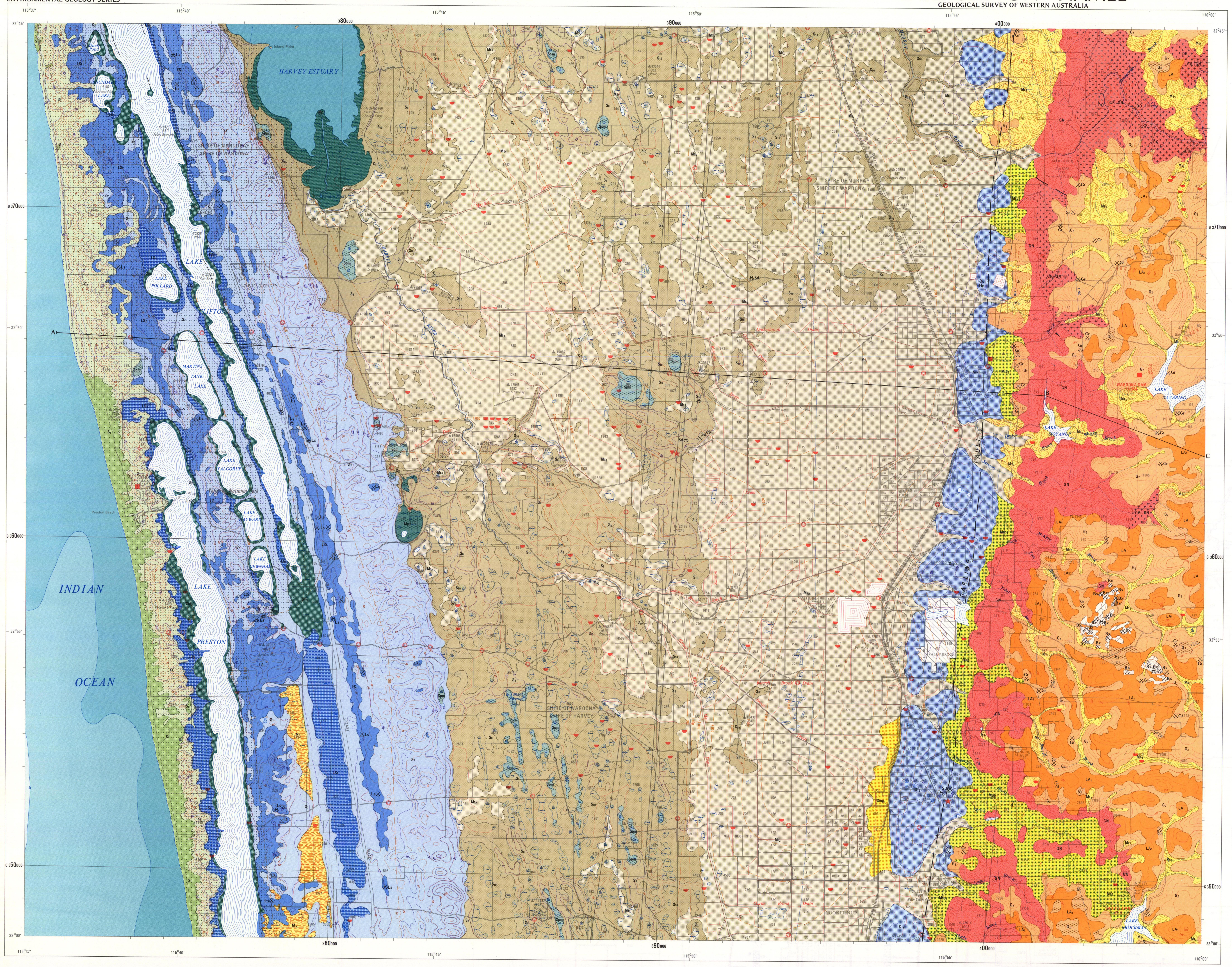
ENVIRONMENTAL GEOLOGY SERIES

LAKE CLIFTON—HAMEL

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET 2032 II AND PART 2032 III



