

TECHNICAL RECOMMENDATIONS
FOR HIGHWAYS

TRH 2 **GEOTECHNICAL AND
SOIL ENGINEERING MAPPING
FOR ROADS AND
THE STORAGE
OF MATERIALS DATA**

1978

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SYNOPSIS

Methods of and instructions for preparing geotechnical and soil engineering maps are described in detail.

Instructions are given on how to prepare and process materials data for storage in a form in which they can easily be retrieved.

SINOPSIS

Metodes en aanwysings vir die opstel van geotegniese en ingenieursgrond-kaarte word breedvoerig behandel.

Leiding word gegee oor hoe om inligting oor materiale voor te berei en te verwerk vir bewaring in 'n maklik herwinbare vorm.

CONTENTS

Page

Synopsis/Sinopsis	iv
1 Introduction	
1.1 Definitions	1
1.2 Data bank	3
1.3 Philosophy of terrain evaluation	3
2 Geotechnical mapping for route location	
2.1 Objective	7
2.2 Preparation of the map	8
2.3 Preparation of the report	12
3 Soil engineering mapping for design and construction	
3.1 Objective	13
3.2 Stage 1	14
3.3 Stage 2	16
3.4 Stage 3	16
4 Materials data banking	
4.1 Objective of data banking	22
4.2 Principles on which materials data banking and extrapolation are based	22
4.3 Processing of data for banking	23
4.4 Service provided by the materials data bank	29
5 References	31

LIST OF FIGURES

	<i>Page</i>
1	Flow diagram of production of soil engineering and geotechnical maps 2
2	Climatic zones for Southern Africa 25
3	Example of a geotechnical map 32
4	Example of a soil engineering map 33
5	Example of a geological section 34

LIST OF TABLES

	<i>Page</i>
1	Key to topographic symbols to be used on geotechnical maps 10
2	Map symbols for materials and problem areas 11
3	Key to abbreviations used in soil descriptions and general borrow pit data 18
4	Aspects to consider in evaluating problem areas and potential construction and maintenance difficulties – subgrade conditions and borrow areas 19
5	Summary of test results ready for storage in Data Bank 21
6	Relief classes as applied to materials data banking 26
7	Descriptive terms for land forms used by the National Data Bank for Roads 27
8	Summary of possible construction problems 28
9	Some environmental and material aspects affecting road construction and design arranged according to their banking potential 30

1 INTRODUCTION

Experience in the production of soil engineering maps for roads has indicated a need to revise the earlier version of TRH2 so that the changed requirements of overall planning and of detailed design may be met. Some of the terms used in this revised document need clarification and are accordingly described below. Geotechnical mapping and soil engineering mapping are later described in detail.

Any one or part of one of the phases of production may be carried out separately, depending on the requirements of the engineer.

The various phases discussed in this document are illustrated in the flow diagram, Figure 1.

1.1 DEFINITIONS

Terrain evaluation

This is a multidisciplinary exercise which correlates the engineering and non-engineering aspects of the information required for route-planning purposes. The inputs required include data on agriculture, ecology, economics, environment and sociology, as well as engineering.

Geotechnical map

This is the means by which the engineering aspects are fed into the terrain evaluation process. It is basically a geological map containing only such soil engineering and materials information as may significantly affect route location. A geotechnical report must of course accompany the map.

A route would normally be selected on the basis of this geotechnical information and the other data mentioned under terrain evaluation.

Soil engineering map

This is a map on which is recorded the soil engineering and materials information of use for road design purposes. An accompanying soil engineering report will give the necessary details and recommendations. The map and report are compiled after the route has been selected. It is convenient to divide the production of a soil engineering map and report into three stages:

