Course content

1 Introduction
2 Performance
3 Design
4 Construction
5 Maintenance
6 Management
7 Investigation & maintenance measure selection
8 Safety aspects
9 Rehab, improvement and upgrading

3 DESIGN

3.7 Material location

- Becoming increasingly difficult to find suitable materials
- Many good sources are worked out or inaccessible
- Material location is a science that is being lost !
- Routine process suggested
- Check existing information
  - Local sources and quarries
  - Experienced staff and local residents
  - Existing source records
  - Construction documentation
- If unsuccessful embark on full process
- Must clarify needs first – properties, how much?, etc

3 DESIGN

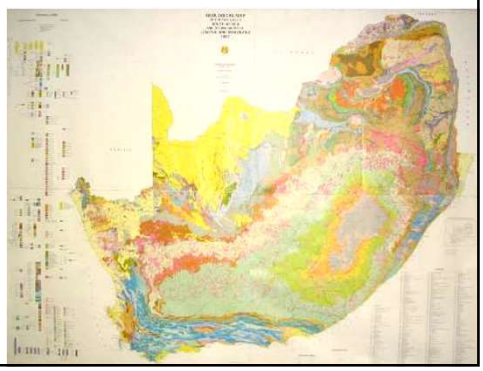
3.7.1 Material location process

- Developing a basic understanding of the local geology and geomorphology
- Developing an understanding of gravel indicators
- A desktop study of maps and aerial photographs
- A reconnaissance survey
- A detailed field survey
- Reporting

3 DESIGN

3.7.2 Basic understanding of local geology and geomorphology

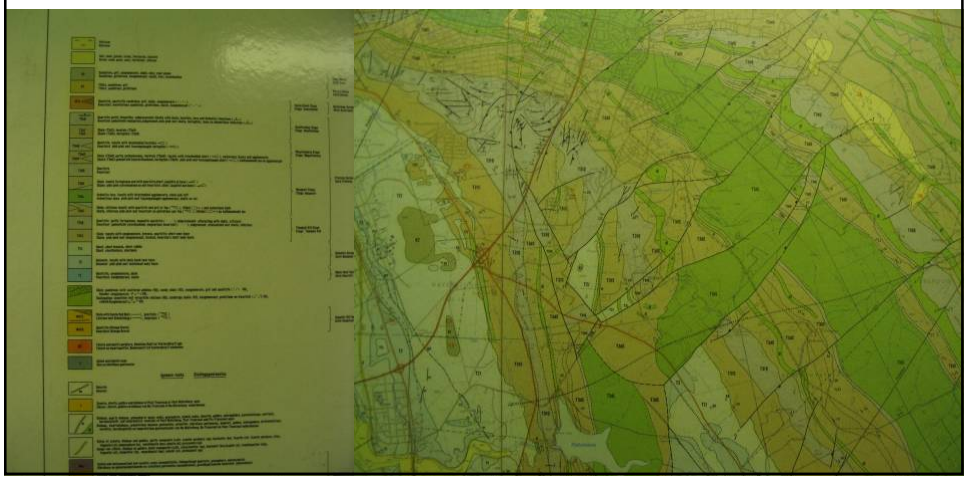
- Assess available maps
  - Geological and topographical
  - 1:50 000 to 1: 1 000 000
- Material types
  - Lithology
  - Decomposition or disintegration (climate)
  - First indication
  - Accompanying Memoir



3 DESIGN

3.7.2 Local geology and geomorphology

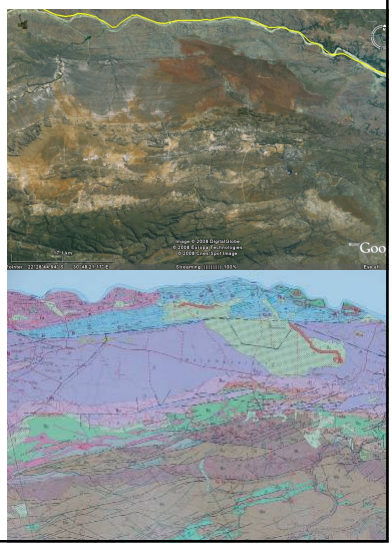
1 : 50 000



3 DESIGN

3.7.2 Local geology and geomorphology

- Topography
  - Topo sheets
  - Google Earth
- Use to identify:
  - Landforms/ weathering (function of erosion cycles)
  - Roads
  - Quarries/mines
  - Water, etc
- Depth of weathering
  - Depends on geomorphology, topography material type, water,
  - Can be highly variable