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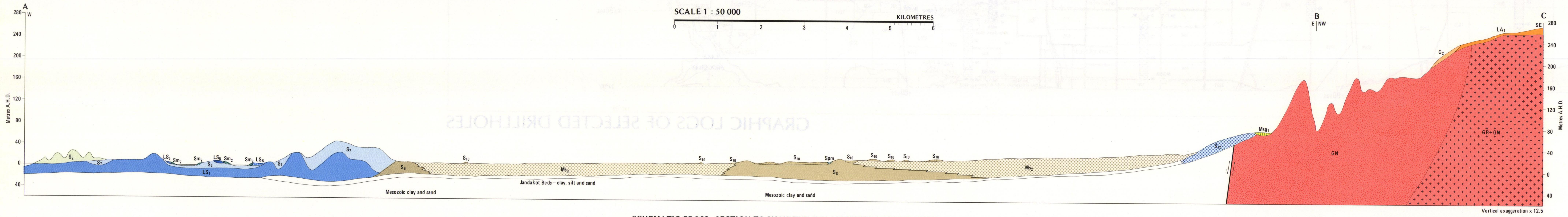


SCHEMATIC CROSS–SECTION TO SHOW THE RELATIONSHIPS OF THE UNITS

Age	Map unit[1]: Unconsolidated material[2]	Map unit[1]: Rock[2]	Description	Equivalent unit on geological maps	[4] Relief; Slope [5]	Industrial Mineral Resources	Shear strength	Compressibility	Permeability	Compaction	Shrink-swell potential	Cohesion	Ease of excavation	USC[7]	Current processes	Foundations	Road fill	Base course	Septic tanks	Sanitary land-fill	Excavation (mining and quarrying)	Notes
CAINOZOIC – QUATERNARY – HOLOCENE	Spm		PEATY SAND – greyish brown[3] and dark grey fine quartz sands, variable organic and silt contents	Swamp deposits (Qhw)	5–10 m; F		L	L	L–M	M	L	L–M	H	SM	Soil moisture changes, flooding	✕	✕	✕	✕	✕	○●	High water table, may be prone to flooding, variable bearing capacity due to organic content
	Mps		PEATY SILT – brownish black, soft, variable organic content, some fine to medium, sub-angular quartz sand		10 m; F		L	M–H	L–M	M–H	M	N–M	H	OL	Soil moisture changes, flooding	✕	✕	✕	✕	✕	○●	High water table, prone to flooding, variable bearing capacity due to organic content
	M5		CALCAREOUS SILT – light brownish grey silts and minor clays, shells and shell fragments and limestone are locally common, a re-cemented limestone is common on some low ridges	Estuarine, lagoonal and lacustrine deposits (Qhg)	5 m; F		L–M	M	L–M	L–H	L–M	N–H	H	ML	Soil moisture changes, flooding	✕	✕	✕	✕	✕	○●	High water table, prone to flooding, differential settlement may occur
	Mp		PEATY SILT – brownish black, soft, fibrous and colloidal peat mainly in upper layers		2–3 m; F		L	M–H	L–M	V	M–H	N–M	H	OL	Soil moisture changes, flooding	✕	✕	✕	✕	✕	✕	High water table, prone to flooding, differential settlement may occur
	Sm		SILTY SAND – brownish grey, fine to medium, sub-angular quartz sand, variably silty, common shell debris		2–5 m; F		L–M	L	L–M	L–M	N–L	L–M	H	SM	Soil moisture changes, flooding	✕	✕	✕	✕	✕	✕	High water table, may be prone to flooding, differential settlement may occur
		LS2	LIMESTONE – very pale yellowish brown, vuggy, fine to medium sub-angular quartz and shell debris, generally friable		2–5 m; F	Agricultural and construction grade limestone	V	V	H	V	N/A	N/A	M–H	N/A	Solution, soil moisture changes	✕	✕	✕	✕	✕	✕	High water table, prone to flooding, variable bearing capacity depending on degree of cementation
	S1		CALCAREOUS SAND – white, fine to medium, sub-rounded quartz and shell debris	Safety Bay Sand (mobile form) (Qhsm)	0–25 m; M	Limesand	H	L	H	L	N	N	H	SW	Wind transport	✕	✕	✕	◆	●	◆	Active blowouts and sand sheets, unvegetated, high lime content gives it potential for fixing certain kinds of waste and neutralising acids, low bearing capacity, settlement is common and can be uneven
	S2		CALCAREOUS SAND – as S1	Safety Bay Sand (Qhs)	5–40 m; M	Limesand	H	L	H	L	N	N	H	SW	Wind transport	✕	●	●	◆	●	◆	Very susceptible to remobilisation where the sparse vegetation is removed, high lime content gives it potential for fixing certain kinds of waste and neutralising acids, low bearing capacity, settlement is common and can be uneven