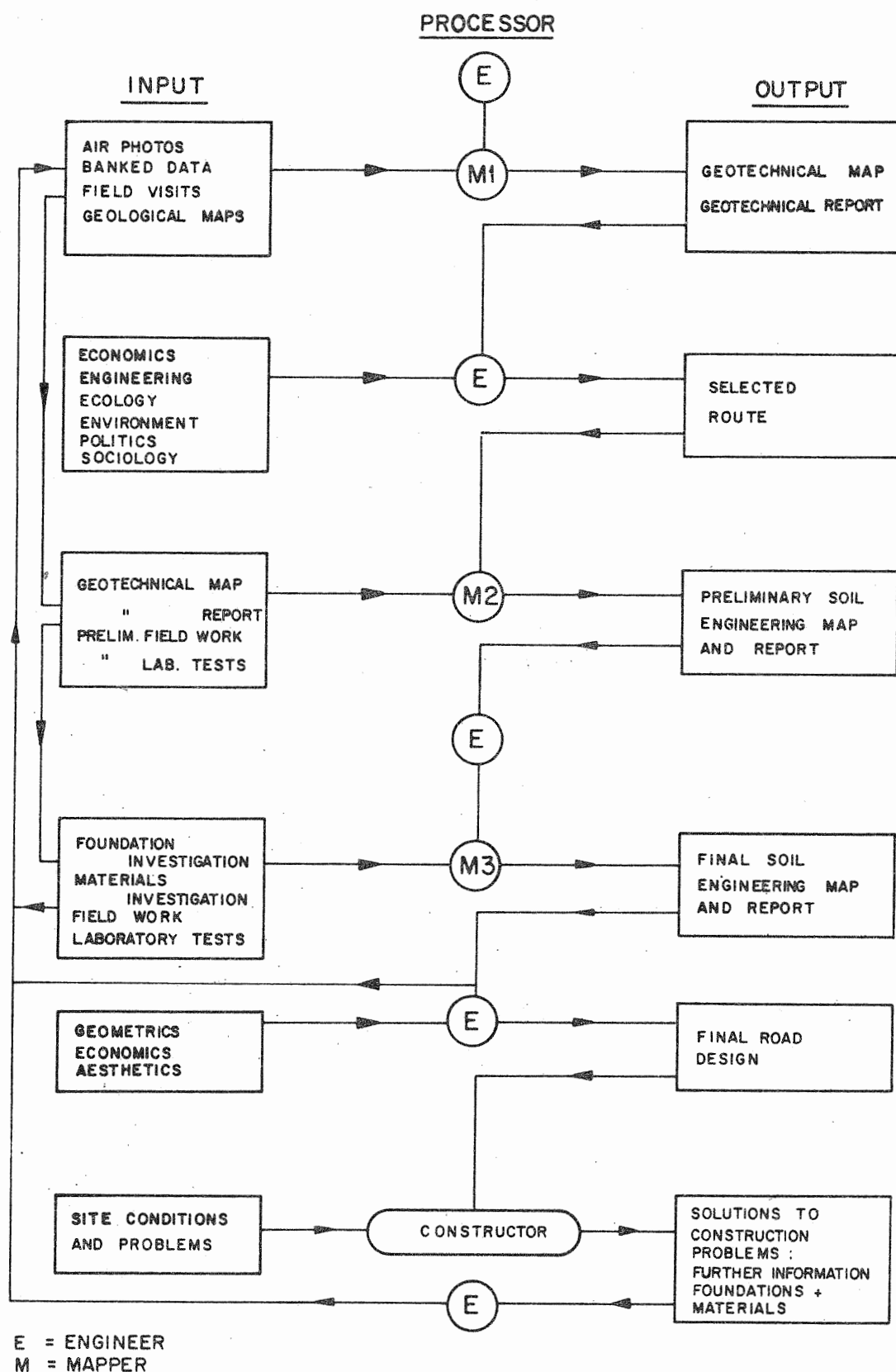


FIGURE 1

*Flow diagram of production of soil engineering
and geotechnical maps*

- (i) Preliminary map – this is used largely as a guide to what further field investigation will be required.
- (ii) Site investigation – including the planning and execution of all the field and laboratory work.
- (iii) Soil engineering map and report – in which all the information relevant to the design and construction of the project is shown and discussed.

1.2 DATA BANK

Some of the information gathered may be stored in a data bank. For this purpose the data must be processed in a specific form which is described in detail in the chapter on Materials Data Banking (p. 22).

It should be noted that information becomes available not only during investigation but also from the construction. Any further information so obtained should also be communicated to the Data Bank. It is not necessary for a geotechnical or soil engineering map to be compiled before the information can be banked. Any data related to materials may be stored in the National Data Bank for Roads (NDBR) for retrieval provided they are submitted in a suitable form.

1.3 PHILOSOPHY OF TERRAIN EVALUATION

In order that the road designer and constructor may fully appreciate the usefulness of geotechnical and soil engineering mapping in terrain evaluation, it is thought desirable to give some explanation of, and background to, the techniques used.

The considerable discussion and professional argument on this topic in the past almost seem to have been designed to obscure the main issues from the engineering profession and to render the whole subject incomprehensible. This is unfortunate, but bearing in mind that there have been recent developments in the subject, these arguments are not only inevitable but may be considered as evidence of healthy growth. Although not all the issues involved have as yet been completely resolved, the sub-committee believes that there is now sufficient agreement for geotechnical and soil engineering mapping to be presented as a working method suitable for use in the design and construction of transportation links.

The basic object of geotechnical and soil engineering mapping is to communicate information about terrain classification. In general no new facts will be deduced from the maps but the engineer will be presented with the information he needs in a form which he can understand.

It is of course not necessary that the user should know and understand the finer details of all the techniques which the mapper may need to produce the map. It is, however, highly desirable that the user should have at least a broad appreciation of mapping since he has to tell the mapper what is required and his demands must be reasonable. He must also have a clear idea of the distinction between facts reported by the mapper and the interpretation of these facts for which he, as the user, is responsible. The mapper in turn must ensure that he understands the user's requirements, and fulfils them as far as possible or points out beforehand that in the circumstances the requirements cannot be met. Failure to communicate effectively undoubtedly led to considerable problems in the past. It must be stressed that there were faults on both sides. After all, an engineer client would not simply instruct a contractor to build him a road, without giving him detailed specifications, yet all too often an instruction to an engineering geologist to provide a map was given in comparably vague terms. It is hoped that this problem will be largely overcome by the present TRH.

It is obvious that whether the desired information concerns geotechnical problems or materials location, it is intimately bound up with terrain. The experienced engineer will feel, for example, that a particular cutting will give drainage and stability problems. He may have difficulty in explaining his feeling, but it could be because he recognizes from the topography that in similar situations he has encountered a dolerite intrusion into a shale, with a consequent marked change of permeability at the interface and decomposition of the dolerite. Similarly, a man looking for suitable subbase material will select preliminary trial hole positions almost on instinct. For example, in an area where ferricretes occur he may begin his selection a little above any depressions because he has noted subconsciously that a particular type of vegetation occurring there is usually associated with ferricretes; he uses a combination of land form and vegetation to locate the required material. He has in fact recognized that the topography can be divided into typical shapes or forms which are repetitive and that the material found in one type of shape can be expected to occur in a similar type located elsewhere. Unfortunately, this knowledge cannot be translated outside the area of that experience without taking into account climate, since this has a very marked effect on the weathering and decomposition and hence on the geotechnical properties of the materials. The experienced man will also have correlated his observations with another vital factor – the geology or parent material. He will probably have done this so automatically that he might even be a little surprised if told that it was thought worth mentioning since it was so obvious to him.

The problem of communicating this experience occurs not only in road building but in almost any activity related to land use, and therefore for some

time attempts have been made to develop a classification of terrain. Understandably it was hoped that some universal system could be applied which would be suited to all disciplines. As always, however, it transpired that such a classification would be either too broad to be of any value or too detailed to be generally applicable and that a compromise was required. Soil engineers want the land to be classified into significantly differing units from the engineering aspect. Care also had to be taken not to pronounce the unit's engineering characteristics good or bad because this would depend on the engineering use to which it was to be put. For example, an outcrop of hard rock in a sand desert could be of such value that it would be worth routing a road close to it or even through it, whereas a similar outcrop, in an area where suitable pavement material is plentiful, could be viewed as simply another expensive cutting. The classification must therefore concentrate on recording what problem or material actually occurs and on giving an indication of its relevant engineering significance on the map. The interpretation of these results in terms of the material's suitability to a particular application or how to overcome a specific construction problem is a separate process.