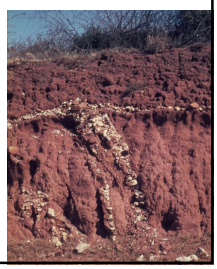


3 DESIGN

3.7.2 Local geology and geomorphology

- Soil profiles
- Transported material may be on top
- Most gravels from B and C
- Sample and test these layers
- PI generally decreases downwards

A	Organic top soil
B	Residual soil – no structure
C	Weathered rock - structured
R	Unweathered rock



3 DESIGN

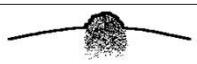
3.7.3 Understanding gravel indicators

- Three main gravel indicators
  - Landform
  - Botanical indicators
  - Animal activities
- Landform
  - Configuration of ground surface
  - Distinctive shape
  - Different gravels associated with different landforms

3 DESIGN

3.7.3 Understanding gravel indicators

- Outcrops
  - Resistant materials – possible quarries
- Geomorphology (NB)
  - Ridges (dykes, sills, cliffs) - resistant rocks
  - Depressions – softer materials
  - Flat areas deeper weathered than steeper
  - Floodplains (gravels)
  - Pans (calcrete and silcrete)
  - Gully heads (ferricrete)
- Landforms of rock regions

Landform	Diagram (cross-section)
Flat hill top Flat, level hill top (plateau) with sharp edges at margins	
Sloping hill top Inclined, flat hill top with sharp edge between (steep) scarp slope and (more gentle) dip slope	
Conical hill Hill with pointed top, more or less circular in plan. Sides may be irregular or smooth **Mound** Rounded hill top with convex slopes, or convex 'bump' on a plateau or hill top	 
Ridge Long, straight, narrow ridge running across country. Usually formed by an igneous intrusion (dyke or sill) or a quartz vein	
Trench Long, straight, narrow depression running across country. Like the Ridge landform (above), usually formed by an igneous intrusion. However, in this case the surrounding rocks are more resistant than the intrusion. Sometimes the trench is formed by a pair of closely-spaced parallel ridges, formed by he surrounding rock being 'baked' hard by the heat of the intrusion	
Footslope Gentle slope at the foot of a steeper slope, formed (in this case) by the accumulation of pedogenic gravel (usually ferricrete) in the soil profile	
Terrace Raised platform situated at the edge of a valley, deposited by a river	
Floodplain Broad, flat valley floor with winding river. Sand and gravel accumulate on the inside of river bends	

Gravel type	Parent material	Landform	Possible engineering problems
Residual gravels			
Weathered rock	Lava	Flat hill top, sloping hill top	Lava of basic composition may contain weatherable minerals
	Igneous dyke	Ridge or trench	Lavas of basic composition may contain weatherable minerals
	Igneous sill	Ridge on side of hill	Lavas of basic composition may contain weatherable minerals. Sill may be difficult to exploit, owing to position on side of hill (- overburden)
	Granite, gneiss	Mound, None	Gneisses may contain weatherable minerals
	Quartzite	Ridge, sloping hill top, flat hill top, mound	Poor mechanical interlock of particles
	Sandstone	Mound, flat hill top None	Particles may be rather soft
	Conglomerate, breccia	Flat hill top, sloping hill top, mound None	Conglomerate particles are rounded. Properties of the coarse particles may be different from those of the matrix
	Limestone, marble, dolomite	Flat hill top, sloping hill top, mound None	
Vein quartz	Granite, gneisses of all types	Ridge	Poor mechanical interlock of particles
Transported gravels			
Quartz stone line		Footslope None	Poor mechanical interlock of particles. May tend to contain too many fines.
Colluvium		Footslope	May contain too many fines
Alluvium		Terrace Floodplain	Rounded particles, often sandy and lacking in fines

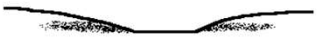
3 DESIGN

3.7.3 Understanding gravel indicators

- Landforms of sand regions

Note:

- Gravel particles may be present at the surface as a result of wind (winnowing)
- May not reflect profile
- Always check

Landform	Diagram (cross-section)
Pan with 'platform' Flat-floored pan with no or minimal vegetation. 'Platform' is a low bench situated on the edge of the pan but usually not extending all the way round. May be more than 500 m across, or less	 Note: Platform is not usually as distinctive or obvious as shown here
Pan without 'platform' Flat-floored pan with no development of a low bench around the edge. May be more than 500 m across, or less. May be without vegetation, or contain grasses	
Depression Concave hollow in the sand surface, containing grasses. The grass communities are often arranged in concentric zones around the depression **Inter-dune hollow** Very long, straight concave channel in sand surface. One of many forming parallel linear rises with hollows between. Calcretes are developed at intervals along the line of the hollow.	 
Valley (old river channel) A dry river valley, filled in with sand. Takes the form of a broad, gentle elongated depression that extends for many kilometres. In places, easily visible on the ground but in others, so wide and shallow as to be hardly detectable.	
Grey sand No topographic relief, only grey sand contrasting with surrounding reddish or brown sands	