CAINOZOIC – QUATERNARY – PLEISTOCENE	S7		SAND – pale yellowish brown, medium to coarse sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted	Sand derived from Tamala Limestone (Qts)	5–70 m; G	Specification sand	H	L	H	L	N	N	H	SW	Wind transport, surface wash	◆	◆	◆	◆	◆	◆	Few limitations, some settlement under foundations can be expected, some ability to attenuate pollutants due to small clay content, usually considerable depth to water table due to topography
		LS1	LIMESTONE – light yellowish brown, fine to coarse, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, surface kankar	Tamala Limestone (Qtl)	3–50 m; G–M	Dimension stone, metallurgical, agricultural and construction grade limestone	V	V	H	V	N/A	N/A	M	N/A	Solution	◆	◆	◆	●	✕	◆	Variable bearing capacity depending on degree of cementation, common solution cavities and fissures could lead to severe settlement and also offer an easy path for pollutants down to the water table, high water table on Yoongarillup Plain
	S8		SAND – very light grey at surface, yellow at depth, fine to medium sub-rounded quartz, moderately sorted	Bassendean Sand (Qpb) and Guildford Formation (Qpa)	5–40 m; G	Construction sand	H	L	H	L	N	N	H	SW	Some wind transport	◆	◆	◆	◆	◆	◆	Well drained, when dry and vegetation free it could be remobilised, drainage disposal is only a problem in areas of high water table
	S10		SAND – as S8 as relatively thin veneer over MS2	Thin Bassendean Sand over Guildford Formation (Qpb/Qpa)	5–15 m; F	Construction sand	H	L	H	L	N	N	H	SW	Some wind transport, surface wash, channelled stream flow	◆	◆	◆	✕	✕	◆	Of variable thickness, the sands physical properties are modified by the underlying material, generally high water table, prone to flooding in part
	S11		SAND – moderate olive-brown, fine, sub-angular quartz, silty in places	Guildford Formation (Qpa)	15–25 m; G–M		M–H	L	M–H	L	N	N–L	H	SW–SM	Channelled stream flow	✕	✕	✕	✕	✕	✕	Restricted to fluvial channel with perennial flow
	Smg		SILTY SAND – moderate brown, fine to medium, sub-angular to sub-round quartz with pebbles and occasional cobbles of rounded quartz and gneiss (GN)		25–30 m; F		M	L	L–M	L–M	N–L	L–M	M–H	SM	Soil moisture changes	○	✕	✕	✕	✕	✕	Restricted occurrence, susceptible to flooding, some settlement of foundations can be expected
	Ms2		SANDY SILT – strong brown, variable clay content, mottled, blocky, silt with disseminated fine sub-angular quartz sand		15–35 m; F	Possibility of silts and clays for brick, pipe and tile manufacture	L–M	M	L	L–M	L–M	L–H	M–H	ML	Soil moisture changes, channelled stream flow	○	✕	✕	✕	✕	○●	Near surface water table, prone to flooding in places, cohesion and shrinkage vary, alternate wetting and drying may cause swelling and shrinkage