The sub-committee has now accepted a system whereby terrain can be classified with regard to materials on the basis of parent material, climate and topography. It is also essential for the engineer to be able to understand from the pictorial representation of the classification on the map what engineering properties the material or problem units shown will possess. These symbols are given in Tables 1 and 2 in the text.

In the past the engineer was able to a large extent to rely on experience in a particular area, both the personal experience of the designer and that gained from discussions with local supervisors. Because of the rapid pace of development and shortage of personnel this is not now always possible. The experience is still there but cannot easily be tapped, so a system was needed whereby this very valuable experience could be stored and later retrieved by any interested party. It was for this reason that the National Data Bank for Roads was started. Using the parameters now accepted for classifying material units, i.e. parent material, climate and topography, the Bank is able to store and retrieve information on road materials. Since it has been shown that it is self-evident that similar material units occurring at different places under the same conditions will have similar properties, provided the basic controlling parameters are the same, information stored in the Bank can be extrapolated from one site to another. Information of vital interest is therefore retained by storage in the NDBR.

It is not possible to discuss terrain evaluation without mentioning the two techniques which are already revolutionizing the study and promise to continue

doing so. These are remote sensing and computer programs capable of analysing and storing data from remote sensing. Local use of these techniques is as yet very new. A banking system has been computerized which concerns itself only with the technical properties of construction materials and certain construction problems. Our present methods will develop as the need develops and the cost of more sophisticated techniques becomes justified. There is, therefore, a danger that if the final users insist that they are only interested in a very limited aspect of the terrain evaluation then the development of better techniques of data collection and retrieval in this field will be hindered.

2 GEOTECHNICAL MAPPING FOR ROUTE LOCATION

2.1 OBJECTIVE

Geotechnical mapping for route location is intended to provide the road authorities with the necessary geotechnical information which may help to indicate the best location of the route of a planned road. Since many other factors (outside the scope of this publication) also affect the final route, the geotechnical map must cover a broad area and not be concerned with a specific route. The area to be investigated will generally be of considerable length and width and the information to be supplied must enable the planner to take full cognizance of the potential geotechnical problems in addition to other important criteria such as:

- (a) Existing land use
- (b) Population densities
- (c) Archaeological and historical sites
- (d) Land values
- (e) Agricultural potential (utilization potential)
- (f) Land parcel size (areas held by individual owners)
- (g) Possible future development
- (h) Wildlife habitats
- (i) Vegetation distribution
- (j) Rare or endangered species
- (k) Areas of recognized scenic beauty
- (l) Any further groupings of criteria thought necessary to assist corridor location in a given area.

The above criteria must be considered when selecting possible routes and will consequently govern the position of the corridor to be covered by the geotechnical map. However, although emphasis will change, the overall impact of each criterion should still be assessed.

The relative importance of the various criteria is a controversial subject, discussion on which is avoided at this stage. Various systems are used to correlate the disparate objectives of the decision-making individuals to achieve a unified, broadly acceptable solution. These systems stem from the recognition that the items considered in finding a least-impact corridor do not all command the same importance; they also allow importance ratios to be assigned to both objective and subjective value judgements.

It must always be borne in mind that the geotechnical map and report form only one part of route location and that the engineer will use this map and report to assess geotechnical aspects only. These are then studied in conjunction with other aspects, such as land use, to arrive at a final corridor.

Although it is anticipated that the geotechnical map will be used as a guide to the soil engineering map, which is required for the subsequent design and construction of each portion of the road, it is essential that only information of importance to route location should be shown on the map and that no unnecessary detail which might confuse the basic issues be mapped. Relevant additional detail may be given in the accompanying report.

It is essential that the mapper adapt his approach to the demands of the terrain and the availability of information. It would be pointless to pay attention to areas where it is immediately apparent that the topography will obviate route location; such areas must be eliminated in consultation with the engineer. The procedures described below should therefore serve only as a guide to obtaining uniformity in the presentation of geotechnical maps and reports. The number of field visits is left to the discretion of the mapper and will be dictated by the complexity of the area to be mapped. Soil profiling or testing is not normally required for route location mapping.

2.2 PREPARATION OF THE MAP (for example see Fig. 3)

- (a) The *title* of the map must be 'Geotechnical Map'.
- (b) The *scale* of the map should normally be 1:50 000 but where the length to be mapped dictates a smaller scale, the scale must be decided in consultation with the engineer.
- (c) The *size* of the map should ideally be A4 fold-out, with a blank A4 size binding margin. However, the engineer may need a different scale. If the length of the study area so demands, the map may be cut into two or more sheets, each sheet being supplied with a legend. The map must be orientated so as to occupy the maximum amount of space on the sheet, but the north point should be clearly indicated.
- (d) The *base* map must be taken from the 1:50 000 sheets of the Topographic Series of South Africa where available, or specially prepared where not available.
- (e) The *topography* and *planimetry* must be shown in sufficient detail to allow easy orientation. The symbols as shown on the 1:50 000 topocadastral map series must be used, supplemented by the symbols shown in Table 1.

- (f) The *geological symbols*, e.g. for fault, strike, dip, etc., must be in accordance with those used by the Geological Survey of the Republic of South Africa and approved by the South African Section of the Association of Engineering Geologists (AEG).
- (g) The *colours* of the mapping units (lithology) must be similar to those used in the standard colour key by the Geological Survey for large-scale maps.
- (h) The *number* of copies and method of reproduction of the map must be determined in consultation with the engineer.
- (i) The *mapping units* must basically be lithostratigraphic units. Only those soil units (as defined under Soil Unit, p. 17) which are of direct significance to route location should be shown.
- (j) Where a *classification of slopes* is specifically required by the engineer, it should generally be based on slope ranges of 0° to 5°, 5° to 15°, 15° to 30° and more than 30°, unless intermediate ranges are requested.
- (k) *Geological contacts* may normally be transferred directly from geological maps to a scale of 1:250 000 or larger where available. In the absence of such maps an attempt should be made to delineate geological contacts by aerial photograph interpretation. Only in cases where the contacts are of significance to route location need they be checked in the field.
- (l) *Faults, joints and brecciated zones, strike and dip* may similarly be transferred from the geological map or obtained from aerial photograph interpretation. Any tectonic and structural features which may have a direct effect on route location must be specifically indicated on the map.
- (m) The *drainage system* is always shown on the 1:50 000 topocadastral sheets and must be transferred to the geotechnical map. Any additional information so shown, such as lakes, pans, dams and bore-holes, must be similarly transferred. Marshy areas and other areas of high water table must be given more prominence than they are normally given on the topocadastral sheets.
- (n) *Seepage zones* evident at the time of mapping or from aerial photograph interpretation should be specifically marked on the map if they are of significance to route location.
- (o) Obvious chemically *aggressive water* must be indicated on the map and enlarged upon in the report.
- (p) Any anticipated *problem areas*, such as those with sinkholes, expansive clays, or soil with a collapsible grain structure, which are of significance

