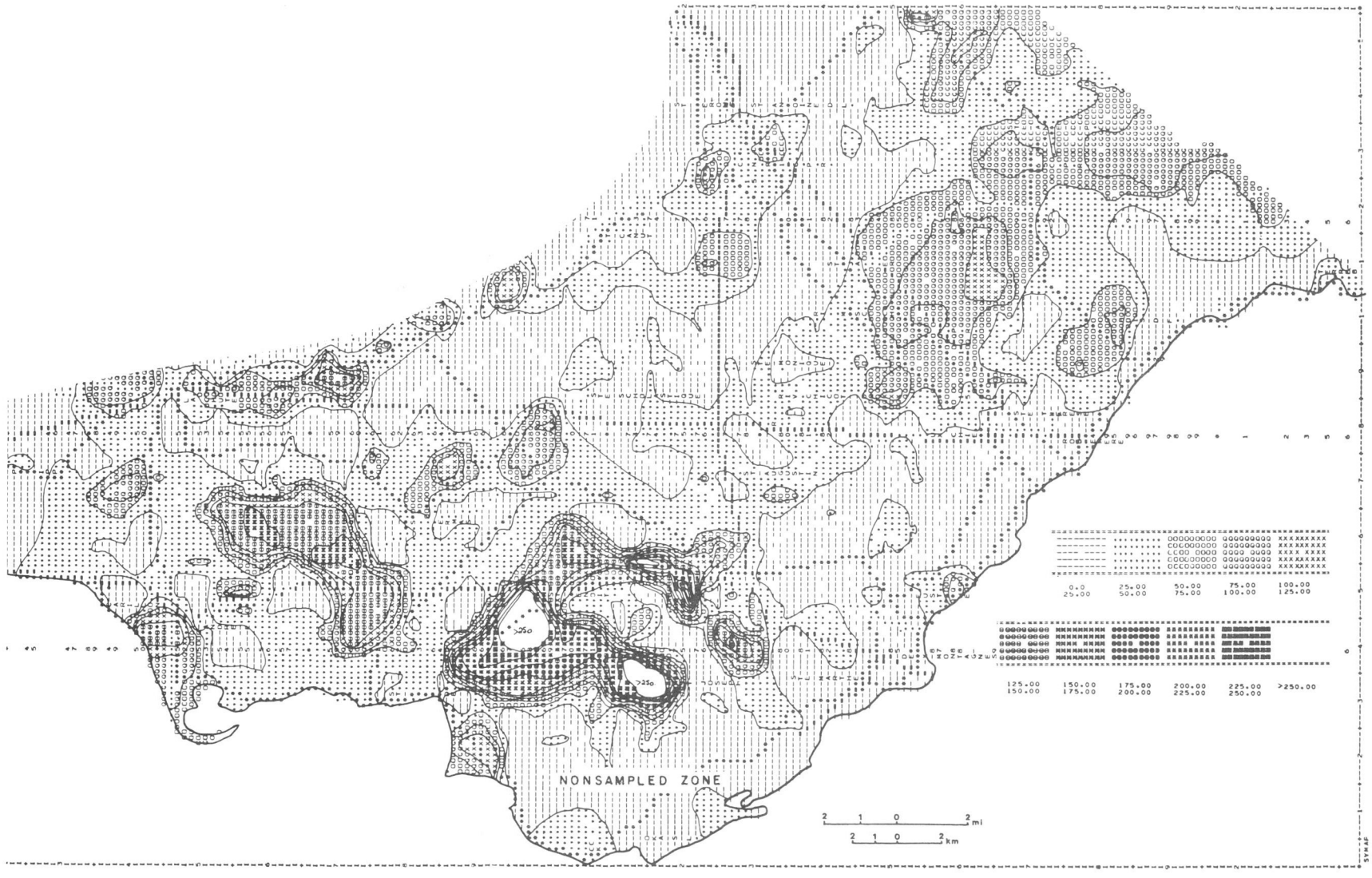


Figure 8. Thickness overburden. See Figure 4 for complete legend. Categories for thickness of overburden (in feet) are given in the figure.