Landform	Material	Characteristics and comments
Pan with platform Around rim	Calcrete, possibly hardpan or nodular Silcrete	The best quality calcrete is found in the pan platform
Pan without platform Around rim	Calcrete Silcrete	Good calcrete may occur but is not usual. Quality is not predictable. Large pans may contain hard or boulder calcrete
Depression	Calcrete can be nodular. Often no occurrence, or calcareous sand	Usually poor quality calcrete. May occur on the side slopes
Inter-dune hollow	Calcrete and silcrete hardpan or honeycomb or nodular	Locally, good quality materials but generally none over most of the hollow's length
Valley (old river channel)	Calcrete, possibly hardpan or nodular	Locally, good quality materials but generally none over most of the valley's length. Some valleys contain extensive calcified sands
No landform - grey sand only, contrasting with surrounding red sand.	Calcareous sand. Possibly some calcrete	Usually poor quality calcrete but may be better if sand is non-plastic. Blackish sands usually yield better quality material

3 DESIGN

3.7.3 Understanding gravel indicators

- Botanical indicators

- Certain plants directly reflect the composition of the material that they grow in
- However plants are adaptable
  - Absence or presence of indicator does not necessarily mean absence or presence of the material
  - Also does not indicate that material may be suitable for use
  - Indicators !
- Identification of plants not always easy
- Don't actually need to identify - look for changes
  - Morphology - stunted, multi-stemmed, etc

3 DESIGN

3.7.3 Understanding gravel indicators

- Botanical indicators

- Particularly useful for "monominerallic" materials, eg pedocretes, when water affected and dykes and intrusions

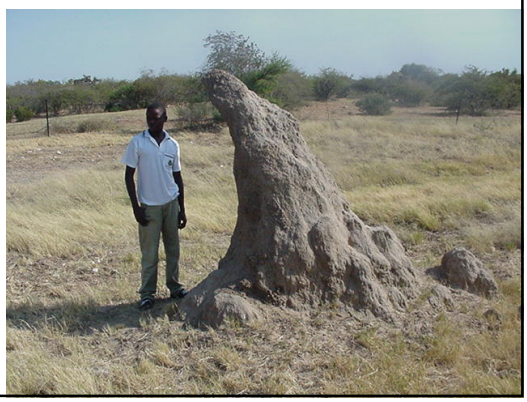
3 DESIGN

3.7.3 Understanding gravel indicators

- Botanical indicators
- Beware of:
  - Influence of man – removal and planting
  - Overgrazing – selective removal
  - Bush fires – removes some species
  - Riverine vegetation

ANIMAL ACTIVITIES

- Termites
  - Natures deep soil samplers
- Burrows (porcupines, warthogs, aardvarks, etc)
  - Material removed
  - Soil profile
- Licks
  - Salt areas



3 DESIGN

3.7.4 Desktop study

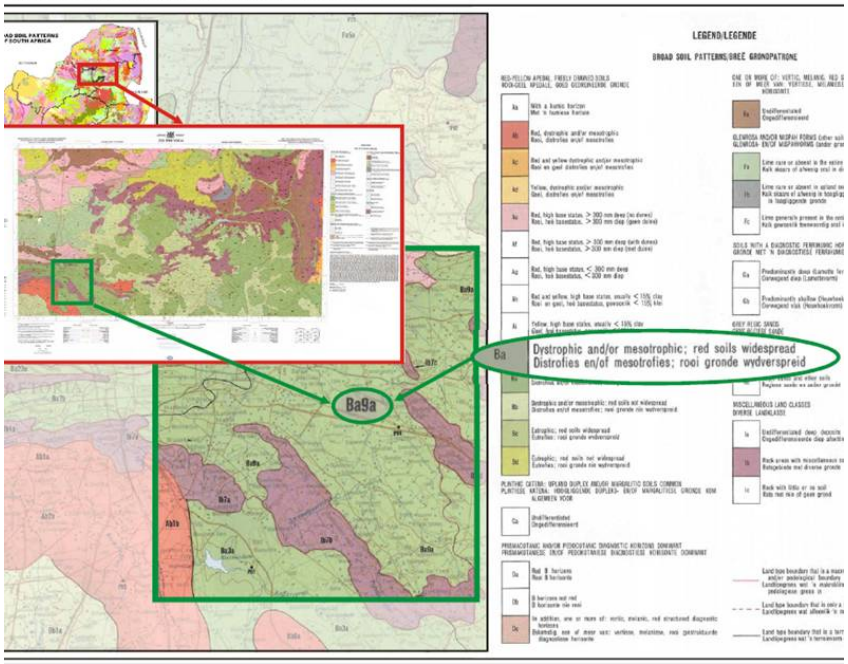
- Topographical maps
- Geological maps
  - Note:
  - Indicates underlying geology – as if no soil were there (except young sands)
  - Maps don't show gravels – Memoirs may indicate
  - Gravels may relate to geology – eg, quartzitic materials