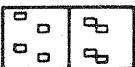
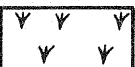
LEGEND

SYMBOL	DESCRIPTION
	Centre line of proposed route with staked values (km)
	Suggested centre line relocation (Based solely on topography, foundations and materials)
	Farm boundaries and farm names
	National road
	Main road
	Secondary road
	Soil profile locations
	Mines and mining areas
	Geological boundaries
	Approximate or inferred geological boundaries
	Geological faults
	Soil unit boundaries (dashed when approximate)
	Base
	Binder
	Subbase
	Selected subgrade
	Aggregate for surfacing
	Aggregate for concrete
	Fill

TABLE 1

Key to topographic symbols to be used on geotechnical maps

MAP SYMBOLS FOR MATERIALS

	Made ground
	Boulders and talus
	Gravels
	Sand and sandy
	Silt and silty
	Clay and clayey
	Salt, gypsum
	Pedogenic materials
	Organic matter
	Transported (T) and residual (R) material

MAP SYMBOLS FOR PROBLEM AREAS

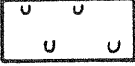
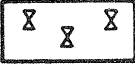
	Sand dunes
	Soilcreep areas
	Slump areas
	Collapsing sand
	Expansive materials

TABLE 2

Map symbols for materials and problem areas

to route location, must be shown on the map using the symbols shown in Table 2.

- (q) The depiction of *potential construction materials* on the map will require careful consideration. The bulk of this information can be covered in the report and it is generally only in areas where construction materials are scarce and widely scattered, so that the cost of hauling may have a bearing on route location, that sources of construction material should be shown on the map.
- (r) All major *existing quarries and borrow pits* which contain material of proven quality must be shown on the map. The use and quality of material in the quarry may be enlarged upon in the report.

2.3 PREPARATION OF THE REPORT

- (a) The *size* of the report must be A4.
- (b) *Problem areas* involving not only unsuitable subgrade conditions and potential construction difficulties, but also longer-term potential stability problems with embankments and cuttings, must be discussed in the report in sufficient detail to enable a geotechnical assessment of the proposed route to be made as an aid to route location.
- (c) The *availability of construction materials* must be discussed briefly in the report in order to assess cases where scarcity of such materials may make hauling an important factor in route location.
- (d) Problems associated with *water* must be discussed in sufficient detail to enable the engineer to take this factor into account, if necessary, in locating the route. Marshy areas and other wet-soil areas, zones of seepage which may adversely affect cuttings or high embankments, must receive due consideration if they will affect route location.
- (e) The need for *stabilization* of potential construction materials must be discussed in broad outline if it will affect route location.
- (f) A *lithostratigraphic column* for the area under consideration must be given.
- (g) A *geological section*, chosen so as to draw attention to any significant aspects which may affect route location, must be given in A4 fold-out size, and supplied with the report.
- (h) *References* used should be quoted by author and title and listed at the end of the report.
- (i) A section dealing with *economic geology* must be included if of significance to route location, e.g. a potential brickfield in a developing area where such materials are scarce.

3 SOIL ENGINEERING MAPPING FOR DESIGN AND CONSTRUCTION

3.1 OBJECTIVE

Soil engineering mapping is generally undertaken to delineate and identify, assisted by suitable testing, significantly different soil and rock types from the point of view of roads and foundation engineering. More specifically it should help to:

- (i) locate suitable construction materials,
- (ii) indicate both favourable and unfavourable subgrade conditions, and
- (iii) define problem areas.

The information produced should be presented in a map and report. All proven borrow areas and quarries must be shown, together with a tabulation of test results and all technical recommendations, supported by test results or other evidence.

Soil engineering mapping for design and construction can be considered as a three-stage procedure. Since the length of the area to be mapped will, in most cases, be considerably less than the length of the area for geotechnical mapping purposes, the map will obviously be drawn to a larger scale and in considerably more detail.

The first stage consists of an initial analysis of the terrain so that a draft soil engineering map can be produced. This may consist of a conventional map, an overlay or annotated aerial photographs. The data shown on such a draft map should generally consist of all that will be shown in the final map as later described, but since little if any field work will have been carried out in this first stage, the information will be largely unconfirmed. Different engineers may specify differing degrees of sampling and testing for this stage and it is therefore of great importance to clarify the engineer's exact requirements for a particular project. It is possible that no further work will be required after the first stage, in which case the draft map should be presented as a preliminary soil engineering map together with the appropriate report.

The second stage consists of the planning and execution of the field work necessary to pinpoint and define the problem areas affecting the route itself, to describe the detailed location and testing of borrow pits for construction material, locate suitable water sources if necessary, and to report on the

investigation for deep cuts and high embankments and foundations for bridges or flyovers. Although this stage is essentially the province of the engineer, the expertise of the engineering geologist can be of great benefit.

Stage three consists of the correlation of all information into a report and the production of a detailed soil engineering map. Borrow areas will have been located, tested and proved. Problem areas will have been fully investigated and potential construction problems evaluated. The final report and map will thus include all the information relevant to the materials design and construction of the project.

3.2 STAGE 1

3.2.1 General

The draft soil engineering map required for Stage 1 can consist of a map prepared from aerial photographs, an overlay to an aerial photograph mosaic, or an annotated aerial photograph mosaic. The draft map must delineate all significant soil units as later defined in this text.

