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SELECTION PROCEDURE OF GEOGRAPHIC INFORMATION SYSTEM SOFTWARE FOR SOTER

V.W.P. van Engelen

August, 1989

ISRIC

INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

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1 INTRODUCTION

The International Society of Soil Science (ISSS) has initiated the development of a proposal designated to utilize data analysis/management systems to produce a world soils and terrain digital database (map and attribute data). The database will have the following characteristics:

1) average scale 1:1 million

2) compatible with databases of other environmental resources

3) amenable to updating and purging of obsolete and/or irrelevant data

4) accessible to a broad array of international, regional and national decision-makers responsible for the development, management and conservation of environmental resources

5) transferable to developing countries for national database development in greater detail.

Within the framework of the project 'Global Assessment of Soil Degradation (GLASOD)' with funding by the United Nations Environment Programme (UNEP), ISRIC has started the development of a database structure for the attribute data as well as the assessment of GIS software for utilization on data collected in the first pilot area, about 250,000 km^2 in S-America (portions of Argentina, Brazil and Uruguay). This paper will focus on the procedures which were followed to come to a choice of GIS software.

Although the general aim of SOTER has been defined (see above), the functional requirements of the GIS to support SOTER are not. These include specifications of the products to be delivered by the system. General ideas about these products exist but a precise definition cannot be given as the client group to be served by SOTER has not yet been defined other than in general terms.

2 GIS COMMITTEE FOR SOTER

2.1 Mandate

As a consequence of item 7.1.10 of the SOTER Project Proposal[1]: 'In order to make rational decisions about the most feasible and cost effective systems to serve the needs of SOTER, it is recommended that a careful assessment by independent specialists be made of the capabilities and the costs of available GIS hardware/software; taking into account the minimum set of required database capabilities" a small group of international specialists attended an ad-hoc meeting organized by the SOTER management in Wageningen on 25 August 1988 at ISRIC to discuss the 'Assessment of current geographic information systems'.

The meeting discussed the following items:

- Requirements from a GIS:

  1) Standards for frequencies of data input
  2) Standards for data transfer
  3) Analytical requirements (for interpretation purposes)
     several pedotransfer functions
     several overlayering (climate, population pressure)

- Agreement was reached on the minimum set of requirements to which a GIS must adhere:

  1) quick overlayering
  2) integration of raster-, vector- and table data files
  3) all operators conditional, relational and arithmetic
  4) easy communication with outside models, databases and files
  5) remote sensing processing included
  6) service/maintenance assured
  7) relatively inexpensive (US$ 15,000 or less).

2.2 Reporting

At the meeting it was decided that an ad-hoc committee[2] be formed and that a comprehensive list of required capabilities and needs for a GIS for SOTER would be prepared by the chairman of the committee. A draft report was prepared in October 1988 and circulated amongst the committee members for comments. The final report appeared in March 1989 (see appendix 1).

Without repeating the entire report the following condensed paragraph will give a summary of its findings. Some of the problems the committee met

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[1] Project proposal, World Soils & Terrain Digital Data Base at a scale 1:1 M ("SOTER"), ISRIC, Wageningen, 1986.

[2] Chair: Bruce MacDonald; Members: Marion Baumgardner, Arnold Bregt (from 4/1989), Peter Burrough, Jürgen Lamp, Eric Smaling (until 4/1989) and Vincent van Engelen.

where related to the lack of a clear requirement definition for GIS to support the SOTER project. Therefore, the committee prepared recommendations based on their knowledge of the project and on the field of GIS. The main recommendations are summarized as follows:

1) the GIS software should be a mature product from a vendor who can provide support and maintenance
2) its is absolutely necessary, especially in the rapidly changing world of microcomputer-based GIS software, to do a market survey to obtain a ranking of vendors who meet the mandatory requirements
3) GIS software which meet the mandatory requirements should be subjected to a benchmark test to verify the required functions, capacity and communication capability.

As a result of the GIS committee report a plan of action for the period April-September was established, with the intention to come to a final choice on software for SOTER in the second half of August.

3 MARKET SURVEY

3.1 Contents of the questionnaire

The list of mandatory and desired requirements as presented in the final report of the ad-hoc committee on GIS formed the basis for the compilation of a questionnaire for the market survey. Additional information to be included in the questionnaire was extracted from similar surveys that have been carried out by other organizations.

The questionnaire was compiled by the author, with assistance from some of the committee members. The complete contents of the document is shown in appendix 2. The desired information on GIS software contained in the market survey can be grouped as follows:

1) Hardware requirements of the software
   The system should run on a microcomputer (IBM compatible) using a DOS operating system with a full functionality with 640 Kb RAM

2) GIS functions
   - data storage format
   - input (direct, and including communication with other GIS's e.g. UNEP/GRID)
   - digitizing/topology creation (joining/edgematching, raster/vector conversion and vice versa)
   - analysis (e.g. overlaying, proximity search, interpolation methods, links with external databases for attribute queries, and models)
   - output (including communication with other GIS's, e.g. UNEP/GRID)
   - "user-friendliness" (menu driven, batch procedures)

3) Corporate structure
   - Maturity of product and company, market share of product, size of support staff etc.

Most of these capabilities can be classified as mandatory, while requirements as running under additional operating systems, and some of the corporate structure requirements are of a lesser level of necessity.

3.2 Selected software packages

Apart from the 7 companies already suggested in the GIS committee report (Appendix 2) the questionnaire was sent to an additional 2 other potential candidates. The complete list of vendors with their GIS packages is as follows:

Vendor	GIS package
CRIES Project	CRIES
Deltasystems/Ponder	DELTAMAP
ESRI/Logisterion	PC ARC/Info
Intergraph Corp.	Intergraph

Vendor	GIS package
ITC	ILWIS
ITD	GRASS
PAMAP Graphics	PAMAP
Terra-Mar	Terra-Pak
TYDAC Technologies	SPANS

3.3 Results of the questionnaire

The scores for the mandatory requirements the software fulfils can be subdivided into two groups:

- requirements that are straightforwardly met (e.g. hardware requirements)
- requirements that are met according to the vendor but about which some uncertainty remains (e.g. links to an external database)

The first group of requirements hardly needs any checking in the benchmark test while the second group should be tested specifically.

Without going into details of the result of the market survey[3)], it can be stated as a general conclusion that most differences occurred between vector and raster based systems. Analyzing capabilities for both groups were satisfactorily although speed of processing was not indicated but should be tested during the benchmark. Difficulties arose for some of the raster based systems in the field of joining and edgematching of two map sheets and in plotting at the required cartographic quality. Some of the systems, being smaller members of mini/mainframe based software packages, do not have the same functionality as their greater versions, while others require a larger RAM than is normally supplied with a microcomputer.

Links with external databases are another point of concern. Some packages have a quick direct link with a SQL database while others communicate slowly through ASCII files. Internal databases of some systems consist only of a single table so that a relational structure as used by SOTER for the attributes cannot be incorporated directly and relational queries cannot be executed. This might create problems as the relational type of database is the most appropriate one for SOTER.

The questionnaire results is not definitive on the amount of data that a system can store. SOTER is expecting rapidly expanding volumes of data in the future, but for the moment the maximum volume of data is directly related to one ONC sheet. There are doubts if all the data (geometric and attribute) of a whole continent can be handled on a microcomputer. However, some systems may have problems in handling the entire attribute data set of the first pilot area.