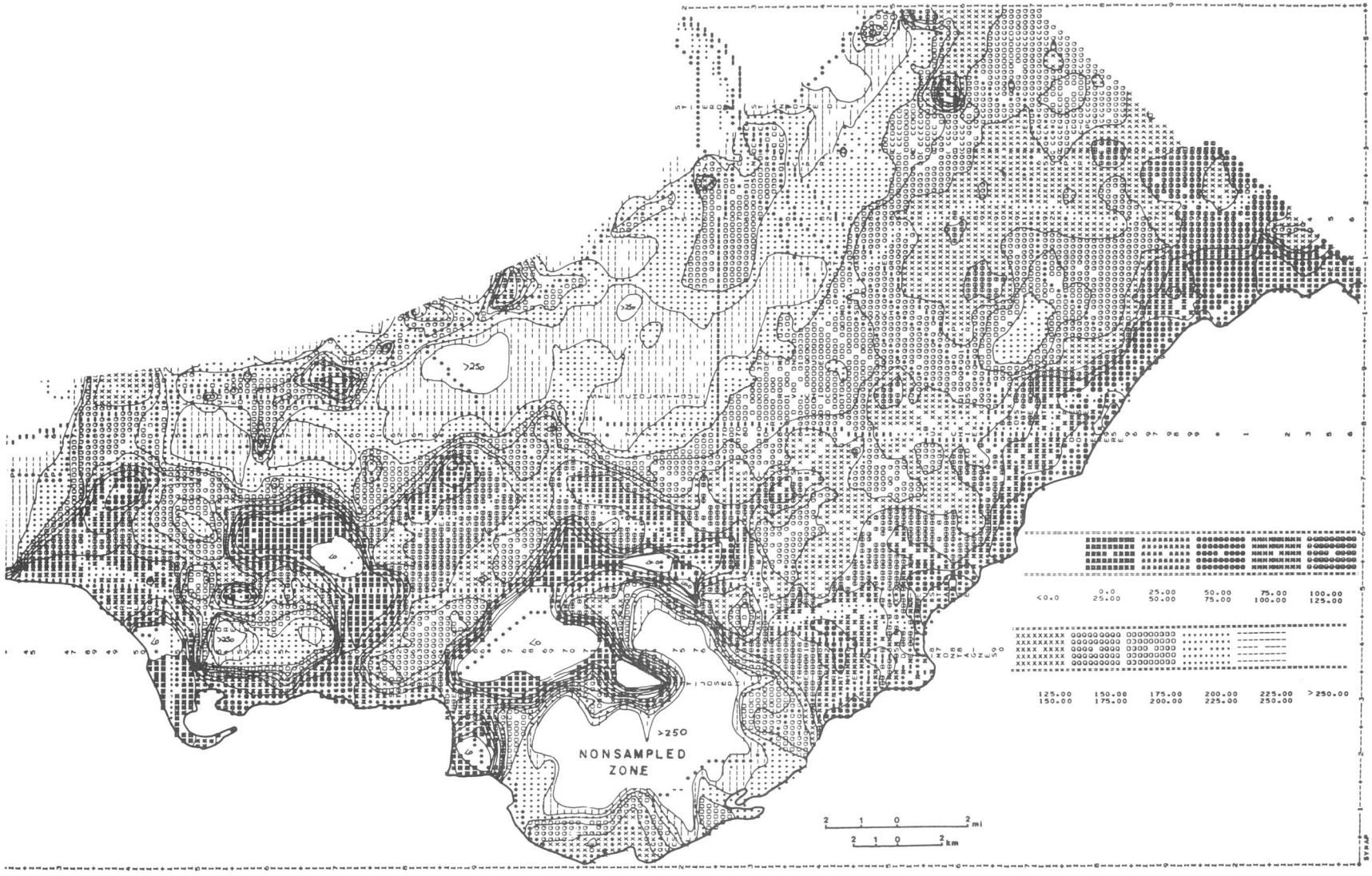


Figure 9. Topography of the bedrock. See Figure 4 for complete legend. Categories for topography of bedrock (in feet a.s.l.) are given in the figure.