3.2.2 Construction materials

The draft map must indicate the probable sources of construction materials and the accompanying report must give sufficient detail to permit planning of the actual location, and sampling and testing of the construction materials. All materials must be indicated and discussed, and must be dealt with in relation to bulk fill, selected subgrade, subbase, base, binder material, and coarse and fine aggregates for concrete and surfacing materials. The report must discuss the occurrence of the materials in the area under consideration with specific reference to any problems that may be encountered.

These problems must be discussed under the following headings, where applicable:

- (a) Thickness of overburden and any problems associated with the overburden.
- (b) Nature of underlying material and any problems associated with the same.
- (c) Probable thickness of material with particular reference to variation in thickness.
- (d) Variability of the material.

- (e) Weathering characteristics and consequent effects on material properties.
- (f) Environmental considerations dictating location of borrow areas.
- (g) Access to borrow areas.
- (h) Land use as a guide to possible expropriation costs and hence best location of borrow areas.
- (i) General directives concerning sources of water for construction purposes.

3.2.3 Profiling and sampling

During Stage 1 investigation, where required, sufficient test pitting and sampling should be carried out to substantiate the statements made in the accompanying report. Test pitting must be carried out in sufficient detail to indicate the probable thickness of likely sources of construction material and to determine details of overburden, underlying material and variation in thickness. Sampling must be carried out from selected trial pits in such a manner as to provide as reasonable a picture of the probable sources of construction material as possible. Only the relevant horizons within soil units of possible engineering importance to the project need be sampled sufficiently for indicator and grading analysis. The location of all test pits must be clearly shown on the accompanying preliminary map and fully described in the report, and the source, including horizon, of all samples taken for testing clearly identified. Drilling and blasting are not intended to form part of the Stage 1 investigation but, where possible from surface exposures, some indication of the hardness of aggregates for use in basecourse, concrete and surfacing would be of value. It must always be borne in mind that the purpose of the preliminary map is to enable efficient planning of the detailed field investigation to be carried out, and that the information should be presented in a form which will assist this operation.

3.2.4 Testing

Generally, laboratory testing for Stage 1 of soil engineering mapping should consist only of grading and Atterberg limit tests. The engineer may, however, require that some initial CBR testing be carried out on samples. Where samples of potential aggregates for base, concrete and surfacing have been obtained, appropriate tests should be carried out.

3.3 STAGE 2

Once the Stage 1 draft map has been prepared and the report completed, the field work required by the engineer can be planned and executed (Stage 2). This includes the detailed location and testing of borrow areas, the centre line soil survey and investigations of problem areas.

As already indicated, the engineer may not require that Stage 2 investigation be carried out. In this case the information from the Stage 1 work would normally be presented in the form of a preliminary soil engineering map and report, the map being in effect a neater version of the draft map referred to earlier.

3.4 STAGE 3

3.4.1 General

Once the detailed investigation of Stage 2 is complete, the soil engineering map must be finalized and all information, including that from Stages 1 and 2 of the investigation, must be correlated. The draft soil engineering map will have been refined, construction materials located, sampled and tested, and construction borrow areas and quarries proven. This information, together with centre line sampling and test results, will normally be bound with the map into a report prepared by the materials engineer. This report generally accompanies the construction documents. Since detailed results and treatment, where necessary, are dealt with on the individual borrow area sheets, the discussion in the report should be more general and draw the attention of the construction engineer to any problems he may encounter in working proposed borrow areas and quarries. If required, recommendations for the restoration of borrow areas and extensions to the same may be included in the report.

3.4.2 Preparation of the map (for example see Fig. 4)

- (a) The *title* of the map must be 'Soil Engineering Map'.
- (b) The *scale* of the map must be decided in consultation with the engineer but will normally be 1:20 000.
- (c) The *size* of the map should ideally be A4 fold-out but this can seldom be achieved in practice. The size of the map must therefore be decided in consultation with the engineer and the map should normally be orientated so that the axis of the road is in the centre of the length of the map, with the north point clearly indicated.
- (d) The *centre line* must be shown clearly on the map, and staked values (km) must be marked.

- (e) The *width of the corridor* to be mapped will depend on circumstances and must be decided in consultation with the engineer. It will usually be approximately 3 km to either side of the road.
- (f) The *topography* and *planimetry* must be shown in sufficient detail to allow easy orientation. The symbols as shown on the 1:50 000 topocadastral map series must be used, supplemented by the symbols shown in Table 1.
- (g) The soil engineering map must therefore represent geology, soil units and problem areas by a combination of the appropriate background *colours* and material and problem *symbols*.
- (h) A *soil unit* is a volume of soil with a consistent profile with respect to its succession of layers. The thickness of the layers need not be uniform from point to point within the unit, but the geotechnical properties of any one layer must be reasonably consistent.
- (i) *Mapping codes*
 - (i) The basic geology of an area must be represented on a soil engineering map by the lithostratigraphic description of the material and shown by colours similar to those used on the geological maps prepared by the Geological Survey of the Republic of South Africa.
 - (ii) A soil unit must be shown on the soil engineering map by using either one conventional map symbol (as shown in the first part of Table 2) for a simple one-material profile, or an appropriate combination of these symbols for a mixed profile.
 - (iii) Problem areas, involving for example adverse subgrade conditions or potential construction difficulties, may also be shown on the soil engineering map by using symbols in addition to those depicting the soil unit. Examples of such symbols are given in the second part of Table 2.
- (j) *Faults, dip and strike* may be shown if significant, using standard map symbols as approved by the Association of Engineering Geologists.
- (k) *Proven quarries and/or pits* must be indicated by the symbols given in Table 1. The land form in which they occur and the Transportation Research Board (TRB) classification of the different soil horizons must be given on the quarry sheets.
- (l) *Land form* is defined in the chapter on Materials Data Banking (p. 22).

- (m) *Profile sites* of technically significant soil profiles, if discussed in the report, must be clearly marked on the map for easy recognition.
- (n) *Abbreviations* used must be in accordance with the standard list given in Table 3.