Irrespective of the two groups of formats clear differences exist between the corporate structure of the vendors, e.g. in the time they are active in the field of GIS (2-20 years), the number of employees (4-300) and in the number of licences (50-2000).

[3)] Results of the market survey are considered confidential and are not published.

4 BENCHMARK TEST

A draft benchmark test script was compiled by the author with assistance from some committee members in particular A. Bregt. It was circulated amongst all the members for comments and a final version was completed in June and sent to the potentially suitable software packages with the request to return the results before August 1st.

The test consisted of the following items:

- importation and handling of a large amount of digitized geo-referenced data. For this matter a digitized soil map of the Dutch Soil Survey Institute was made available.
- digitizing of topographical base and soil map of a part of the S-American SOTER pilot area
- analysis of these data
- exportation of the results
- output (plot/tabular reports)

Image processing capabilities were not tested as such as the committee thought that the possibility to import raster data could link a GIS to any image processing software. In most countries some form of image processing software is already available and this capability does not need to be an integral part of the GIS software.

The software packages which were selected for the benchmark test were: ARC/Info, DELTAMAP, ILWIS, PAMAP and Terra-Pak. In order to check on user-friendliness and realtime questions the tests were observed by representatives of SOTER: B. MacDonald at PAMAP, N. Fernandez at Terra-Mar and V. van Engelen at ARC/Info, DELTAMAP and ILWIS.

A full description of the benchmark is given in appendix 3. Results of the tests are considered confidential and will not be published.

APPENDIX 1

SELECTION OF A
GEOGRAPHIC INFORMATION SYSTEM (GIS)
FOR SOTER

Final

Report of Sub-Committee on GIS Selection

Sub-Committee members:

B. MacDonald, (chair) Canada
M. Baumgardner, USA
J. Lamp, W. Germany
P. Burrough, Netherlands
V. van Engelen, Netherlands
E. Smaling, Netherlands
A. Bregt, Netherlands

Report Submitted: March 1989

SUMMARY

The attached committee report outlines a suggested procedure for selecting a GIS for the SOTER project. It stresses the need for a mature product and a vendor who can provide support and maintenance.

The steps suggested are:
- identification of possible vendors (the list included is adequate but other committee members may wish to add suggestions)
- evaluate the potential vendors in a market survey against mandatory and highly desirable requirements
- carry out benchmark tests with the systems rating highest on the market survey (suggest up to 3 systems be tested)

The market survey is extremely important to the success of the project. A suggested set of criteria is contained in this report. The result will e a ranking of vendors who will meet the mandatory market survey requirements. In our opinion, the market survey doesn't require in depth knowledge of GIS but
does need more time than this committee can provide. We estimate that the survey will take about 3 weeks of actual time over approximately 2 months of elapsed time. Possible options are to have it done by:
(a) personnel at Wageningen (ISRIC)
(b) a cooperative project where ISRIC/SOTER provide funds for technical salary support and the committee members could contribute some professional time
(c) an educational institution for academic credits or modest support (e.g. Purdue or Utrecht University).

The benchmark test would verify that the required GIS functions, capacity and communication capability are present. The benchmark study should be conducted by a neutral third party such as an educational institution. The College of Geographic Sciences at Lawrencetown, Nova Scotia or other similar agency could be considered. If it must be carried out by the vendor, it should include a section in which someone from the SOTER project is present and asks a series of questions which require the vendor to respond in "real-time". This will give an evaluation of how quickly and easily the system can respond to a series of scenario type questions.

Comments and suggestions on this report should be sent directly to ISRIC with a copy to MacDonald.

CONSIDERATIONS FOR GIS ACQUISITION FOR THE SOTER PROJECT

The following document represent comment and input from members of a small ad hoc committee (Baumgardner, Burrough, Lamp, MacDonald, Oldeman, Smaling, and van Engelen) who were given the task of recommending a microcomputer based GIS for use in the SOTER project. Credit should be given to all committee members for their valuable input but the author accepts responsibility for errors or omissions in this committee report.

GENERAL RECOMMENDATION

Geographic Information System tools are available for mapping projects that appear to be similar in principles to the requirements of SOTER. A definitive recommendation cannot be made until SOTER provides clear and thorough guidelines.

CAVEAT

In the short term it is unlikely that SOTER will provide strong direction and clear requirement definition for GIS to support the project. The committee was therefore directed to prepare recommendations based on their knowledge of the project and on the field of GIS. The problems and potential hazards inherent in this approach are readily apparent; nevertheless, this report the committee's efforts to respond to the request.

This approach has several likely results:
(i) the recommendations for a GIS may well include some features and capabilities in excess of those which are truly required for the project in the short and intermediate term (luxury capabilities).
(ii) the recommendations may miss some features or capabilities which are absolutely needed for the project. The most critical potential problem is insufficient data handling capability (in terms of volume of data or speed of processing) as this cannot be overcome by contracting as suggested below.
(iii) to avoid the problem identified in (ii), the recommendations will include a strong component of communication and connectivity with other systems so that features which must be used can be obtained by contract with other agencies and third party systems.

Regardless of the system(s) selected by SOTER, it is certain that it will change and evolve rapidly. Considerations for system selection MUST INCLUDE cost estimates for maintenance and SHOULD INCLUDE an annual trip for the operators at each installation to a Users Group Conference and Refresher Course. If this is not provided the operators will be out-of-date and the system will likely FAIL.

The following suggestions are offered within the context of the above considerations.

SUGGESTED PROCEDURE FOR GIS ACQUISITION BY SOTER

The following approach includes a brief statement of the aim of SOTER as summarized by P. Burrough.

Suggestions for computer hardware are presented. If the hardware suggestions are accepted than the software can be evaluated on its performance in this environment. It is much more difficult to attempt to rate the myriad of hardware/software options simultaneously.

The procedure to identify an appropriate GIS software package for SOTER is outlined as steps required to acquire a GIS. Two levels of review and evaluation are suggested; namely a market survey review of potential vendors of systems and a benchmark evaluation of a short list of most likely suppliers.

The evaluation criteria for both these evaluations must be established before the evaluation. The suggested criteria include mandatory requirements (failure to meet any of these requirements will exclude a potential vendor) and highly desirable requirements which are assessed points and allow for an ordering of vendors who meet the mandatory requirements.

Operational definition of the Aim of SOTER

The aim of Soter is to produce a 1:1,000,000 soil map of the world.

Procedure for data base building:

1. Obtain digital base map at 1:1,000,000 (ONC's)

2. Convert to standard projection (UTM or Lat-Long)

3. Digitize matched and corrected national soil maps and associated attributes of soil polygons and fit to standard projection.

Note: the matching and correction must occur before digitizing. The matching, correction and correlation needs to be done on site, the database building can take place at SOTER headquarters or at distant sites.

Analysis capabilities can be anywhere; they should be at SOTER HQ but can also be at any other agency that can get the data via an exchange format.

Other analytical capabilities may be required in addition to spatial analysis; such as, multi-temporal studies for limited areas in conjunction with remote sensing data e.g. most susceptible areas in times of drought.