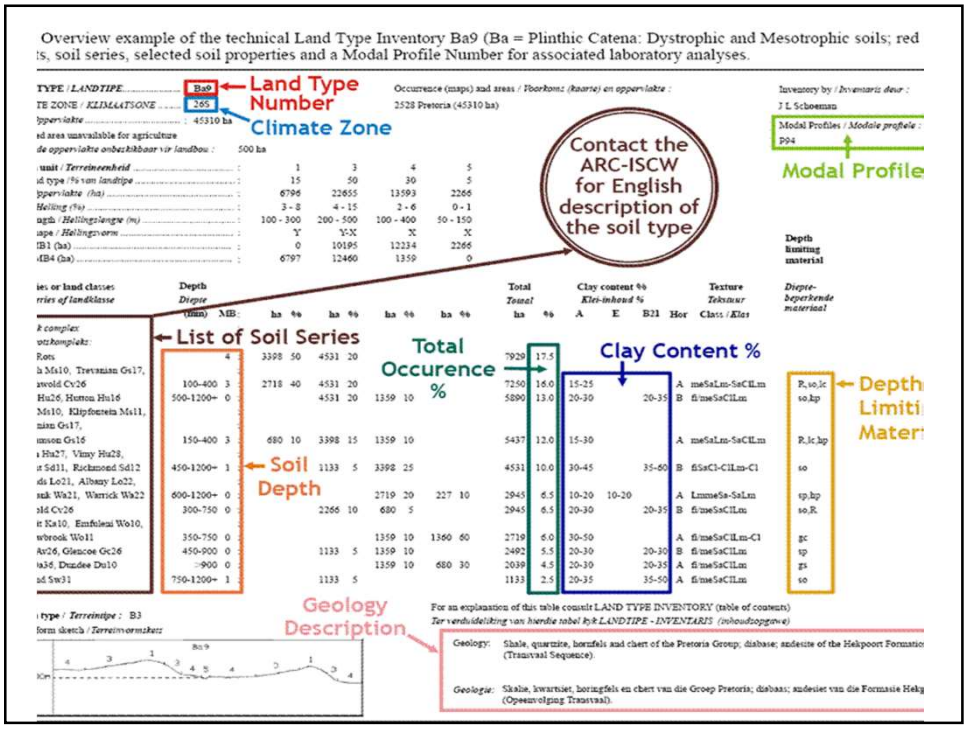
3 DESIGN

3.7.4 Desktop study

- Soil (agricultural) maps (1: 250 000)
  - Problem soils (vertisols, halomorphic soils (solonetz, solonchaks, etc))
  - Accompanying memoir
  - Depth limiting materials, etc
  - Pedogenic materials

A 1: Overview example of the 1 : 250 000 Land Type Map 2528 Pretoria (1° x 2° size). The Land Type Ba9 and its legend de
ıckground location is visible. A Broad Soil Pattern map is inset.





3 DESIGN

3.7.4 Desktop study

- Aerial photographs
  - Tone and texture
  - Lineaments
  - Relief and landforms
  - Drainage
  - Vegetation and land-use
  - Human features
  - Aerial photos can be viewed in 3-d
- Satellite photographs
  - Improving all of the time
  - LiDAR, InSAR, etc
  - False colour
  - All can be useful

PRELIMINARY MAP

- Terrain map
- Land pattern-facet map (out of fashion, but many are asking why?)
  - Pattern - geomorphological unit in a single occurrence
  - Facet – smaller geomorphological units – reasonably consistent engineering properties
- Annotated photo mozaic