GEOLOGICAL NOMENCLATURE		SOIL TYPE	
Dolomite	Do	Clay	cl
Calcrete	Calc	Silt	st
Ferricrete	Ferr	Sand	s
Silcrete	Silc	Pebbles	peb
Quartz	Qtz	Gravel	grav
Quartzite	Qtzte	Boulders	bldrs
Quartzitic	Qtztc		
Shale	Sh	STATE OF WEATHERING	
Sandstone	Ss	Highly weathered	H. Weath
Mudstone	Ms	Weathered	weath
Limestone	Ls	VISUAL ASSESSMENT OF FINES	
Tillite	T	Clayey	cly
Dolerite	Dol	Silty	sty
Basalt	Ba	Sandy	sdv
Ventersdorp Lava	VentLava	GENERAL DESCRIPTIONS	
Granite	Gr	Hard	H
Norite	Nor	Residual	res
COLOURS		Indurated	ind
Blue	B	Not sampled	N/S
Black	Bl	Not tested	N/T
Brown	Br	Oversize	O/S
Grey	G	Transported	tpd
Red	R	Fragments	Frag
Yellow	Y	Aggregate	Agg
White	W	Water Table	W/T
Khaki	Kh	Extension	Uitbr
Mauve	M	Adjacent	Aang
Purple	P	Lime	L
Orange	O	Slag	Sl
Green	Gn	Cement	C
Olive	Ol	Optimum Moisture Cont	OVG
COLOUR INTENSITY		Max. Dry Density	M.D.D.
Light	lt		
Dark	dk		

TABLE 3

*Key to abbreviations used in soil descriptions and
general borrow pit data*

Access to borrow areas	Groundwater hydrology
Bridge foundations	Landslides
Collapsing soils	Material in deep cuts
Construction water	Mineral springs
Dykes	Restoration of borrow areas
Earthquake areas	Rippability
Environmental considerations	Sink-holes
Erodible slopes	Subsidence areas
Expansive soils	Temporary river crossings
Faults	Undermined areas
Flood potential	Unstable slopes
Founding for embankments	Variability in materials

TABLE 4

Aspects to consider in evaluating problem areas and potential construction and maintenance difficulties — subgrade conditions and borrow areas

3.4.3 Preparation of the report

- (a) The size of the report must be A4.
- (b) *Problem* areas involving subgrade conditions and potential construction difficulties must be discussed in detail and must cover the relevant items from those listed in Table 4 and any other items pertinent to the project.
- (c) The *availability of construction materials* within the area of the project must be discussed in the order in which construction is normally carried out, namely:
 - fill
 - selected subgrade
 - subbase
 - base
 - aggregates

Aggregates must include both surfacing aggregates and coarse and fine aggregate for concrete work. Binders will normally be discussed under the heading base but, if required for mechanical stabilization of

lower layers, must be discussed where relevant. Any other items of construction material pertinent to the particular project, e.g. drainage filter materials, must be included where applicable.

- (d) *Stabilization*, if required, must be discussed in broad outline with details given on forms similar to Table 5 in the report.
- (e) *References* used should be quoted by author and title and listed at the end of the report.
- (f) A *lithostratigraphic column* for the area under consideration must be given.
- (g) A *geological section* along the route must be given (A4 fold-out; black and white) summarizing subgrade conditions, stability, drainage, rippability, etc. (For example see Fig. 5).
- (h) *Test results* must be presented on forms similar to Table 5.
- (i) *Soil profiles* should generally be described according to the procedure outlined by Jennings, Brink and Williams³.

Any other items of
project, e.g. drainage

broad outline with
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Table 5.
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TABLE 5
Summary of test results for storage in Data Bank

4 MATERIALS DATA BANKING

4.1 OBJECTIVE OF DATA BANKING

The National Data Bank for Roads (NDBR) is operated as a materials data bank. Its objective is to supply, with reasonable accuracy, the following information for a given area:

- (a) Material localities
- (b) Material uses
- (c) Material problems
- (d) Construction hazards related to materials.

If the given area is already traversed by an existing road, most of the information required can be obtained from old material survey data. If, however, the given area is virgin land as far as road construction is concerned, the provision of information as detailed above becomes a matter of extrapolation from known areas.

4.2 PRINCIPLES ON WHICH MATERIALS DATA BANKING AND EXTRAPOLATION ARE BASED

4.2.1 Parent rock, climate and relief

The more important soil-forming factors which are considered responsible, over a period of time, for the technical properties of any material or soil class are the natural conditions: parent rock, climate and relief. If any of these parameters change, the material types and problems change as well; on the other hand, one may expect the same technical properties in materials which are found in different localities but have the same parameters. Such a group of related materials has been termed a material analogue and is defined as 'a number of material classes with the same parent rock, climate and relief'.

Consequently, the following standard references have been introduced by the NDBR for the coding of materials data and the description of material analogues:

- (a) Applicable terms from the legend of the 1:1 000 000 geological map of

the Republic of South Africa and South West Africa for the lithostratigraphical (material/age) description of the construction materials.

- (b) The climate of the locality where the material was found, according to Figure 2.

The NDBR is not quite satisfied with the N-value concept as a climatic reference for materials data banking, and the use of mean rainfall ranges is being investigated.

- (c) The relief of the area (ca. 25 km²) with respect to the road according to Table 6.

4.2.2 Land form

This general principle, however, is not sufficient to provide a field team with directives in their search for materials and a further reference is required indicating where materials with specific engineering properties may be located within an area of the same material analogue (as defined above). It has been found that the most acceptable and practical reference is an indication of the relevant land surface forms. The land form has therefore been chosen as a sub-unit for materials data banking and is defined as 'a term used by the NDBR for materials data banking, which describes the surface form of the locality of road construction materials or soil classes'. Material or soil class, in turn, is a material unit which is found in a specific land form and contains materials with reasonably uniform engineering properties; it is a sub-unit of a material analogue.

Terms for describing the more important land forms are given in Table 7.

4.2.3. Construction problems

It has been found that construction problems, as shown in Table 8, and construction experience are sometimes related to material analogues and sometimes to land surface forms. No definite and relevant materials parameter for banking such data can therefore be singled out. Material analogue and/or land form may be referred to.

4.2.4 Engineering properties

Finally, the engineering properties of construction materials must be described quantitatively (e.g. by test results, Table 5). To store this information so that it can be effectively re-used, an efficient banking code is required, and the material analogue is used for this purpose.

4.3 PROCESSING OF DATA FOR BANKING

Any data may be stored for re-use in the NDBR provided they are related to materials and can be tied to material analogues. To make data banking a routine operation a number of forms have been developed. These are listed below and an example of each is given.