<u>HARDWARE OPTIONS</u>

To the extent possible, the hardware for the SOTER GIS should be standard and readily available and supportable in the countries where the system is located. The most universally available systems worldwide appear to be based on IBM compatible computers using a DOS operating system. The hardware based on this computer configuration adequate for requirements for the GIS capabilities could include the following components:

- Computer (386 clone, 20 Mhz, 70 Mb hard drive, 80387 math coprocessor, mono monitor and card, streaming tape backup unit — $7500

- High resolution graphics card and high resolution colour monitor (1280 x 1024) — $6000

- Cartographic quality pen plotter (maximum size plot 55 x 85 cm) $6500

- Digitizer (as above) $3000

(Prices are in US$ and are approximations only, an additional cost of $4000 - 8000 should be included for shipping, installation, miscellaneous cables and training).

The consultants's report "Specifications for microcomputer-based system for image processing and management of spatial and attribute databases" by Baumgardner and Fernandez submitted to FAO in November 1988, outlines requirements for a facility to provide basic capabilities for image processing and geographic information systems.

STEPS IN ACQUIRING GIS CAPABILITY FOR SOTER

1. Definition of the functional requirements

In specific terms, the client group to be served by the system (this group has not yet been defined for SOTER) must reach consensus on the functional requirements. These include descriptions of the products of the system with information provided for each product giving (a) the product title, (b) the data needed and its source, (c) a description of a possible method of using GIS functions to incorporate the data into the product for each type of data, (d) a mock-up of the product including a sketch map where a map is to be produced. Such a map should contain all the requirements for symbols, line types and weights, label placement, shading, overlays, legend etc. For lists or reports the formats should be given and sample outputs defining the maximum lengths and complexity provided (e) the volume required for each product should be estimated as the number of copies of each product and the number of times per year a similar product will be requested.

The sum of products required together with the sources and format of data provide an estimate of the system capabilities and capacities required. In addition, the definition of functional requirements should contain a description of desirable or mandatory user interface characteristics.

2. Specifications of Generic GIS Capabilities

The basic system capabilities in terms of GIS functions are derived from the
total functional requirements. These generic GIS functions are then rated as mandatory, highly desirable or desirable and used as a basis for establishing acceptable hardware and software capabilities. The list prepared by van Engelen can be used as a basis for SOTER GIS requirements.

3. Market Survey

The GIS market (in particular for microcomputer based systems) in changing very rapidly. For this reason, it is crucially important to carry out a timely market survey to support any acquisition. The evaluation criteria for this survey should be sufficiently rigorous that only a limited number of potential systems are identified.
Some systems which should be screened in the market survey include:

ARC/Info - wide distribution, proven track record, expensive

Intergraph - wide distribution in associated mapping activities, rapidly developing GIS capabilities, expensive

Deltamap - cost effective system (UNIX operating system)

ILWIS - well known in Wageningen, not as complete or well supported as some

PAMAP? - not as wide distribution as first two but recognized in FAO, reasonable price

TYDAC? - good analytical capabilities, expensive

Terrasoft? -

Others from other countries.

<u>SUGGESTED PROCEDURE FOR RATING POTENTIAL VENDORS DURING THE MARKET SURVEY</u>

A. Hardware Requirements for GIS

A1. MANDATORY - GIS operates on the proposed hardware configuration; namely, IBM pc or compatible using a DOS operating system (all functionality is possible with 640 Kb RAM).

A2. HIGHLY DESIRABLE - GIS operates on other hardware and operating systems as VAX VMS, UNIX, OS/2, PRIME, UNISYS, etc. This potentially increases the flexibility for growth an development without changing GIS. Score 5 points for each additional system up to maximum of 15 points.

B. Vendor Specified Software Capability

B1. MANDATORY - Vendor specifies that GIS will perform complete list of required GIS functions for input, topology creation, analysis and output including communications with other systems. The list of functions compiled by van Engelen in a draft proposal benchmark test (March 3, 1989) could be used for this evaluation.

B2. MANDATORY - Vendor specifies that GIS can exchange data with other major systems; including, either ARC/Info or Intergraph.

B3. HIGHLY DESIRABLE - Image analysis software fully integrated with GIS to allow registration and analysis between satellite imagery and GIS data. (Rating of specifications 0 - 10 points)

C. Corporate Structure

C1. MANDATORY - Mature company with greater than 5 years experience marketing GIS.

C2. MANDATORY - Critical mass of development and support personnel at least 30 full time employees in marketing, development and support.

C3. MANDATORY - "Mature" software product i.e. all mandatory functions must be available in current release of software and in previous release.

C4. MANDATORY - Critical mass of distributed operating licenses e.g. must have distributed more than 100 licences worldwide.

C5. HIGHLY DESIRABLE - Vendor marketing and support offices within 500 km of South American Pilot and Wageningen and other potential project sites. Rating 5 points for each positive response up to 20 points.

C6. HIGHLY DESIRABLE - System installed in associated International Resource Based Agencies (e.g. FAO). Score 5 points for each up to maximum of 20 points. System installed in associated national agencies either university or governmental. Score 5 points for each up to maximum of 10 points per SOTER site.

D. Reference Check

Potential vendors should provide at least 3 clients as references for their product. SOTER would average responses from each of 3 references rating their responses on a scale of 0 to 10 for each of

D1. Degree of agreement between product and specifications

D2. Quality of hotline support

D3. Quality of documentation

D4. Overall assessment of quality of product - does it meet expectations.

4. Benchmark Evaluation of Potential Systems

Suggested requirements for GIS benchmark - detailed script must be produced by SOTER staff which will include specific evaluation criteria.

A. Test of importation of base data in digital form and ability of system to manage large data sets and handle a variety of geo-referenced datasets.

- accept ONC base in digital form, input and create topology.
- "deseam" the base map sheets e.g. convert to geographic coordinates (Lat-Long), transform to appropriate projection for study area, edgematch and combine, and window out base for pilot.

B. Soil Data Input

- Input thematic lines in point and stream mode
- build topology with thematic and shared boundaries (i.e. extracting hydrological boundaries from base data)
- add feature codes and label points
- input attribute data directly and from magnetic media

C. Point Data Input

- input from a data file 'x', 'y' and 'z' data and build surfaces
- input climatic station data and build coverage with attributes

D. Remotely Sensed Data

- import satellite image (e.g. AVHRR) in digital form, rubbersheet and register to soil theme and base and extract thematic of vegetation greenness.

E. Analysis

- Interpret the SOTER theme e.g. produce a map of rooting depth
- Generate an elevation contour map
- Combine climate layer, SOTER theme, elevation data giving slope steepness and length and vegetation as a measure of crop factor to generate an erosion potential map

F. Output

- Full scale soil map - plotted to scale with base data and surround (legend) information with and without symbols in the polygon areas
- Erosion potential map using classes and patterns with base and legend
- Tabular summary reports giving extent of various textures for a window of the pilot project (e.g. for Brazilian portion)
- Data on magnetic media (tape or diskette for exchange) and test of exchange by loading on another system
- Soil derivative map produced on a windowed area of the pilot map. Produced quickly as a screen dump.

For the GIS for Phase 1 of SOTER, it is suggested that the limited funds available be used to purchase.

APPENDIX 2

QUESTIONNAIRE ON GIS SOFTWARE

N.B. - Please circle the correct answers
- Feel free to annotate your replies

Name and version of the software:......................................

a) Hardware requirements

a1 Does the GIS operate on the following hardware configuration?

- IBM AT pc or 80286 clone
- IBM PS2-80 or 80386 clone

a2 What operating system is required?

PC/MS-DOS OS/2 XENIX

Other (specify):..

a3 Is all functionality possible with 640 Kb RAM? Yes No

a4 Does the GIS operates on other hardware and operating systems?

VAX/VMS UNIX OS/2 PRIME UNISYS

Other (specify):..