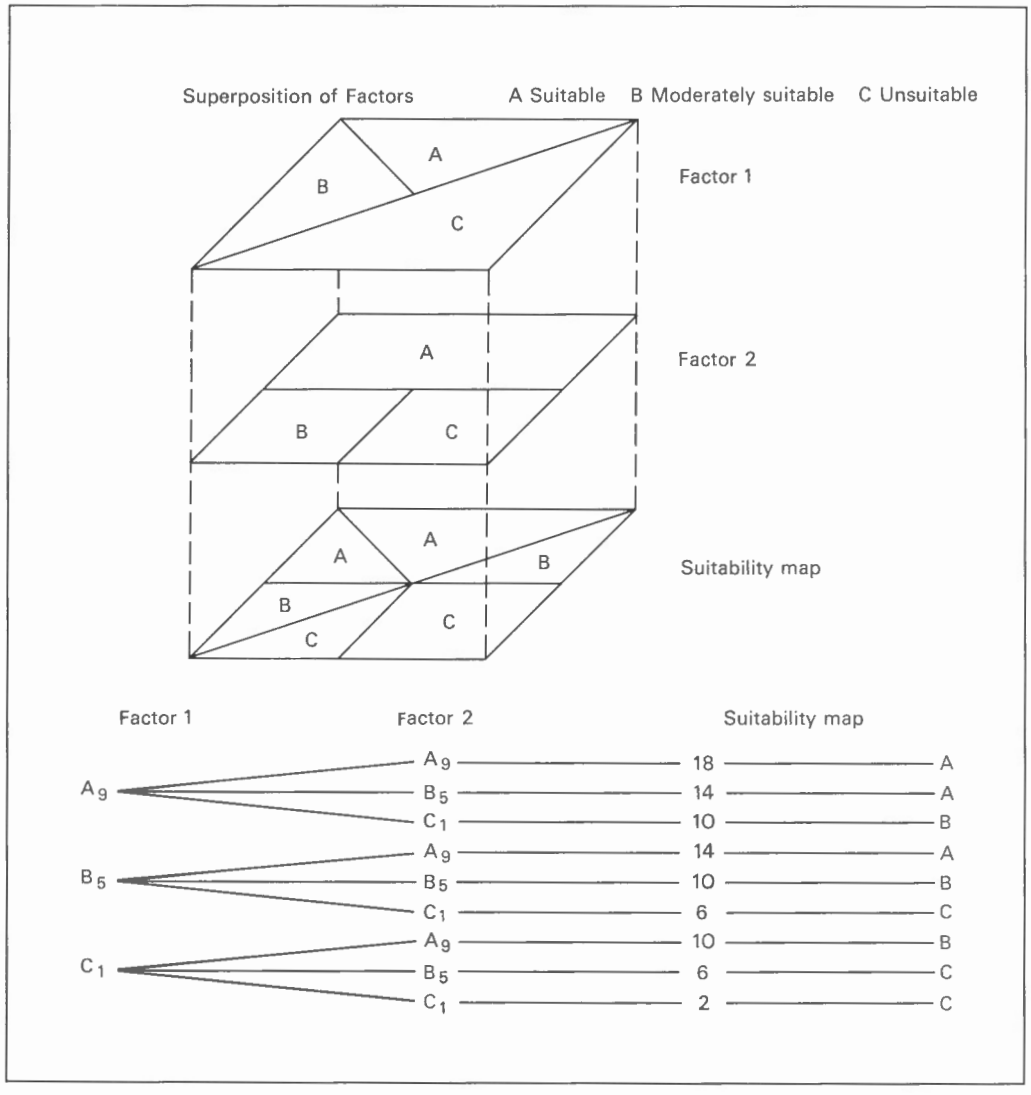


Figure 10. Suitability map construction: superposition of factors.