4.3.1 Test results from routine material surveys (quarry sheets) and borrow pits approved during construction

These should preferably be entered on a form similar to that reproduced in Table 5. The 'land form' must be identified and named according to the standard list of land forms given in Table 7. It is sufficient for the reference number to be entered in the space provided.

4.3.2 Information on construction experience (Table 8)

This may be submitted during or after completion of the road. It is intended to be used to indicate possible construction problems related to particular material analogues, at a future date.

Ideally, the information should be submitted during construction.

4.3.3 Miscellaneous Information

The NDBR also stores information produced during mapping or other operations. Since this is also tied to material analogues and land forms if possible, it will be supplied as part of the answer to a routine enquiry together with the information mentioned above. Examples of such information are soil profiles or geological sections.

provided they are related to
To make data banking a
developed. These are listed

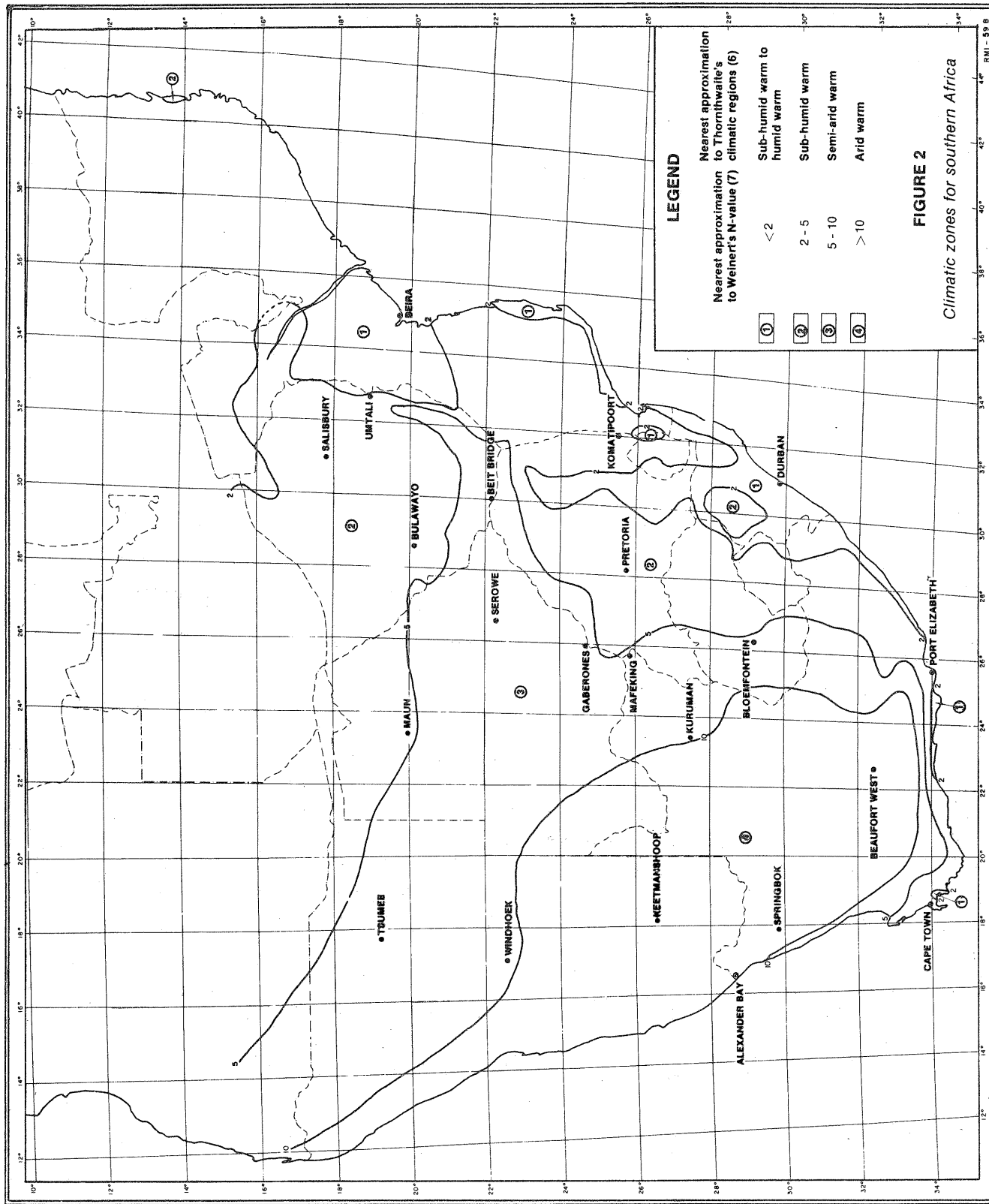
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f the road. It is intended to
ems related to particular
g construction.

g mapping or other opera-
d land forms if possible, it
enquiry together with the
formation are soil profiles



RELIEF CLASS	PHYSIOGRAPHIC DESCRIPTION	RELIEF (m)
1	<i>Nearly flat plains</i> — low relief, much of it nearly level.	< 5
2	<i>Rolling and irregular plains</i> — fairly low relief with high percentage of near-level land; no high steep slopes.	5 - 100
3	<i>Low hills</i> — moderate relief; low percentage of near-level land.	100 - 200
5	<i>High hills</i> — moderate to high relief; low percentage of near-level land.	200 - 300
7	<i>Low mountains and escarpments</i> — high relief; low percentage of near-level land.	300 - 1 000
8	<i>High mountains and escarpments</i> — very high relief; little near-level ground.	> 1 000