If more versions of your software are available, do they have a compatible interchange format? Yes No

a5 Which devices (specify) are supported by the software?

Displays:...

Digitizers:...

Pen plotters:

- drum type:...
- flatbed:...

Inkjet plotters:..

Colour raster plotters:.......................................

b) GIS functions

b1 On which data storage format are the processing routines based?

Vector Raster/grid Raster/quadtree

Other (specify):..

b2 Which of the following functions are available?

b21 Input

- Digitizing in 'spaghetti' mode
  - stream mode: Yes No
  - point mode: Yes No
- Weeding of excess data: Yes No
- Joining of mapsheets and edgematching: Yes No
- Rubberstretching: Yes No
- Transferring the vector polygon map into raster format and vice versa: Yes No
- How many map projections are supported (give number)?..........
- Are all the conversion routines between these projections available? Yes No
- During interactive editing of digitized data, can the software
  - indicate location of digitizing errors? Yes No
  - snap lines to features on background maps? Yes No
  - take lines from background maps? Yes No

b22 Topology building

- Building polygon topology from manually digitized data:

  Yes No

- Interactive coding of polygons: Yes No

- Automatic error detection routine: Yes No

b23 Analysis

- Topological overlay (e.g. polygon on polygon): Yes No

- Aggregation of polygons by attributes: Yes No

- Elimination of slivers by merging with neighboring polygons with largest adjacent boundary: Yes No

- Proximity search (buffer) around polygons/lines: Yes No

- Is the software linked to an external DBMS software? Yes No

- If yes, name of the DBMS:...................................

- Can arithmetic/logical/relational operations be carried out on the attributes of spatial features using the DBMS? Yes No

- Are the attribute tables corresponding to the output of spatial operations (e.g. polygon overlay) produced and placed under the DBMS? Yes No

- Is a library (browsing) feature available on spatial data? Yes No

b24 Output

- Using 3 dimensional data can the software
  - Generate contour lines? Yes No
  - Generate slope and aspect maps? Yes No

- Are conversion routines available to/from any other GIS data formats? (If yes, specify the GIS and the format)

- Raster:	Yes	No	to	from...........
- Vector:	Yes	No	to	from...........
- SUF2:	Yes	No	to	from...........
- SIF:	Yes	No	to	from...........
- IGES:	Yes	No	to	from...........
- DLG-3:	Yes	No	to	from...........

- DIME: Yes No to from...........

- Other (specify)..................to from..........

b25 Other

- Are there any software limitations on the possible maximum data size? Yes No

- If yes, specify...

- Are the routines (commands) of the software accessible from a higher level programming language? Yes No

- Is the software accessible through menus? Yes No

- Can 'batch' procedures be supported? Yes No

- Are all GIS functions listed under (b) available in the current release of the software and in its previous release? Yes No

- If no, indicate which functions were added in latest release

....

c) Corporate structure

- How many years is your company active in the field of GIS software? ....

- What is the number of full time employees of your company active in the field of marketing, development and support?...

- How many operating licenses have been distributed in the home country of your company and abroad?
  Home country:............. Abroad:.................

- Where are your marketing and support offices located?

  ....

- Is your software installed in International Resource Based Agencies (e.g. FAO)? (If yes, specify) Yes No

  ....

- Is your software installed in national agencies either universities or government? (If yes, specify) Yes No

  ....

- Indicate 3 clients as references for your product (name, address and telephone).

  1)...

  2)...

  3)...

d) Others

- Are you willing to do a benchmark test on user-delivered materials? Yes No

- Are you willing to make available the software for a benchmark test by a third party? Yes No

- What is the price of a software licence? (Specify per module if applicable)
  US$...

- How much do you charge for a software maintenance/service contract?
  US$...

APPENDIX 3

INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

B E N C H M A R K   T E S T   S C R I P T

FOR THE ASSESSMENT

OF MICRO-COMPUTER GIS SOFTWARE

FOR THE GLASOD-SOTER PROJECT

Wageningen, June 1989

1 INTRODUCTION

The test is meant for assessing the suitability of micro-computer GIS software for the GLASOD-SOTER project by executing the tasks indicated in this script. Results of the test will not be made public without written permission of the software owner.

The test consists of two main items: (1) the ability of the system to import and handle large amounts of digital data and (2) the performance of the system to execute functional tests with a limited amount of data.

Several products have been identified that illustrate the geo-processing functionality needed and desired. Each product represents a specific functionality required by the GLASOD-SOTER project. This functionality is a realistic portrayal of current needs and short term requirements. No attempt has been made to include longer term processing needs.

The products currently included in this benchmark test are as follows:

1 Importation of digitized geo-referenced data
2 Digitizing (of hardcopy soils & terrain maps) and exportation in SIF format
3 Analysis products like:
   - buffer zone creation
   - isoline map of rainfall from point data
   - rooting depth map
   - soil erosion factors

The test is to be executed by the software owner on a recommended hardware configuration of which a full description should be included in the test report.

2 SOURCE MATERIALS

The line and label files needed for the execution of this test are provided in ASCII format. The distribution of the various files over the diskettes is explained in appendix 2. The contents of these files is explained under 2.2.

All attribute files are also ASCII and give a byte by byte description of the different items in each record.

All data is on two 1.2 megabyte 5.25 inch floppy diskettes. Data was put on diskette using the DOS (DISK)COPY command. DOS version 3.30 was used. Diskettes are identified by numbers 1 and 2.

A more detailed description of the contents of the various files is given in appendix 1. Products that require a (simple) model have full descriptions of the modelling formula.

The following source materials accompany this script:

2.1 Hardcopy maps

2.1.1 TOPOGRAPHY

Two topographical maps (13 x 15 cm and 6.5 x 15 cm) at scale 1:1 million, with hydrography, main roads, towns and international boundaries. It covers a part of a greater map sheet (not part of the source materials) in Lambert Conformal Conic Projection with standard parallels 30°40' and 25°20' and central meridian 64°. Convergence factor is 0.46965.

Standard reference points are the four neatline corners of each of the two small maps.

2.1.2 SOILS & TERRAIN

Two polygon (soils & terrain) maps (13 x 15 cm and 6.5 x 15 cm) at scale 1:1 million, and where polygons are identified by a code number. ('POLYID' from table 'polygon, see also 2.3.1.1). The maps cover a slightly larger area than that of the topographical maps of 2.1.1.

Map specifications are identical to those of item 2.1.1, except for standard reference points which are indicated by ticks.

2.2 Line and label files

2.2.1 LINE.DAT

A complete digitized soil map, on 1.2 megabytes floppy disk, at scale 1:50,000, with x and y coordinates of lines and line_id.

Example:

```
        3                               = line_id
    200.636993  500.000000              = x and y coordinates
    200.000000  500.000000              =       ,,
END
        3                               = line_id
    200.636993  500.000000              = x and y coordinates
    200.742996  500.000000              =       ,,
END
```

2.2.2 LABEL.DAT

A file containing the x and y coordinates, a map unit ID and a map unit code of the label points.

Example:

x-coordinate	y-coordinate	map_unit_id	map_unit_code
200.164	499.644	148	Rn62CpIV
200.458	499.824	134	Rn95AIII
200.826	499.510	253	|h BEBOUW-
202.082	498.929	245	Ass119-

2.3 Attribute files

2.3.1 Soils & terrain map and climate

Attribute data belonging to the soils & terrain map (item 2.1.2) and data which form the climatic information.