Terrain map

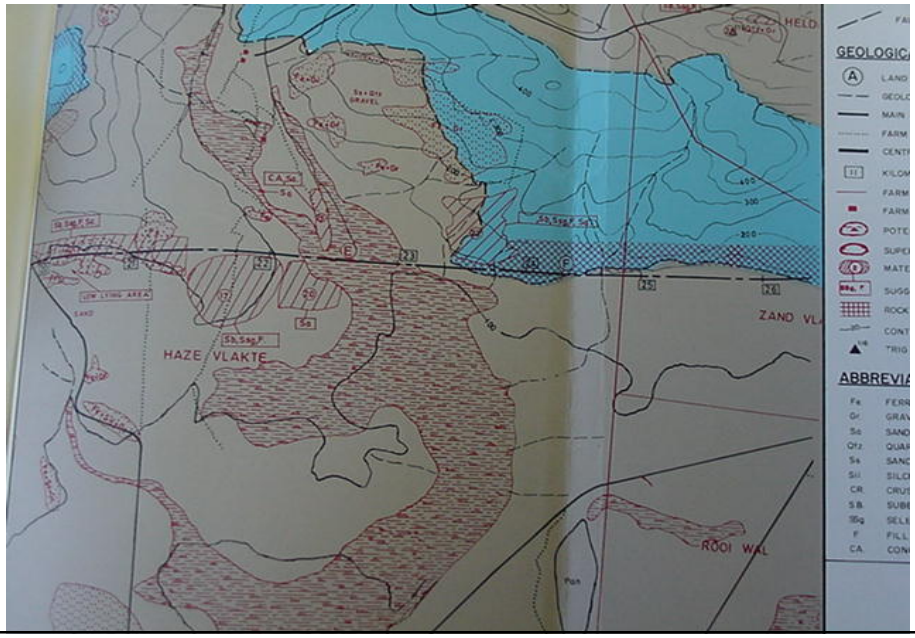
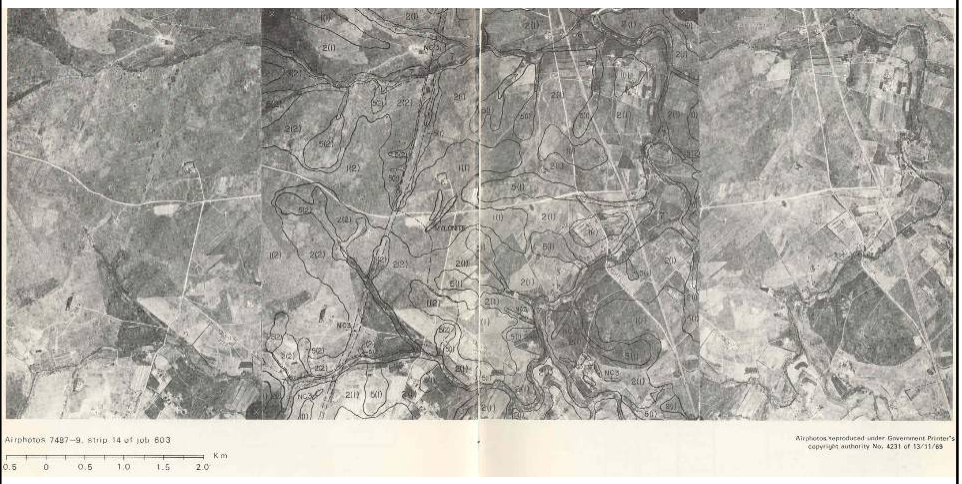