INTEGRATED MAPS

Before and during field work it was not possible to identify all the eventual users or the nature of their requirements. Thus data collection and laboratory procedures were designed to study the basic physical properties of soils so as to cover as broad a spectrum of variables as possible. It soon became obvious that raw data maps did not fully meet the requirements of some users. Integrated maps or master maps (Dubois, 1974) would have to be produced to ensure that physical parameters would be considered in the planning process. Table 1 gives an example of three planning criteria, the factors affecting these criteria, and the field and laboratory data used to evaluate these factors.

To illustrate the possibilities of the integrated mapping computer program, suitability maps were produced for four land-use types (low density residential, light industry, septic tanks, landfills) and for landslide susceptibility. In order to combine various data maps the different variables must be weighted according to their specific land use suitability. Weighting is based on suitable (A9, Figs. 10 and 11), moderately suitable (B5), and unsuitable (C1) categories. Combinations of variable maps were made from two different routines. The first method (superposition method) involves a simple addition of the weight of every variable for each point on the map (Fig. 10). The second one, the taxonomic method, adds an interfactorial weighting process (Fig. 11). Using this method, the order in which the variables enter the combination plays the role of an intervariable weighting. If an area is unsuitable for the second variable, for example, the computer program will not take into account the values of the succeeding variables for that area. Thus, to produce a map of residential suitability for an area (e.g. Ste-Scholastique map-area) the following factors are combined: slope data, surficial deposits, thickness of the surficial deposits, depth to water table, and the distribution of till, gravel, and outcrops.

The map obtained by the superposition method (Fig. 12) and the one using the taxonomic method (Fig. 13) are different. By the second method, slope and drainage were considered to be the most important variables (Table 2); a large area was found to be unsuitable for residential housing using the taxonomic method (Fig. 13). Figure 14 was produced by the same combination process (taxonomic method), but the water table depth data were omitted in order to simulate the same area with no drainage constraint. Thus if the drainage of the area is improved, only the steepest slopes appear as unsuitable sites. Comparison of the two maps (Figs. 13 and 14) clearly indicates that poor drainage was a very important factor. Producing various maps by superposition and taxonomic methods, and in the