2.3.1.1 POLY.DAT

Polygon data of the soils & terrain map (polygon, terrain, soil, profile and layer files) belonging to item 2.1.2, from an area much larger than that of the topographical maps of 2.1.1.

The structure and contents of these files are explained in appendix 1.1.

2.3.1.2 CLIM.DAT

Point data (climate files) from a wider area than the test zone, belonging to item 2.1.1.

The structure and contents of these files are explained in appendix 1.2.

2.3.2 Digitized soil map

Attribute data belonging to item 2.2.1/2.2.2.

2.3.2.1 SOIL1.DAT

This file contains:

- map unit code
- number of reference profile descriptions in map unit
- ghg (mean highest groundwater level)
- bew (rooting depth in cm)

2.3.2.2 SOIL2.DAT

This file contains:

- map unit code
- number of reference profile descriptions in map unit
- laag_id (layer number_id)
- horcode (horizon code)
- org (organic carbon percentage)

3 EXECUTION OF THE TEST

The following requirements are mandatory for each task:

- Report actions taken in performing the task
- Indicate hardware/software configuration actually used vs. minimum required
- Execution parameters like time, disk storage, materials used, manpower required
- Problems encountered with the source material or the test definition
- Devices used for digitizing or plotting (specify)

4 PRODUCT DESCRIPTIONS

4.1 IMPORTATION OF DIGITIZED GEO-REFERENCED DATA

4.1.1 Import line and label files of the digitized soil map from diskette (items 2.2.1 and 2.2.2 of source materials; filenames: LINE.DAT and LABEL.DAT). Create topology, label polygons.

4.1.2 Plot the soil map of 4.1.1 in cartographic quality to the scale of the manuscript (1:50,000). Number the polygons.

4.1.3 Import attribute data of the map under 4.1.1 from diskette (items 2.3.2.1 and 2.3.2.2 of source materials; filenames: SOIL1.DAT and SOIL2.DAT).

4.1.4 Select polygons where 'ghg' > 50 cm, 'horcode' = A1 and 'org' > 1. Display the selected polygons on screen. Make a plot of these polygons (inkjet type).

Make a tabular listing of the selected polygons; include columns with appropriate headings for polygon number, map unit code and extent in hectares.

4.1.5 Select all lines with line_id = 3. Make a plot of this map (inkjet type).

4.2 DIGITIZING

4.2.1 Topography

4.2.1.1 Digitize the two topographical maps (item 2.1.1 of source materials) except for the international boundaries for each sheet separately in 'spaghetti' mode. Create topology. Weed excess data. Add labels to roads, rivers, and towns as appropriate:

main roads
rivers with names
land/water boundaries
towns with names

Edgematch and join the two parts of the topography. Edit line segments at the edges of the sheets if necessary.

4.2.1.2 Digitize international boundaries using the hydrology of the topographical map as a background for the international boundaries. Merge with topographical map.

4.2.2 Soils & terrain

4.2.2.1 Create a soils & terrain polygon coverage by using the thematic boundaries from the soils & terrain theme (item 2.1.2 of source materials) and combine them with the lines from the topographic cover which also represent some soils & terrain theme boundaries. Indicate wether the polygon cover is created by copying all associated boundaries to a single cover layer or wether boundaries are only recorded once with pointers.

Edgematch and join the two sheets. For those lines where edgematching cannot be done automatically edit faulty line connections manually if necessary. Report which polygons cannot be matched automatically.

Snap soils & terrain boundaries at the edges of the topographical base map.

4.2.2.2 Plot the soils & terrain map (polygon map) with the topographical base at cartographic quality to a scale of 1:1,000,000, with an UTM grid and geographic registration points, using different line styles to differentiate between soils & terrain polygon boundaries and additional features like neatline, hydrography (with names), roads, towns (with names) and international boundaries. Put numbers in polygons. Create a legend, together with map title and scale bar.

4.2.2.3 Accept digitized attribute data of the soils and terrain map from diskette (item 2.3.1.1 of source materials; filename: POLY.DAT). Link data to polygons by means of labels.

4.2.2.4 Change polygon identifier 1166 into 1159. Let the software find the error.

4.2.2.5 Export the data of 4.2.2.1 and 4.2.2.3 to diskette in SIF format.

4.2.3 Point data (climate)

4.2.3.1 Input from diskette of the climatic data file in which coordinates and attributes of the climate file (item 2.3.1.2 of source materials; filename: CLIM.DAT).

The climate data stations (points) are spread over a much greater area than the soils and terrain map.

4.3 ANALYSIS PRODUCTS

4.3.1 Rainfall isoline map

Make a rainfall map with isohyetes ('rainfall contours') at 100 mm intervals using all stations in the database. Particulars of the projection of the topography are identical to those of item 2.1.1. A selection of yearly rainfall per station can be made by selecting the value of attribute code 'ANNU' from table 'climkey', filename CLIM.DAT, while other attribute codes are as follows:

'KD' = '01'
'T' = '2'
'P' = '0'
'UM' = '01'

Methods of interpolation: inverse distance and/or kriging, taking into account the greater area of the climate data points. Display on screen only the window as used in the topographical map of 4.2.1.

Combine rainfall isoline map with topographical map.

Plot the rainfall isoline map at cartographic quality to a scale of 1:1,000,000, with an UTM grid and geographic registration points, using different line styles to differentiate between rainfall isolines and additional features like neatline, hydrography (with names), roads, towns (with names) and international boundaries. Put labels on rainfall contours indicating their values.

Plot the same map not to scale at inkjet quality.

4.3.2 Let the software find the steepest gradient in the rainfall isoline map (item 4.3.1).

4.3.3 Rooting depth map

Produce a map of rooting depth of the dominant terrain component per polygon.

The dominant terrain component of each polygon can be found by selecting the greatest proportion of the terrain components in each polygon (attribute code 'TERRPROP' in table 'terrain'). From the selected terrain component the rooting depth can be selected and grouped into one of the three following classes:

- 0 - 49 cm (attribute code 'ROOTDEPTH': '1' and '25')
- 50 - 99 cm (,, ,, ,, : '50')
- >=100 cm (,, ,, ,, : '100' and '150')

Plot this map in cartographic quality on stable base material at scale 1:1,000,000 with a UTM grid, using different line styles to identify neatline, hydrography (with names), roads, towns (with names) and polygons. Identical polygons should designated in three different ways:

by symbols, by hatching and by a combination of full colour and numbers. The three maps must contain the scale, a scale bar, the map title and a legend with the three rooting depth classes.

4.3.4 Buffer zone creation

Create a zone 10 km wide (1 cm on map) on both sides of the Rio Uruguay (river on the border between Argentina and Brazil/Uruguay).

Select in this area all polygons with (for the whole polygon) a rooting depth > 100 cm and a slope gradient =< 3 percent. Eliminate slivers with a width less than 1.5 mm and a length less than 10 mm.

A rooting depth greater than 100 cm for the whole polygon can be obtained by the following procedure:

- check if rooting depth for each terrain component of a polygon is greater than 100 cm (attribute code for rooting depth ('ROOTDEPTH' from table 'terrain') should be '100' or '150')
- check if slope gradient for each terrain component of a polygon is equal or smaller than 3 percent (attribute code for slope gradient ('SLOPGRAD' from table 'terrain') should be '1')
- only those polygons to which both conditions apply are valid.

