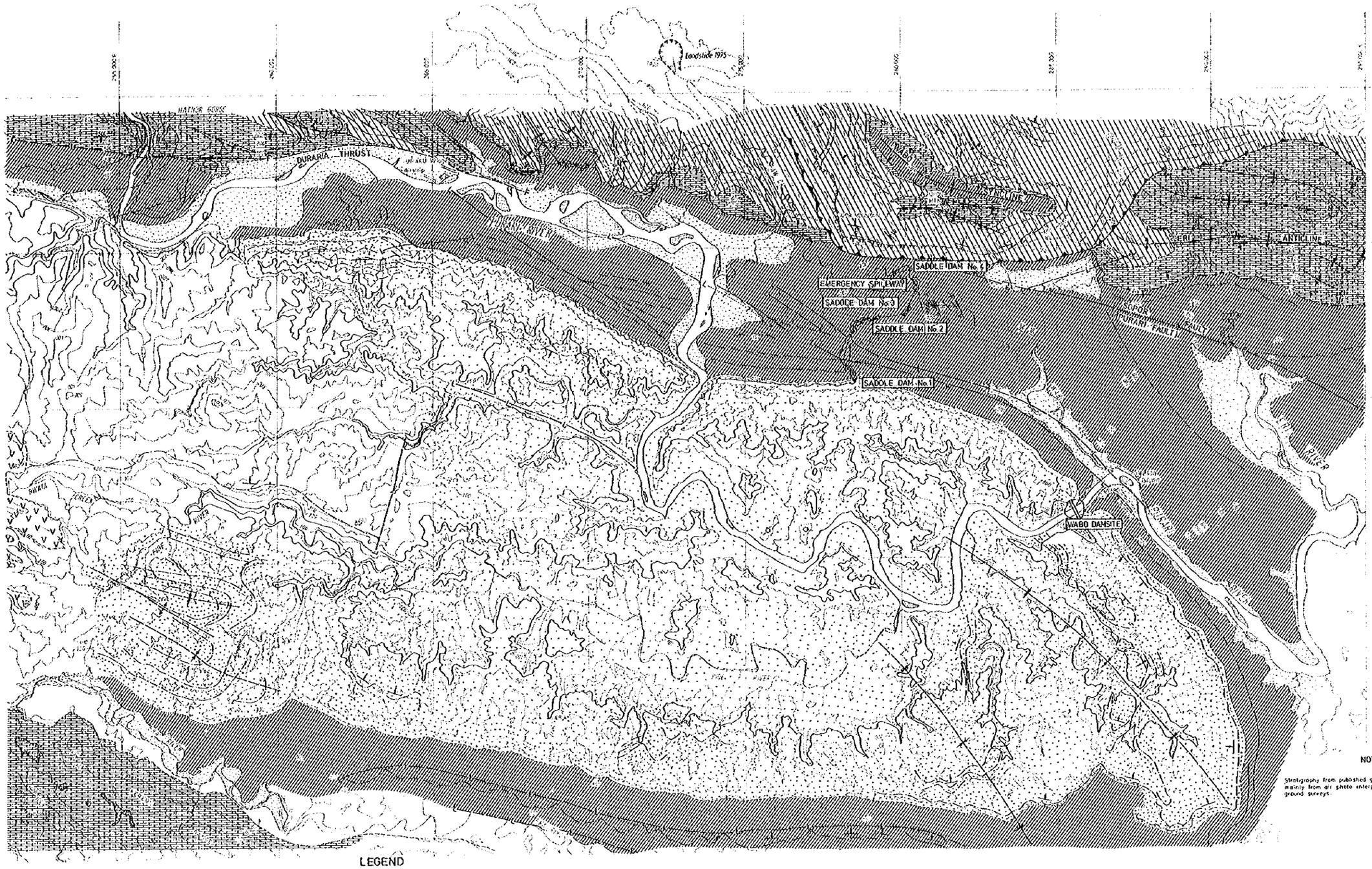
添　付　図

第1部　地質調査：図2～図63

第2部　建設材料調査：図64～図88



NOTE

Stratigraphy from published geological maps, geology mainly from air photo interpretation with limited ground surveys.