	S12		SAND – dark yellowish orange, medium to coarse, sub-angular to sub-rounded quartz with heavy minerals	Yoganup Formation (Qpr)	35–70 m; F–G	Construction and specification sand, heavy minerals	H	L	H	L	N	N	H	SW	Some channelled stream flow and surface wash	◆	◆	◆	◆	◆	◆	Settlement could occur under load, requires protection against erosion when exposed
	Ms3		SANDY SILT – light brown to moderate brown silt with disseminated fine, sub-angular quartz sand, sand content is variable	Colluvium (Qc)	30–290 m; M		L–M	M	L–M	L–M	L–M	N–H	M–H	ML	Creep, landslips, soil moisture changes	○	◆	◆	✕	◆	◆	Variable value as a foundation, permanent cuts are unstable
	Msg		SANDY SILT – moderate brown silt with medium to coarse, sub-angular quartz sand and pebbles and cobbles of gneiss (GN) and dolerite (DO) throughout		45–225 m; M		L–M	L–M	L–M	L–M	L–M	N–H	M–H	ML	Creep, landslips, soil moisture changes	○	◆	◆	✕	◆	◆	Variable value as a foundation, permanent cuts are unstable
TERTIARY	G2		GRAVEL – yellow-brown to dark reddish brown, ferruginous or bauxitic, pisolithic, irregular to well rounded, poorly sorted, variable amounts of sand and silt in matrix	Laterite (Czl)	50–330 m; G	Gravel	H	L	H	L	N	N	H	GW	Soil moisture changes, some surface wash	◆	◆	◆	◆	◆	◆	Very loose though occasionally weakly consolidated, needs protection against water erosion, fluctuations in moisture content, when compacted can withstand heavy loads
	G3		GRAVEL – as G2 but black, individual pisoliths exhibit coating partial or total replacement by maghemite		250–330 m; G	Gravel	H	L	H	L	N	N	H	GW	Soil moisture changes, some surface wash	◆	◆	◆	◆	◆	◆	Restricted occurrence otherwise see G2
		LA1	LATERITE – massive, friable to strongly indurated, occasionally vesicular, iron rich, developed on Archaean bedrock		240–340 m; G	Bauxite	N/A	N/A	N/A	N/A	N/A	N/A	L	N/A	Some surface wash	◆	◆	◆	○	✕	◆	Usually excavated by blasting, variable foundations, sub-surface drainage is a problem
ARCHAEAN		GR-GN	GRANITES AND GNEISSES – intimate association of gneissic rocks (GN) pervaded by a granitic component, intruded by dolerite (DO) dykes	Migmatite (Am)	50–290 m; M–S	Crushed rock aggregate	N/A	N/A	N/A	N/A	N/A	N/A	L	N/A	Channelled stream flow, surface wash	◆	◆	◆	✕	○●	◆	Heterogeneous material, adequate foundations providing requisite preparation is carried out
		GN	GNEISS – fine to medium, even-grained, layered gneiss and coarse, even-grained and porphyritic gneiss with imperfect gneissic texture, intruded by dolerite (DO) dykes	Gneiss (An)	30–240 m; M–S	Crushed rock aggregate	N/A	N/A	N/A	N/A	N/A	N/A	L	N/A	Channelled stream flow, surface wash	◆	◆	◆	✕	○●	◆	Foundation conditions variable and can be good providing requisite preparation conditions are carried out
		DO	DOLERITE – fine-grained, melanocratic 2–10 wide dykes trending northeast, intruded into gneissic rocks	Dolerite (d)	50–200 m; M	Crushed rock aggregate	N/A	N/A	N/A	N/A	N/A	N/A	L	N/A	Channelled stream flow, surface wash	◆	◆	◆	✕	✕	◆	Can be a good foundation when fresh but soils developed on dolerite (plastic clays) give poor foundations unless moisture content is kept constant