Plot the new map in cartographic quality at scale 1:500,000 with an UTM grid, using different line styles to identify neatline, hydrography (with names), roads, towns (with names) and polygons. The latter should be designated by a symbol. The legend should indicate the polygon symbol and additional features, scale, scale bar and map title.

Create table with extent of all polygons in the buffer zone with the above mentioned attributes; include columns with appropriate headings for polygon number, rooting depth, slope gradient and extent in hectares.

4.3.5 Create a zone of 50 km wide (5 cm on the map) around polygon 2024. Merge this map with the resulting map of 4.3.4.

Eliminate slivers when less than 1.5 mm wide and 5 mm long according to:

- greatest percentage of common boundary

- attributes (attribute codes rooting depth > 50 cm; 'ROOTDEPTH': '100' or '150' from table 'terrain')

Create new map legend and plot map in cartographic quality at scale 1:1,000,000 with an UTM grid, using different line styles to identify polygons, neatline, hydrography with names, roads, towns with names. Designate polygons by hatching.

4.3.6 Soil erosion factors

Overlay soils & terrain map (4.2.2) and rainfall isoline map (4.3.1) to form new polygons. Consider the following attributes from the soils & terrain map: slope gradient, slope length, vegetation ('SLOPGRAD', 'SLOPLENG' and 'VEGETATION' from table 'terrain') and rainfall isolines created under 4.3.1.

Eliminate slivers when less than 1.5 mm wide and 10 mm long according to greatest percentage of common boundary.

Select polygons with for the whole polygon the following two groups of attributes:

- 'SLOPGRAD' < '3'
- 'SLOPLENG' = '300'
- 'VEGETATION' = 'GR'

or:

- 'SLOPGRAD' < '3'
- 'SLOPLENG' = '600'
- 'VEGETATION' = 'GR'

(all three attributes originate from table 'terrain')

Generate new map legend. Plot the new map to cartographic quality at scale 1:1,000,000 with an UTM grid, using different line styles to identify polygons, neatline, hydrography with names, roads, towns with names. Designate polygons by hatching. Generate legend with the two soil erosion factor combinations.

4.3.7 Aggregation of polygons with identical attributes.

Merge all polygons with similar attribute pH-H_2O for the topsoil. Attribute 'PH_H20' for the topsoil can be obtained from table 'layer' where attribute 'LAYER_ID' = '1'.

Plot this map with legend to cartographic quality at scale 1:2,000,000 with an UTM grid, using different line styles to identify polygons, neatline, hydrography with names, roads, towns with names. Designate polygon groupings by hatching.

4.4 OTHER

4.4.1 Transfer of the soils & terrain map (4.2.2) from vector to raster (raster size 2 by 2 km) and back to vector.

Plot the raster and the last version of the vector map to cartographic quality at scale 1:1,000,000 with an UTM grid, using different line styles to identify polygons, neatline, hydrography with names, roads, towns with names.

Appendix 1.1 DESCRIPTION OF SOILS & TERRAIN DATABASE FILES

```
SQL> describe polygon
 Name                            Null?    Type          Description⁴⁾
 ------------------------------- -------- ----          -----------
 POLYID                          NOT NULL NUMBER        polygon number
 COUNTRY                                  CHAR(4)       country
 STATPROV                                 CHAR(2)       state/province
 BASEMAP                                  CHAR(4)       base map
 REPORTREF                                CHAR(4)       report
 YEARREC                                  NUMBER(4)     observation year
 LANDFORM                                 CHAR(1)       landform
 RELIEF                                   NUMBER(4)     relief
 ELEVATION                                NUMBER(4)     elevation
 LITHOLOGY                                CHAR(4)       lithology
 LAKESURF                                 NUMBER(3)     lake surface
 SEASINUND                                NUMBER(3)     seasonal inundat.
 RIVERDIST                                NUMBER(3)     river distance
 DRAINDENS                                CHAR(1)       drainage density
 LANDUSE                                  CHAR(4)       land use

SQL> describe terrain
 Name                            Null?    Type          Description
 ------------------------------- -------- ----          -----------
 POLYID                          NOT NULL NUMBER        polygon number
 TERRID                          NOT NULL NUMBER(1)     terrain comp. No.
 TERRPROP                                 NUMBER(3)     proportion
 PARENTMAT                                CHAR(2)       parent material
 TEXTGROUP                                CHAR(1)       textural group
 SURFFORM                                 CHAR(1)       surface form
 SLOPGRAD                                 NUMBER(2)     slope gradient
 SLOPLENG                                 NUMBER(3)     slope length
 STONINESS                                NUMBER(3,1)   stoniness
 ROCKINESS                                CHAR(3)       rockiness
 GRWDEPTH                                 CHAR(5)       groundwater depth
 GRWQUAL                                  NUMBER(4)     groundw. quality
 ROOTDEPTH                                NUMBER(3)     rooting depth
 VEGETATION                               CHAR(2)       vegetation
 FLOODING                                 CHAR(3)       flooding hazard
 CRUSTING                                 CHAR(3)       crusting
 SURFDRAIN                                CHAR(4)       surface drainage
 OVERWASH                                 NUMBER(3)     overwash
 OVERBLOW                                 NUMBER(3)     overblow
 WATERSTAT                                CHAR(1)       water erosion
 WINDSTAT                                 CHAR(1)       wind erosion
 COMPLEXMAT                               CHAR(1)       complex materials
 PERMAFROST                               CHAR(1)       permafrost
 ICECONTENT                               CHAR(1)       icecontent
```

---

[4] Not part of the database file. Only for explanation.

```
SQL> describe soil
 Name                            Null?    Type
 ------------------------------- -------- ----
 POLYID                          NOT NULL NUMBER
 TERRID                          NOT NULL NUMBER(1)
 SOILID                          NOT NULL NUMBER(1)
 SOILPROP                                 NUMBER(3)
 SLOPEPOS                                 CHAR(3)
 PROFID                          NOT NULL NUMBER
```

```
SQL> describe profile
 Name                            Null?    Type
 ------------------------------- -------- ----
 PROFID                          NOT NULL NUMBER
 INTDRAIN                                 CHAR(4)
 SYSCLASS                                 CHAR(3)
 SOILDEV                                  CHAR(4)
 REFPEDON                                 CHAR(7)
```

```
SQL> describe layer
 Name                            Null?    Type
 ------------------------------- -------- ----
 PROFID                          NOT NULL NUMBER
 LAYERID                         NOT NULL NUMBER(1)
 LOWERDEPTH                               NUMBER(3)
 ABRUPTNESS                               CHAR(2)
 MOISTHUE                                 CHAR(5)
 MOISTVAL                                 NUMBER(2,1)
 MOISTCHR                                 NUMBER(2,1)
 DRYHUE                                   CHAR(5)
 DRYVAL                                   NUMBER(2,1)
 DRYCHR                                   NUMBER(2,1)
 DEGRDECOMP                               CHAR(3)
 BIOLACT                                  CHAR(3)
 CLAYMIN                                  CHAR(4)
 CONTRAST                                 CHAR(1)
 DISTURBANCE                              CHAR(2)
 DIAGNHOR                                 CHAR(4)
 COARSE                                   NUMBER(2)
 SAND                                     NUMBER(2)
 VERY_FINE                                NUMBER(2)
 SILT                                     NUMBER(2)
 CLAY                                     NUMBER(2)
 TEXTCLASS                                CHAR(4)
 UPWAT_KPA                                NUMBER(2)
 LOWAT_KPA                                NUMBER(4)
 UPWAT_VOL                                NUMBER(2)
 LOWAT_VOL                                NUMBER(2)
 BULKDENS                                 NUMBER(3,2)
 INFILTRAT                                NUMBER(4,1)
 SATHYDCON                                NUMBER(4,1)
 STRUCTURE                                CHAR(2)
 STABAGGR                                 NUMBER(2)
 ORGCARBON                                NUMBER(3,1)
```