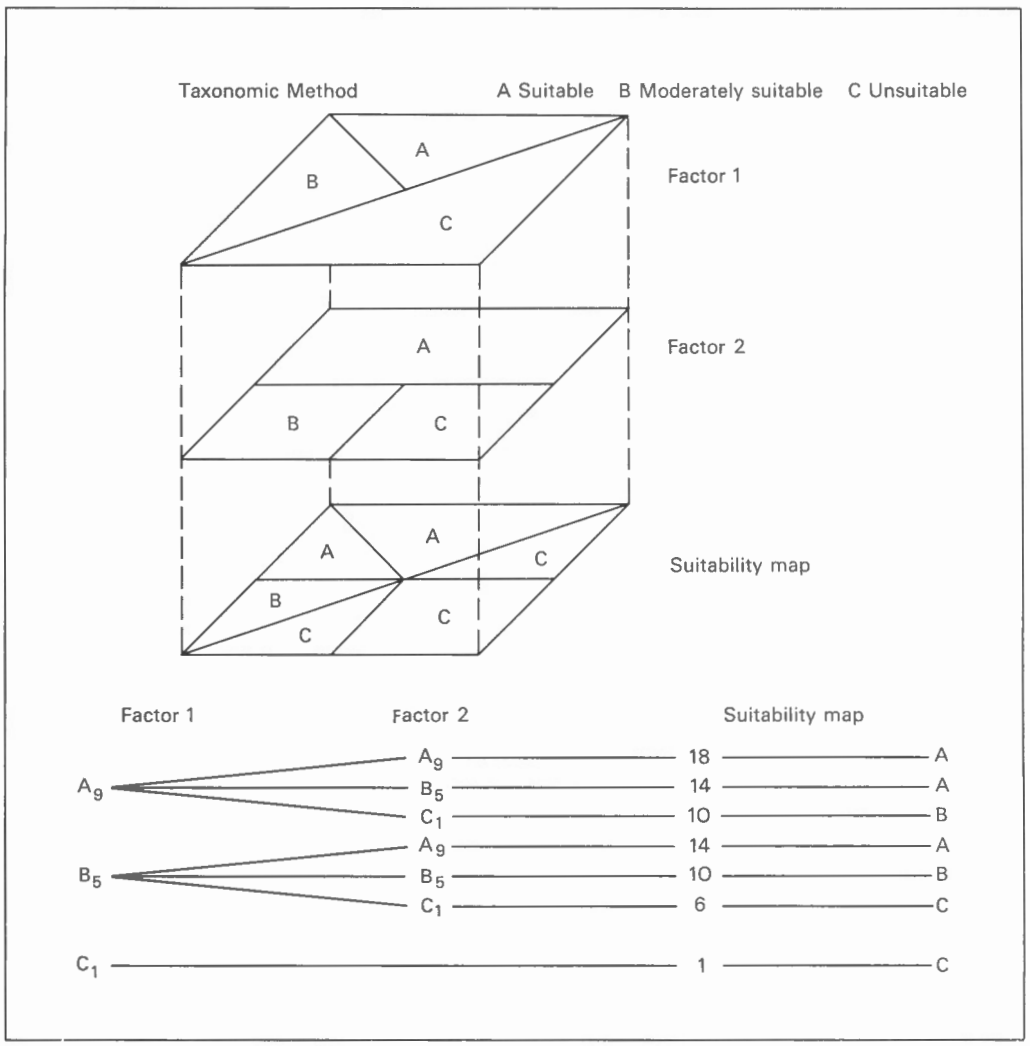


Figure 11. Suitability map construction: taxonomic method.

latter case with or without water table data, not only demonstrates the flexibility of the system but also could indicate to a planner the importance of one particular constraint (e.g. high water table). Planners then could incorporate costs of remedial measures in their proposals. By including the variable of anticipated noise level generated by the airport activities, Figure 15 shows the residential suitability outside the noise zones. As the area is not in the vicinity of runways, the noise zone here is located along one of the airport access roads.

CONCLUSIONS

This example of integrated mapping shows some of the advantages and disadvantages of the geoscientific information system for the North Montreal Region.

The main advantages are the ease with which it is assembled and the fact that information can be made available to planners at any time during its various stages of preparation. The system described here represents solution to the problem of information dissemination encountered by planners, especially in the urban fringe where analytical information must be delivered quickly and where good raw data exist but usually are scattered in the files of various agencies or consulting firms. Other information systems only make interpreted syntheses available whereas this system allows easy access to the information base. The information can be updated, and maps can be produced at any scale. As this is a 'custom' mapping system, the user of the system chooses, with the operator, the type of data and the type of combinations that are required. Also the operating cost is low compared to the cost of a traditional study.

The main disadvantage of the system is the SYMAP V computer program, which is not completely satisfactory for mapping geoscientific data. In future projects it is recommended that a more specialized program be used (Delfiner and Delhomme, 1973; Chiles and Chauvet, 1973; Laffitte, 1972). The type of basic information to be combined as variables to produce integrated maps should result from an interdisciplinary study and not from the available data as was done here. Weighting of variables in the integrated mapping process must be improved in order to take into account the positive and negative influences of one variable on another. Improvements are under way to make the programming system more generally applicable regardless of the local stratigraphy and to change the mapping program and the programs for weighting and choosing the variables. It would also be desirable to have an interactive remote terminal which would allow a dialogue between the user and the system.