GENERAL FEATURES – PHYSICAL PROPERTIES[6] – SUITABILITY FOR SPECIFIED LAND USES[8]

REFERENCES

1. See Lithological classification
2. These terms are used in the engineering sense of "soil" and "rock". The term "soil" denotes an aggregate of mineral grains which can be separated by gentle mechanical means. The term "rock" denotes an aggregate of minerals connected by strong and permanent forces.
3. Colours were derived from Standard Soil Colour Charts, notation omitted
4. Maximum and minimum elevation of the unit with respect to Australian Height Datum
5. Slopes expressed qualitatively
   F–flat . . . . . < 3^0
   G–gentle . . . . . 3^0–10^0
   M–moderate . . . . . 10^0–20^0
   S–steep . . . . . > 20^0
   The dominant slope of each unit is given
6. H . . . . . high
   M . . . . . moderate
   L . . . . . low
   N . . . . . none
   V . . . . . variable
   N/A . . . . . not applicable
   Properties vary with degree of weathering
7. Unified Soil Classification System which describes soils in terms of grain size, grading characteristics and compressibility
   N/A not applicable
8. ✕ land use undesirable for the environment
   ○ possible problems for the land use
   ● possible problems for the environment
   ◆ land use compatible with unit

The data contained on this sheet are provided for preliminary studies and are not intended as a substitute for detailed on site investigation

LITHOLOGICAL CLASSIFICATION

UNCONSOLIDATED MATERIAL

A single capital letter denotes the main lithology of the soil unit followed, if required, by lower case letters denoting qualifying lithologies in decreasing order of importance – left to right

C. . . . . clay
M. . . . . silt
G . . . . gravel
P . . . . organic material
S . . . . sand

ROCK

Double capital letters denote lithological symbols of rocks

LS . . . . limestone
LA . . . . laterite
GR . . . . granite
GN . . . . gneiss
DO . . . . dolerite

Different mappable units of similar lithologies are shown by the lithological symbol followed by an Arabic number

SYMBOLS

GEOLOGY

. . . . . geological boundary
. . . concealed trace of Darling Fault (from gravity data)
. . . . . fault
. . . . . zone of stromatolites
. . . . . made ground
. . . . . landslip

HYDROGRAPHY

. . . . . perennial stream with direction of flow
. . . . . seasonal stream with direction of flow
. . . . . marsh
. . . . . lake
1 200 . . . . . isohyet (mm) figure on high side of line
40 . . . . . depth to groundwater, metres
500 . . . . . isohaline (mg/L T.D.S.)
. . . . . area subject to inundation
5 . . . . . bathymetric contour in metres
. . . . . inland extent of saltwater interface

BOREHOLES, WELLS AND OTHER WORKS

production borehole, Water Authority of Western Australia
observation borehole, Geological Survey of Western Australia
. . . . . storage reservoir, dam or tank
. . . . . high level tank
. . . . . irrigation channel
. . . . . drain
. . . . . tailing pond
. . . . . solid waste disposal site, active
. . . . . solid waste disposal site, inactive
. . . . . liquid waste disposal site, active
. . . . . liquid waste disposal site, inactive
2.29 . . . . . dam, capacity in millions of cubic metres

MINERAL RESOURCES

. . . . . quarry or pit, active
. . . . . quarry or pit, inactive

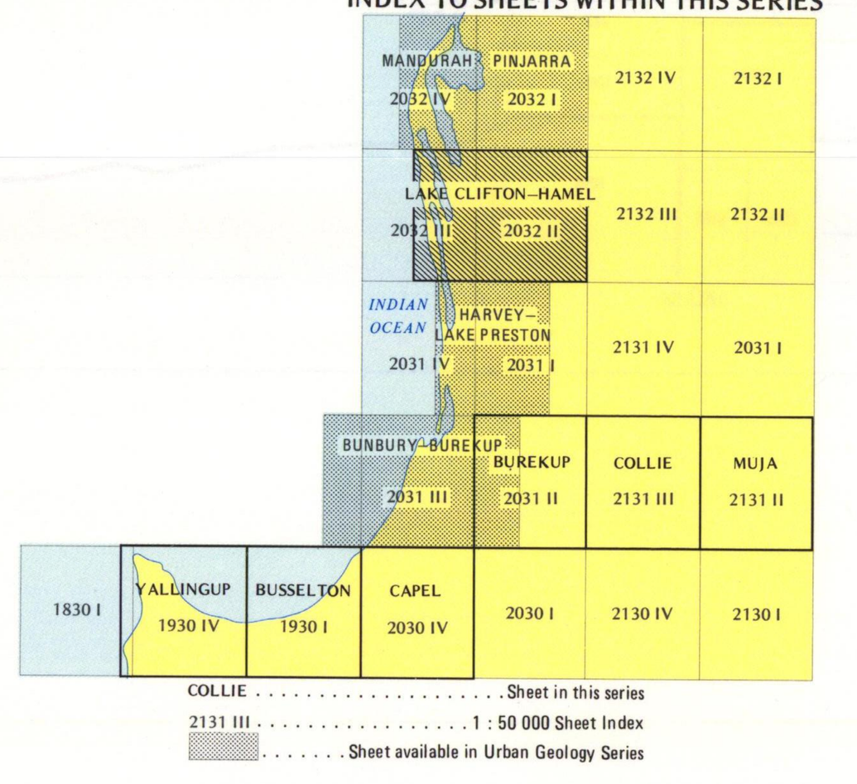
mineral occurrence
Sd . . . . . sand
Ls . . . . . limestone
Gr . . . . . gravel
Hm . . . . . heavy minerals
Bx . . . . . bauxite