Photo mozaic/triplet



Land pattern/facet

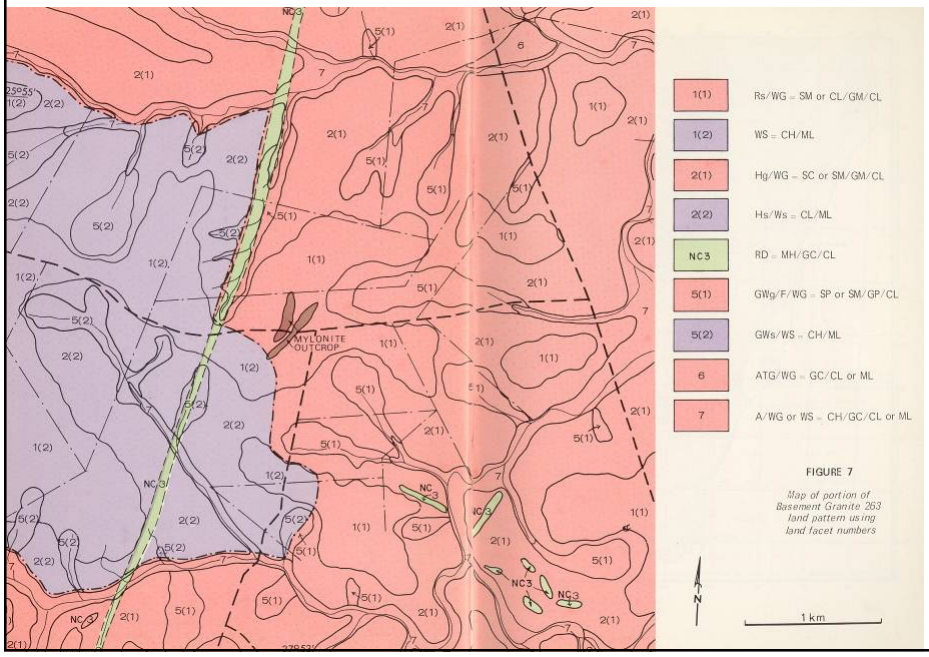


FIGURE 7

Map of portion of Basement Granite 263 land pattern using land facet numbers

Land pattern/soil classification

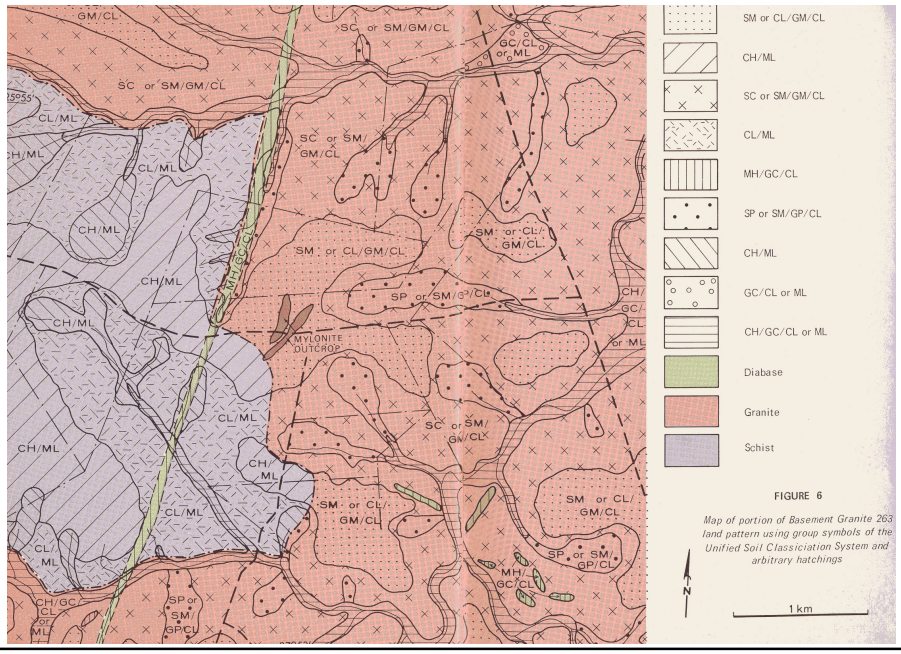


FIGURE 6

Map of portion of Basement Granite 263 land pattern using group symbols of the Unified Soil Classiciation System and arbitrary hatchings

Land pattern/soil profile

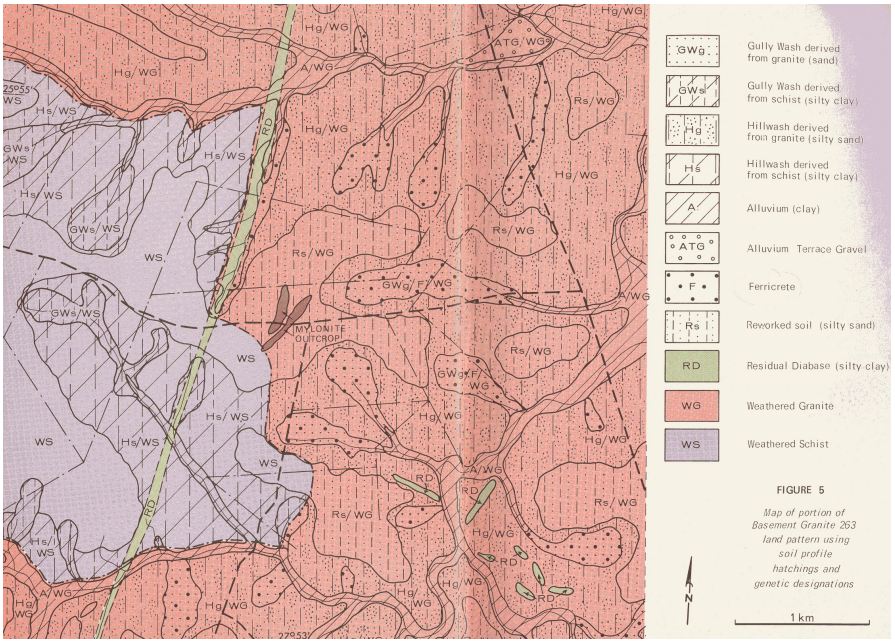


FIGURE 5

Map of portion of Basement Granite 263 land pattern using soil profile hatchings and genetic designations