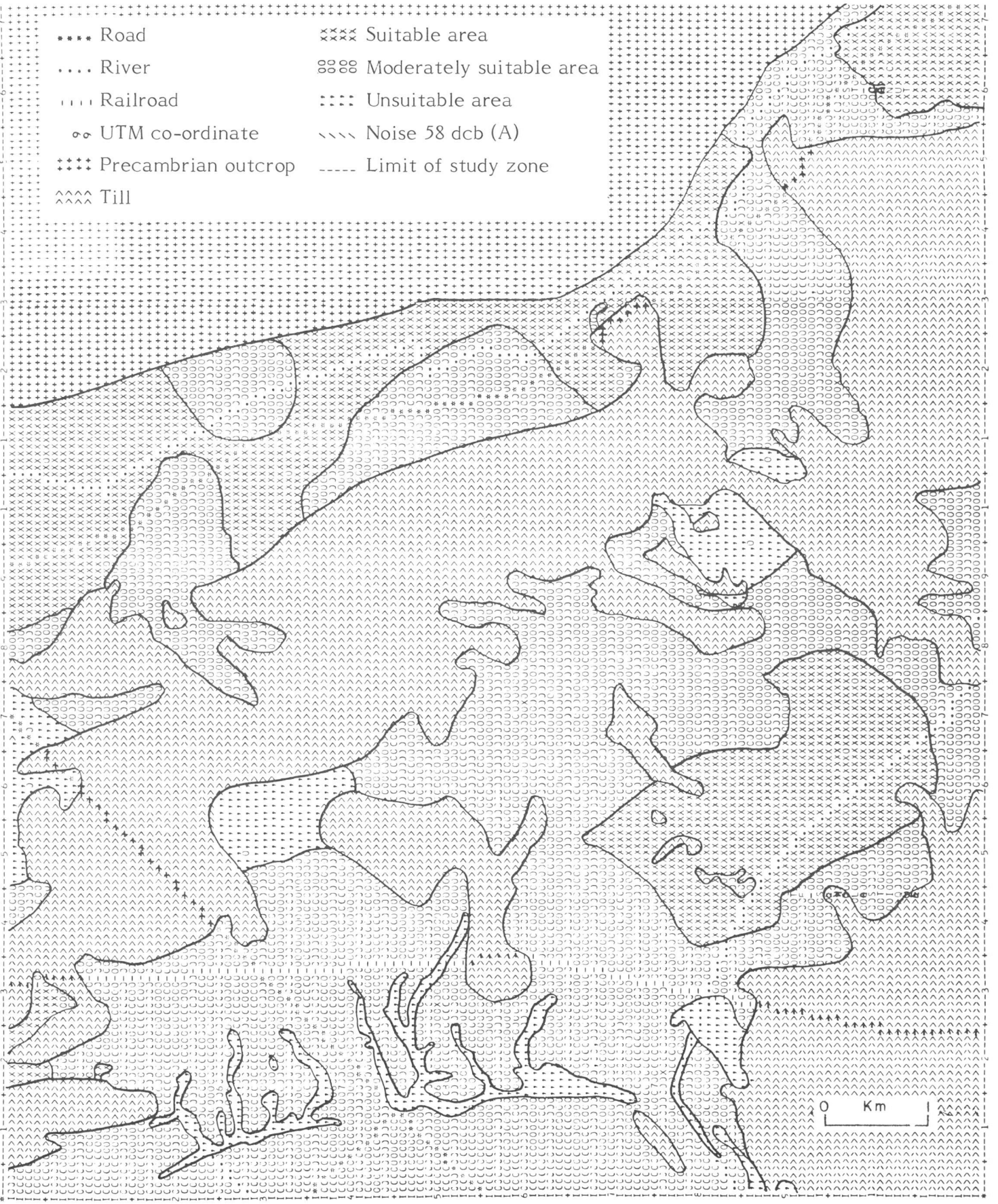


Figure 12. Suitability for residential housing, superposition of factors method, St-Scholastique map-area.