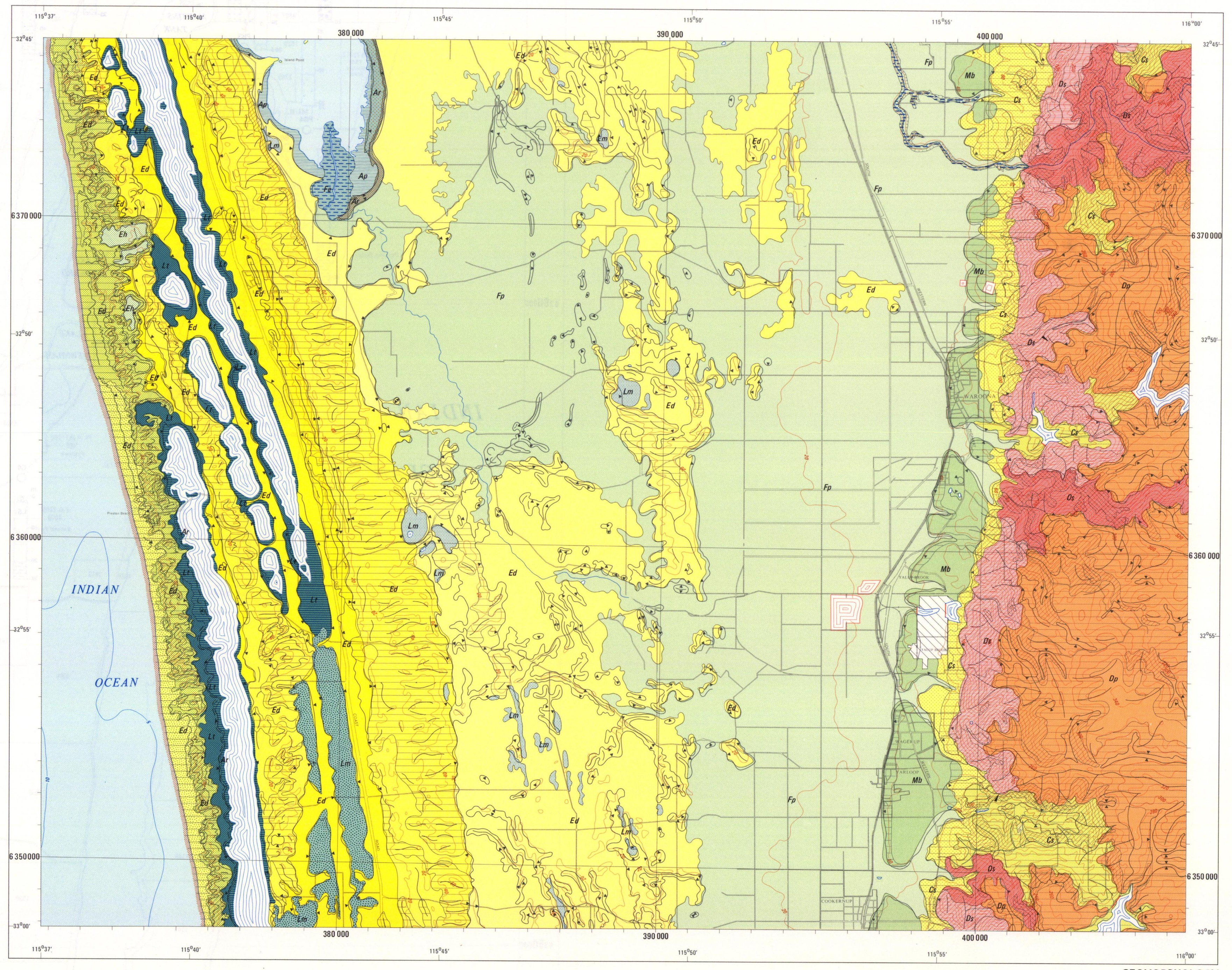
TOPOCADASTRAL INFORMATION

HIGHWAY . . . . . road, classification as shown
. . . . . railway
. . . . . powerline
. . . . . land district boundary
. . . . . local authority boundary
80 . . . . . contour in metres

The Australian Map Grid covers Australia and the Territories administered by Australia. Zones are 6^0 wide plus $½^0$ overlap. A.M.G. zones are numbered from zone 47 with central meridian 99^0E to zone 58 with central meridian 165^0E. The origin of each zone is the intersection of the central meridian with the equator. On this map ticks on the sheet edge represent 1000 metre intervals on the superimposed A.M.G. Zone 50.

INDEX TO SHEETS WITHIN THIS SERIES





GEOMORPHOLOGY

SCALE 1 : 1 00 000

KILOMETRES

GEOMORPHOLOGICAL CLASSIFICATION

Symbol	Description
Fe	Delta
Ar	Estuarine beach ridges
Ar	Shell bank
Ar	Estuarine storm ridge
Ap	Estuarine saline flats
Ed	Parabolic and nested parabolic dunes, mobile Quindalup Dune System
Ed	Parabolic and nested parabolic dunes, fixed, Quindalup Dune System
Eh	Deflation areas
Lt	Lake terrace, high level, Yoongarillup Plain
Lt	Lake terrace, low level, Yoongarillup Plain
Ed	Degraded surface of eolian origin, Yoongarillup Plain
Ed	Degraded surface of eolian origin, Spearwood Dune System
Ed	Degraded surface of eolian origin, Bassendean Dune System
Lm	Marsh in interbarrier depression
Lm	Marsh in interdunal swale