Soil profiles of facets

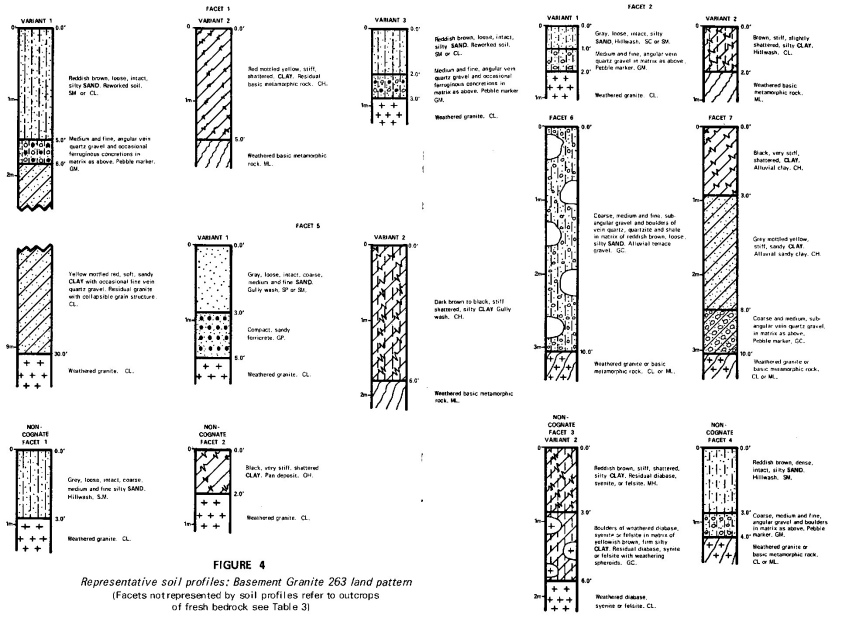


FIGURE 4

Representative soil profiles: Basement Granite 263 land pattern
(Facets not represented by soil profiles refer to outcrops of fresh bedrock see Table 3)

Desk study methodology

- Project briefing
  - Purposes and quantities of materials
- Interpretation of background information
  - Collection and analysis of all available information
- Collation of information (20 steps in document)
  - Prepare base maps
  - Insert all information
  - Identify most likely sites
  - Obtain permission to enter land
  - Develop field survey methodology

Regions	Methodology									
	Desk study				Field survey					
	Geological maps	Air photos	Satellite images	Past records	Macro topography	Micro topography	Vegetation	Animal	Soil colour	Aerial survey
Rock	1	1	2	1	2	1	2	2	3	2
Sand	2	1	2	1	3	1	1	1	1	1

1 Strongly recommended
2 Useful
3 Of marginal benefit

Desk study methodology

- At end of desk-top study
  - Location of potential materials (and their indicators) should be known and transferred to the base map
- The field survey can then be planned
  - Logistics
  - Resources (equipment and labour)
  - Appropriate sampling equipment (bags, etc)

Reconnaissance survey

- Purpose
  - Familiarise with the corridor, mark existing pits and potential sites
- Procedure
  - Systematically traverse the area relating data on the base map to the prospecting corridor
  - 11 points suggested
    - Confirm base map data, look for things missed, plot GPS coordinates, etc

Reconnaissance survey

- May be difficult in flat terrain or thickly wooded areas
  - Use helicopter or ultralight aircraft

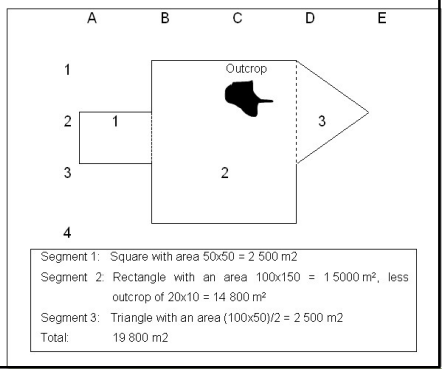
Detailed field survey

- Objectives are to establish:
  - Areal extent of gravel sources
  - Thickness and quality of deposits
  - Characteristics of deposits (which layers can be used)
  - Type and properties of overlying materials
  - Thickness and volume of overburden
  - Suitability of the material and wastage