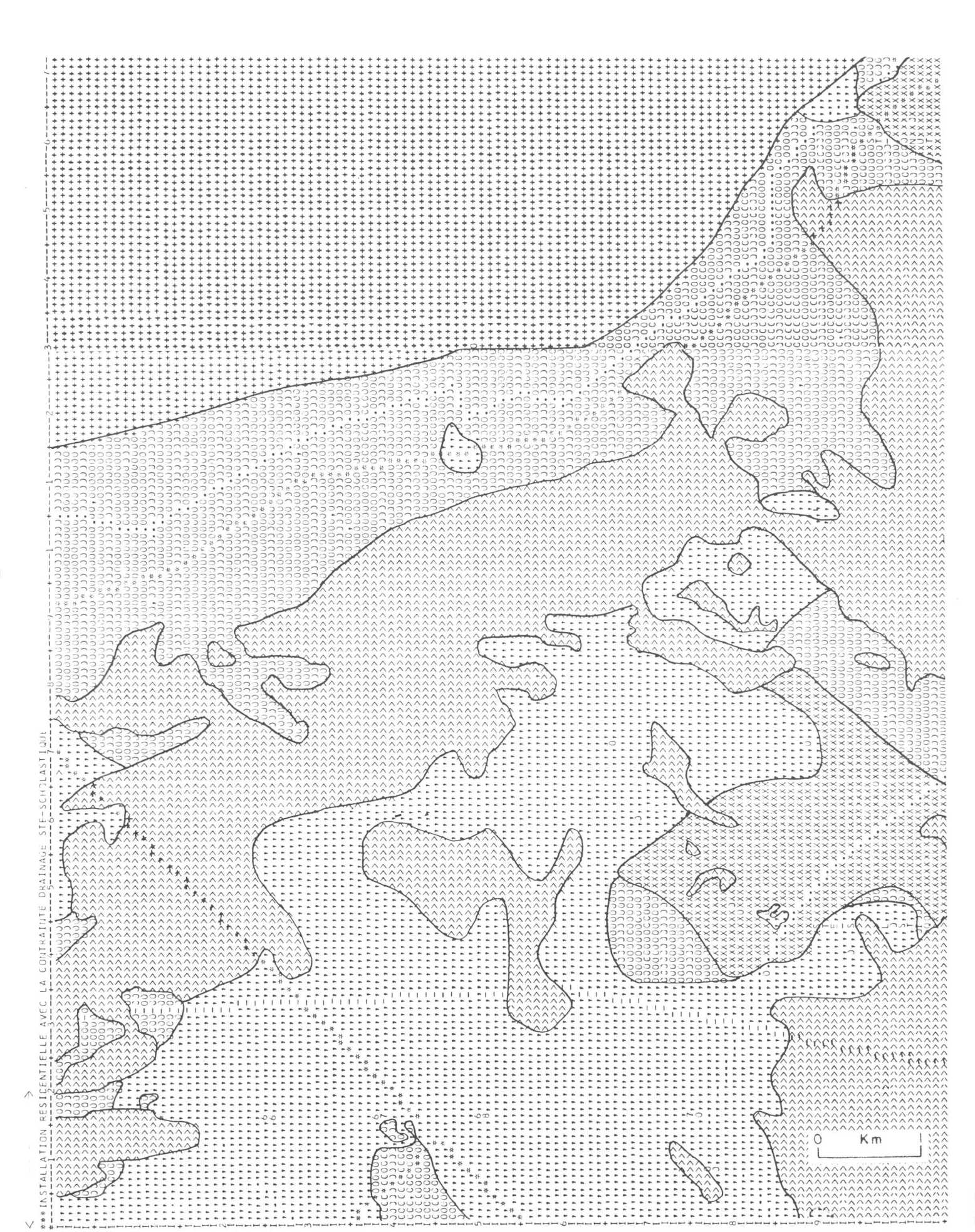


Figure 13. Suitability for residential housing, taxonomic method, Ste-Scholastique map-area. See Figure 12 for complete legend.