TABLE 6

Relief classes as applied to materials data banking

**SUMMARY OF POTENTIAL MATERIAL SOURCES:
MATERIAL ANALOGUE**

REF. NO.	LAND FORM GROUP	DESCRIPTIVE TERMS	NUMBER OF BORROW PITS FOUND IN PREVIOUS INVESTIGATIONS*
1	Crest	1.1 Mountain crest	
		1.2 Hill crest	
		1.3 Ridge crest	
		1.4 Plateau crest	
		1.8 Bump	
2	Free face/cliff	2.1 Free face/cliff	
3	Slope	3.1 Talus slope	
		3.2 Convex side slope	
		3.3 Concave side slope	
		3.4 Constant slope	
		3.5 Pediment	
		3.6 Ledge	
		3.7 Landslide	
		3.8 Fan	
4	Plains and dunes	4.1 Plain	
		4.2 Shifting dunes	
		4.3 Stabilized dunes	
		4.4 Dune street	
5	Drainage features	5.1 Gully head	
		5.2 Gully	
		5.3 Pan side	
		5.4 Pan floor	
		5.5 River terrace	
		5.6 River bank and/or levee	
		5.7 Flood plain	
		5.8 Swamp	
		5.9 Delta	
		5.10 Sand bank	
		5.11 River channel	
6	Solution featires	6.1 Subsidence area (doline)	
		6.2 Sinkhole	
7	Surface water	Dams, springs, lakes	
8	Coast	8.1 Lagoon	
		8.2 Raised beach	
		8.3 Beach	
TOTAL			

TABLE 7

*Descriptive terms for land forms used by the
National Data Bank for Roads (2)*

MATERIAL ANALOGUE:

PROBLEM (underline those encountered)	LAND FORM	REMEDY RECOMMENDED AND REMEDY APPLIED
Access Flood potential Subgrade moisture conditions Unstable slopes Landslides Slope erosion Active material Swelling soils Collapsing soils Subsidence area Sink-holes Rippability Material contamination encountered		

Interpretative comments that the resident engineer feels are relevant:

TABLE 8

Summary of possible construction problems (2)

4.4 SERVICE PROVIDED BY THE MATERIALS DATA BANK

Table 9 shows in a general way which information can be provided by the NDBR and which cannot.

More specifically, information may be requested for planning the material survey and certain limited aspects of the design of a road, although all the information obtained must be confirmed in the field. Data bank staff will issue the enquirer with the relevant information described in the previous section and with a 'summary of potential material sources' given on the form shown in Table 7. The latter form is intended to show the enquirer in which land form, within a material analogue, material sources have been found in the past and, consequently, where the probabilities for new borrow pits will be highest.

A material survey team will therefore be able to concentrate its efforts on the most probable material localities and have a fair warning of potential construction hazards.

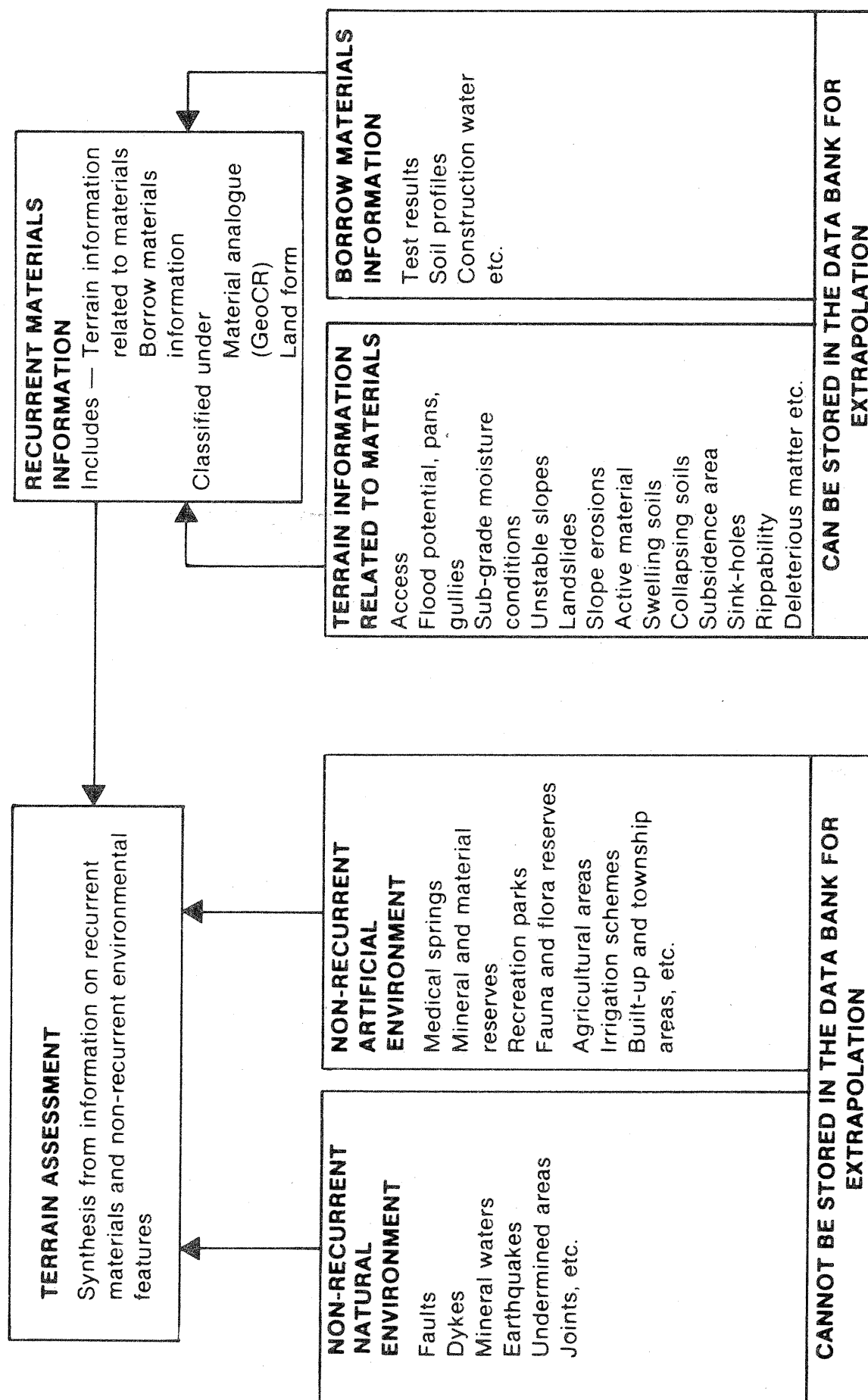


TABLE 9

Some environmental and material aspects affecting road construction and design arranged according to their banking potential (1)