TOTNITRO	NUMBER(3,2)
CEC_SOIL	NUMBER(2)
CEC_CLAY	NUMBER(3,1)
CEC_EFF	NUMBER(3,1)
AEC_SOIL	NUMBER(3,2)
CA_EXCH	NUMBER(4,2)
MG_EXCH	NUMBER(3,2)
NA_EXCH	NUMBER(3,2)
K_EXCH	NUMBER(3,2)
MN_EXCH	NUMBER(3,2)
AL_EXCH	NUMBER(2,1)
CA_MG_RAT	NUMBER(2,1)
CA_K_RAT	NUMBER(2,1)
MG_K_RAT	NUMBER(2,1)
AL_SATPERC	NUMBER(3)
P_AVAIL	CHAR(1)
P_FIXATION	CHAR(4)
S_AVAIL	CHAR(4)
TRACE_DEF	CHAR(4)
TOXIC_POT	CHAR(4)
BASE_SAT	NUMBER(3)
PH_H2O	NUMBER(3,1)
PH_CACL2	NUMBER(3,1)
ELECT_COND	NUMBER(3)
ESP	NUMBER(2)
CACO3	CHAR(3)
GYPSUM	NUMBER(2)

Appendix 1.2 DESCRIPTION OF THE CLIMATE DATABASE FILES

```
SQL> describe climstat
 Name                            Null?    Type              Description
 ------------------------------- -------- ----              -----------
 CCD                             NOT NULL CHAR(3)           country code
 SCD                             NOT NULL NUMBER(4)         station code
 STATNAME                                 CHAR(20)          station name
 LATIT                                    NUMBER(4)         latitude (degrees/
                                                            minutes)
 LONGIT                                   NUMBER(5)         longitude(degrees/
                                                            minutes)
 ALTI                                     NUMBER(4)         altitude (meters)
```

```
SQL> describe climkey
 Name                            Null?    Type              Description
 ------------------------------- -------- ----              -----------
 CCD                             NOT NULL CHAR(3)           country code
 SCD                             NOT NULL NUMBER(4)         station code
 KD                              NOT NULL CHAR(2)           kind of data
 T                               NOT NULL CHAR(1)           time period
 P                               NOT NULL CHAR(2)           interval period
 UM                              NOT NULL CHAR(2)           unit of mesure
 STA                                      NUMBER(4)         starting year
 END                                      NUMBER(4)         ending year
 YRS                                      NUMBER(3)         number of years
 OBYR                                     NUMBER(4)         observation year
 SO                                       CHAR(2)           source
 JAN                                      NUMBER(5,1)       January
 FEB                                      NUMBER(5,1)       February
 MAR                                      NUMBER(5,1)       March
 APR                                      NUMBER(5,1)       April
 MAY                                      NUMBER(5,1)       May
 JUN                                      NUMBER(5,1)       June
 JUL                                      NUMBER(5,1)       July
 AUG                                      NUMBER(5,1)       August
 SEP                                      NUMBER(5,1)       September
 OCT                                      NUMBER(5,1)       October
 NOV                                      NUMBER(5,1)       November
 DEC                                      NUMBER(5,1)       December
 ANNU                                     NUMBER(6,1)       annual
```

Appendix 2 CONTENTS OF THE DISKETTES

The two diskettes accompanying this script have the following files:

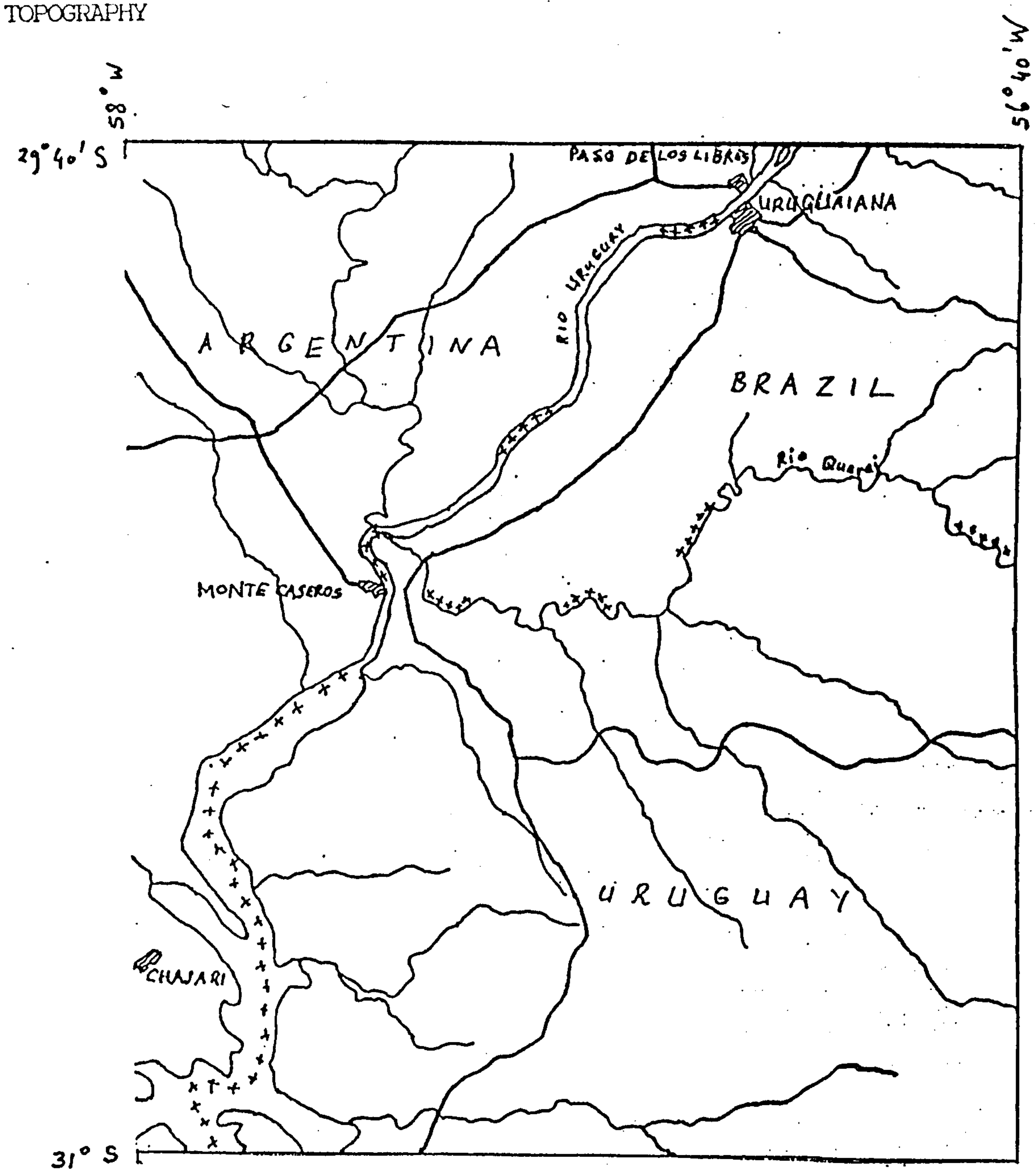
DISK 1:

- LINE.DAT
- LABEL.DAT
- SOIL1.DAT
- SOIL2.DAT

DISK 2:

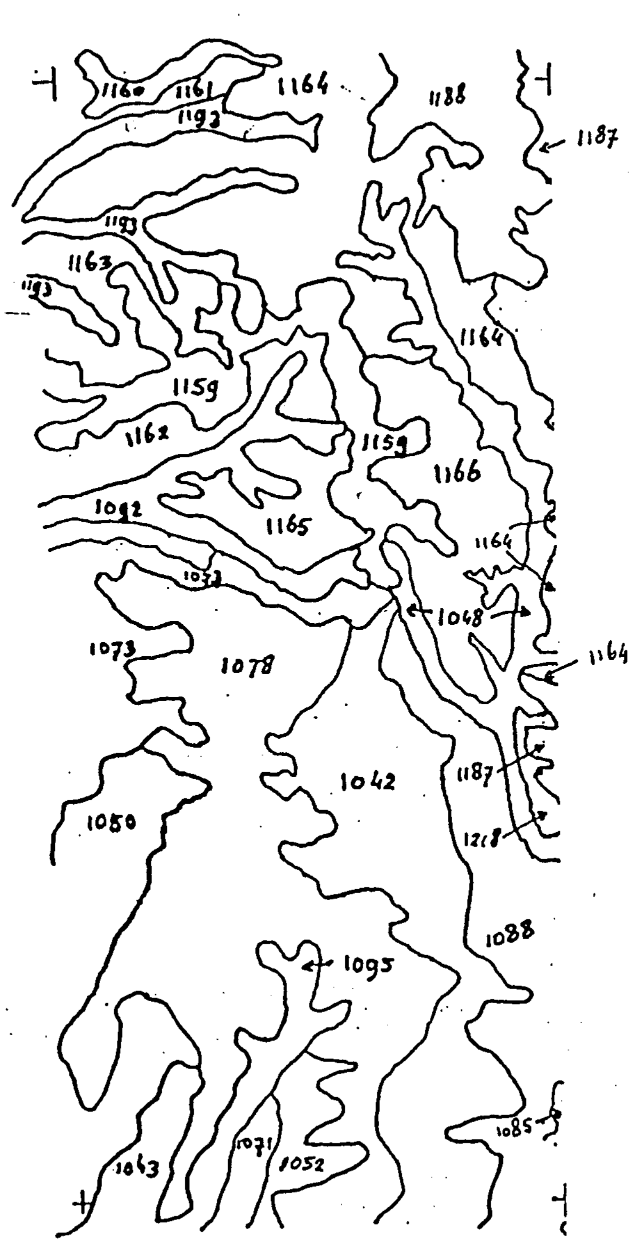
- POLY.DAT
- CLIM.DAT

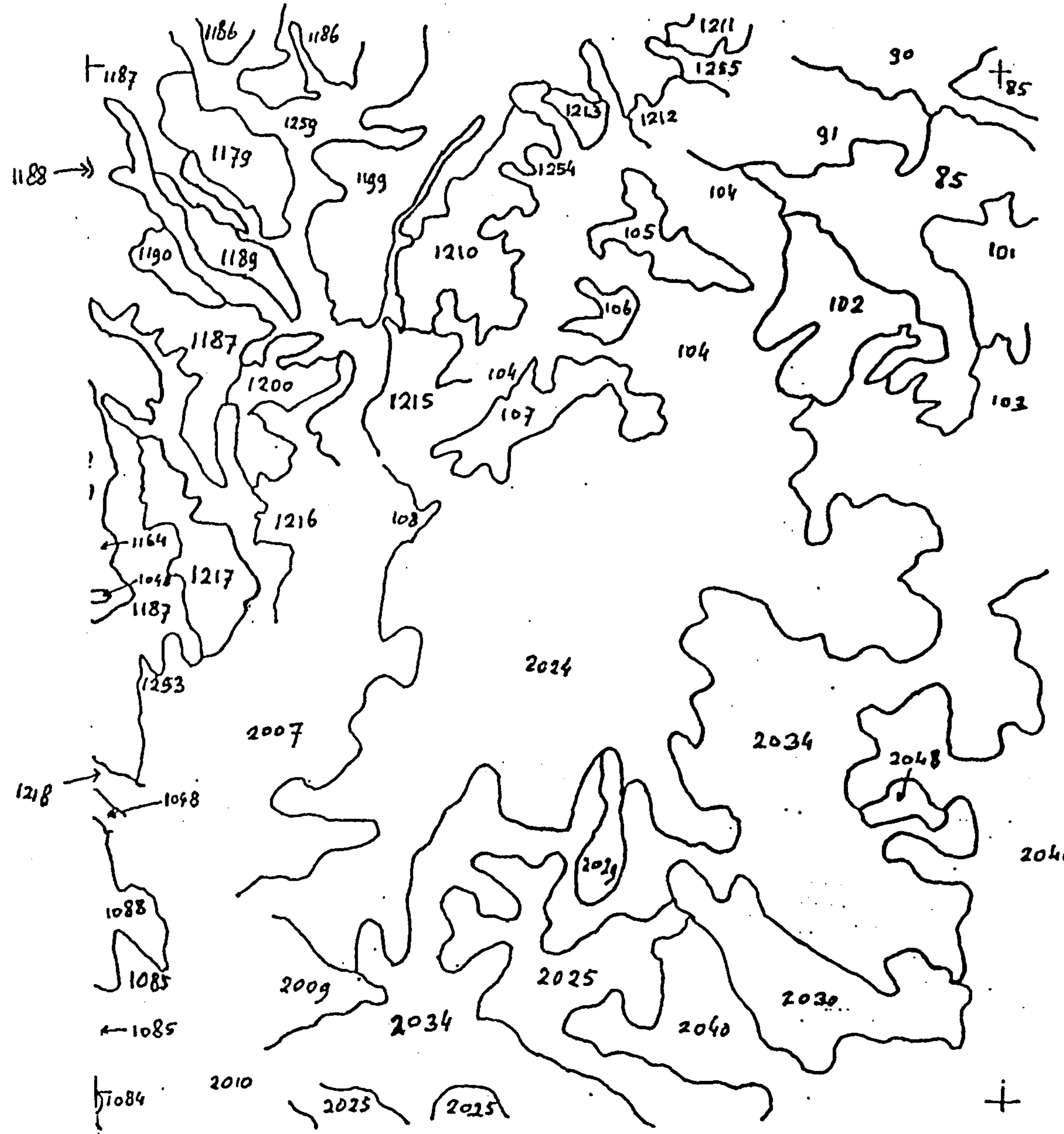
TOPOGRAPHY



LEGEND

rivers
main roads
water
international boundary
town


1160
1161
1164
1188
1187
1193
1163
1159
1162
1166
1092
1165
1073
1078
1048
1042
1050
1187
1218
1088
1095
1043
1071
1052
1085


1186
1187
1259
1179
1188
1199
1190
1189
1210
1187
1200
1215
1216
1217
1253
2007
2024
1218
1048
1088
1085
2009
2034
2010
2025
104
105
106
107
108
1211
1255
1212
1213
1254
90
91
85
101
102
103
2034
2048
2040
2039
2025
2040