Fp	River floodplain
Fp	Alluvial plain, Pinjarra Plain
Mb	Raised marine surface, Yoganup shoreline
Cs	Colluvial slope at foot of scarp
Ds	Gently to steeply inclined scarp face
Ds	Deeply incised steep-sided valleys
Cs	Broad valleys with gentle to moderate slopes
Dp	Gently undulating lateritic upland
	Lake
	Tailing pond

The geomorphological classification comprises a single capital letter which denotes the origin of the material and a lower case letter which represents the landform

ORIGIN

E. . . . . eolian
L. . . . . lacustrine
F. . . . . fluvial
A. . . . . estuarine
M. . . . . marine
C. . . . . colluvial
D. . . . . denudational

LANDFORM

d. . . . . dune
s. . . . . slope
p. . . . . plain
e. . . . . delta
m. . . . . marsh
b. . . . . beach
r. . . . . ridge
t. . . . . terrace
h. . . . . hollow

e.g. Cs . . . . . colluvial slope
Fp . . . . . flood plain

SLOPES

Slope
0^0 – 3^0
3^0 – 10^0
10^0 – 20^0
20^0 – 30^0

FEATURES

Prominent ridge
Sharp convex break of slope
Sharp concave break of slope
Sharp convex and concave breaks of slope too close to be shown individually
Landslip

Sandy coast. Storm and erosion cycles have the greatest impact on these coasts. Without protection, large scale erosion during stormy years is likely to occur. Once it does start there is little to stop it. Preservation of the dunes and their vegetation is important in facilitating recovery following storm onset and beach erosion.