- Involves:
  - Test pitting
  - Profiling (MCCSSO)
  - Sampling
  - Reinstatement of pits
  - Sketch and marking of limits, etc
  - Mini EIA (environmental, archaeological, etc)

Estimation of material quantities

- Full description
  - Define geometric shapes and calculate areas
  - Define thicknesses of layers
  - Calculate volume
  - Determine bulking , wastage, etc



Segment 1:	Square with area 50x50 = 2 500 m2
Segment 2:	Rectangle with an area 100x150 = 1 5000 m², less outcrop of 20x10 = 14 800 m²
Segment 3:	Triangle with an area (100x50)/2 = 2 500 m2
Total:	19 800 m2

Laboratory testing and materials report

- Routine indicator and classification tests (Chapter 3)
- Materials report
  - Record survey results
  - Record locations and depths of samples

- Two components
  - Factual report
  - Interpretive report and recommendations

3.8 Environmental and sustainability issues

- Increasing importance
  - Environmental impact of road
  - Environmental impact of obtaining material resources
  - Impact of operational issues (dust, erosion)
  - Sustainability issues – non-renewable resources
  - Minimise gravel losses

- Various requirements by law
  - National Environmental Management Act 107 of 1998
  - EIA Regulations of 2006

3.8 Environmental and sustainability issues

- Nature of project determines EIA requirements
  - Localised borrow pits – exemption from EIA may be obtained
  - In general, require either a:
    - Basic Assessment Report
    - Full Scoping and Environment Impact Assessment
- Even BAR requires :
  - Public notice and participation
  - Consideration of potential impacts (material extraction and construction operations)
  - Assessment of possible mitigation measures
  - Need for further investigations

3.8 Environmental and sustainability issues

- Full Scoping and Environment Impact Assessment
- Comprehensive programme
- Initial scoping report
  - Descriptions of proposed works, property and environment that will be impacted and social, biological, economic and cultural environment may be affected
  - Description of environmental issues and impacts, including cumulative impacts
  - Details of public participation process followed
- Followed by full EIA (specialist)
  - Following approval
  - Environmental Authorisation issued
  - Work can commence

EFFECT OF GEOLOGY

Too many geological materials to look at each one

Use Weinert's Engineering Geology Classification system

Classifies materials on basis of composition and weathering and ignores genesis

BASIC CRYSTALLINE ROCKS

Dolerite, gabbro, norite, amphibolite, greenschist, etc

Normally good materials

Often contain large hard spheroids – remove

Where N = 2-5 sugar dolerites – very good but may have insufficient plasticity

Where N < 2 often too plastic

Often very dusty

ACID CRYSTALLINE ROCKS

Granite, rhyolite, felsite, gneiss, pegmatite, etc

Normally low plasticity with some corestones

Usually have insufficient plasticity – corrugate – can be maintained out

Where N < 2 can be too soft and plastic

Usually not very dusty

HIGH SILICA ROCKS

Quartzite, chert, hornfels, vein quartz, etc
Usually lack fines and contain large stones – remove
Quartz porphyry tends to give good gravel
Cherts tend to be very dusty

ARENACEOUS ROCKS

Sandstone, arkose, conglomerate, mica schist, etc
Either form stony gravel or fine sandy gravel
Often form potholes and corrugations or thick loose material
Usually little dust

ARGILLACEOUS ROCKS

Shale, mudstone, phyllite, slate, etc
Usually either too clayey or too stony
Fine materials become very slippery and pothole
Fissile shales often good although stony and sharp
Widely used but mediocre performance
Invariably very dusty

CARBONATES

Dolomite, limestone, marble, etc
Usually weather to a chert wad – high silica
Carbonates dissolve
Not really used

DIAMICTITES

Tillite, greywacke, breccia, etc
Large stones (erratics) must be removed
Where N < 2 often too plastic
Often very dusty

METALLIFEROUS ROCKS

Ironstone, magnesite, magnetite, etc
High specific gravity – haulage costly
Low plasticity - corrugate
Often very dusty

PEDOCRETES

Ferricrete, calcrete, silcrete, gypcrete, etc

Ferricrete and calcrete are the most widely used wearing course materials in SA

Often contain oversize – remove

Silcretes may have insufficient fines

Gypcrete good but dusty

SUMMARY

Entire design process covered

Important to get it right and minimise costs