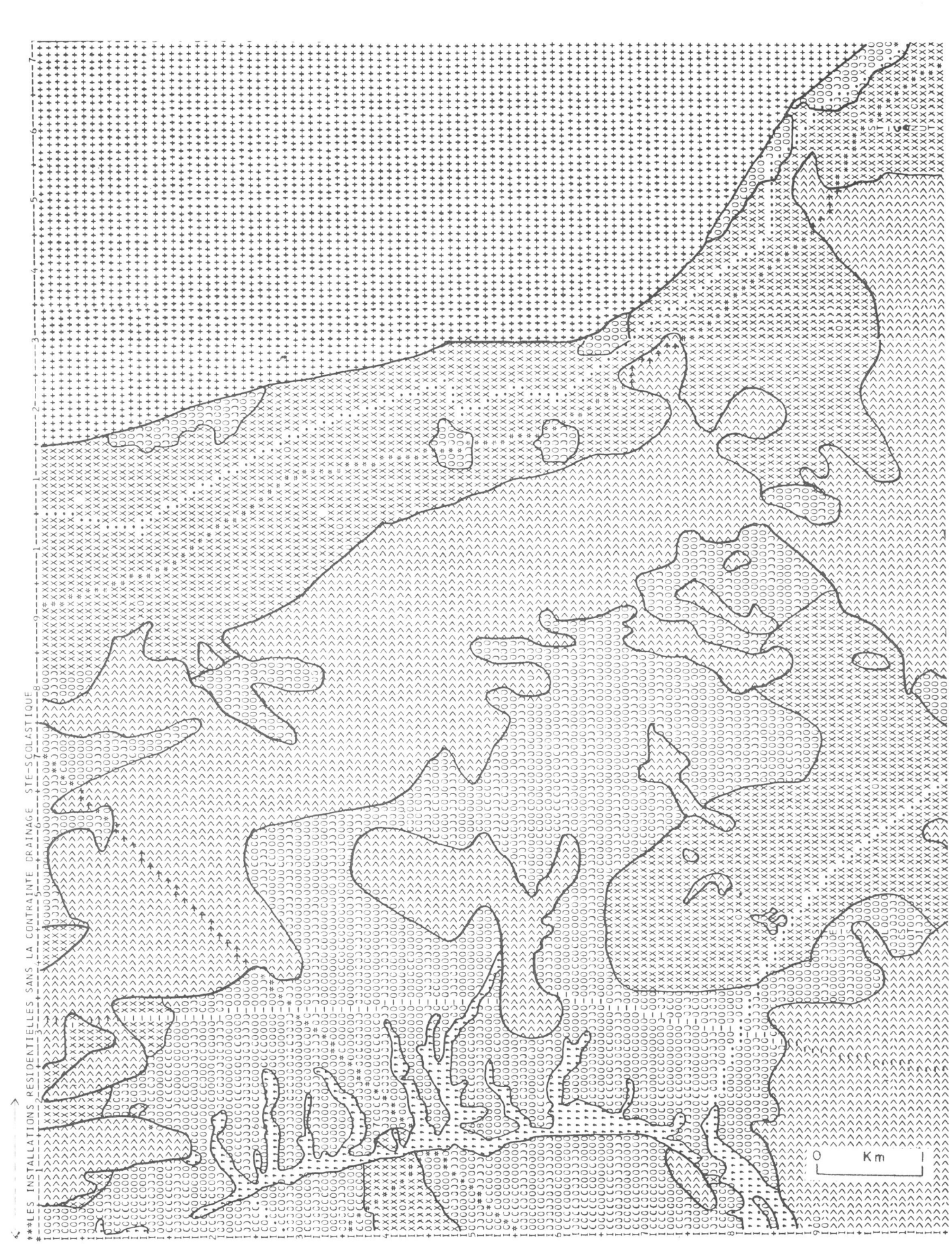


Figure 14. Suitability for residential housing, taxonomic method, with improved drainage, Ste-Scholastique map- area. See Figure 12 for complete legend.

Figure 15. Suitability for residential housing, superposition of factors method, including noise factor, Ste- Scholastique map-area. See Figure 12 for complete legend.

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