Cartography by the Surveys and Mapping Division, Department of Mines, Western Australia.
Topographic base from compilations by the Department of Land Administration. Cadastral base from the Department of Conservation and Land Management.
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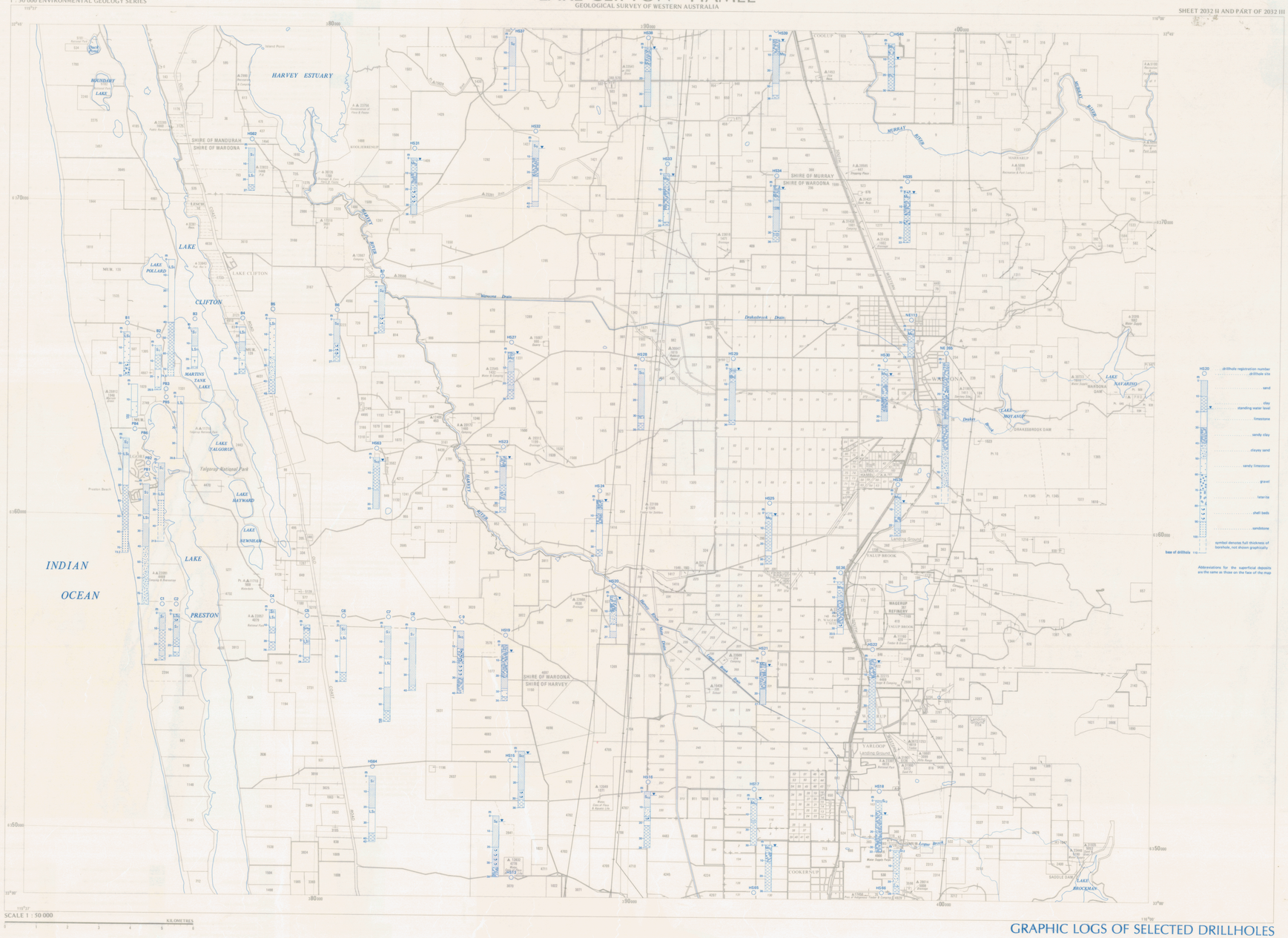

drillhole registration number
drillhole site
sand
clay
standing water level
limestone
sandy clay
clayey sand
sandy limestone
gravel
laterite
shell beds
sandstone
symbol denotes full thickness of borehole, not shown graphically
base of drillhole

Abbreviations for the superficial deposits are the same as those on the face of the map

GRAPHIC LOGS OF SELECTED DRILLHOLES