LEGEND

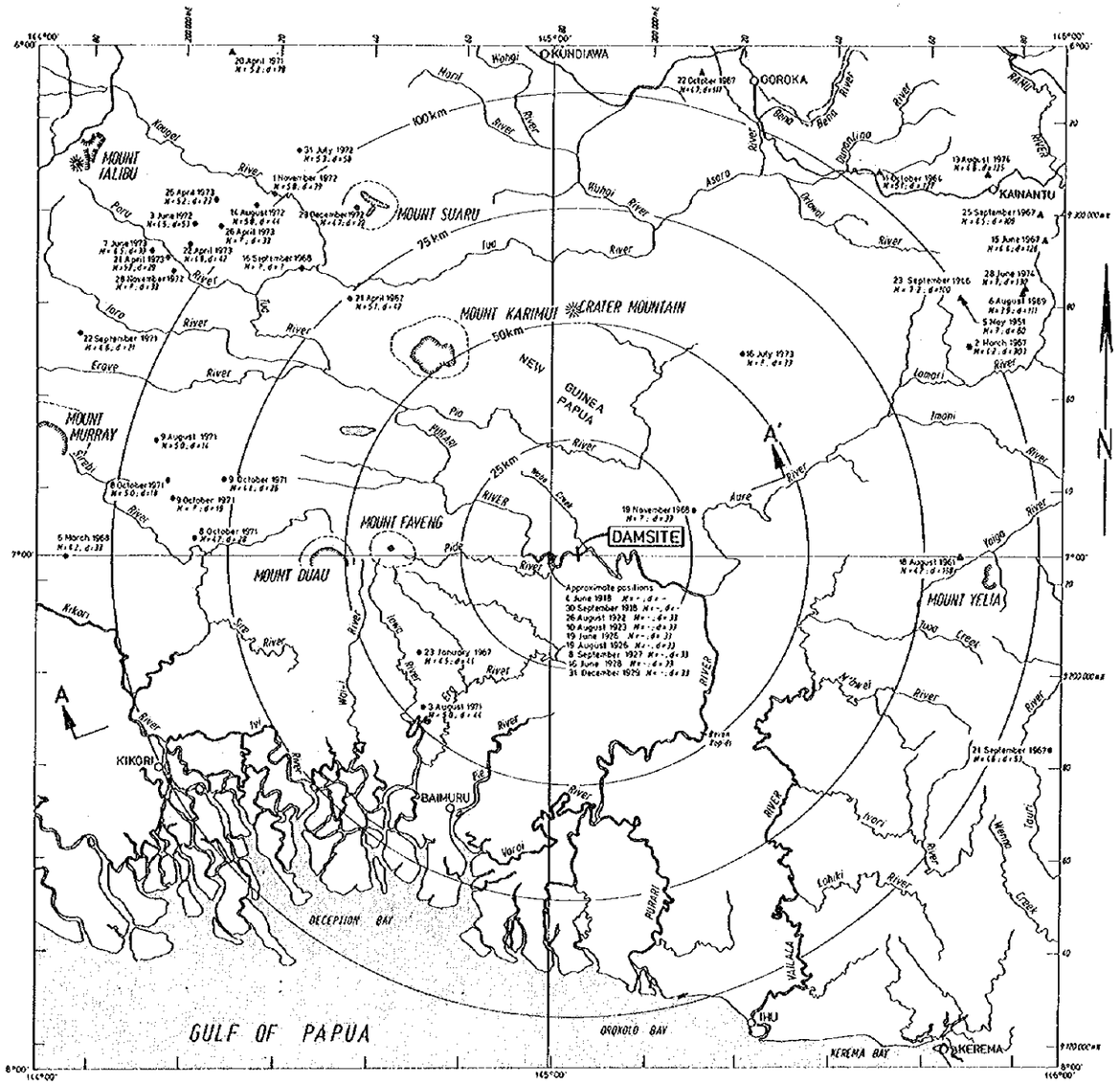
- HOLOCENE — Alluvium. Gravel, sand, clay.
- HOLOCENE — QUAU VOLCANICS. Tuff
- PLEISTOCENE to PLIOCENE — ERA BEDS. Interbedded sandstone, siltstone and mudstone.
- PLIOCENE, UPPER MIOCENE and MIDDLE MIOCENE, UPPER OLIGOCENE — ORUBADI BEDS and AURE BEDS, undifferentiated. Mainly mudstone and siltstone, some sandstone.
- MIDDLE MIOCENE to UPPER OLIGOCENE — OARAI LIMESTONE. Limestone of AURE BEDS
- CRETACEOUS — Sandstone, siltstone, mudstone.
- Strike and dip of bedding - measured
- Strike and dip of bedding - air photo interpretation
- Anticline
- Syncline
- Depression contours and sinkholes
- Strike lines of bedding - air photo interpretation
- L — L Air photo lineament
- F — F Fault
- Thrust fault
- Approximate Geological boundaries (mainly from air photo interpretation)
- Inferred
- Full Supply Level

SCALE 0 0.5 1 2 3 4 5km

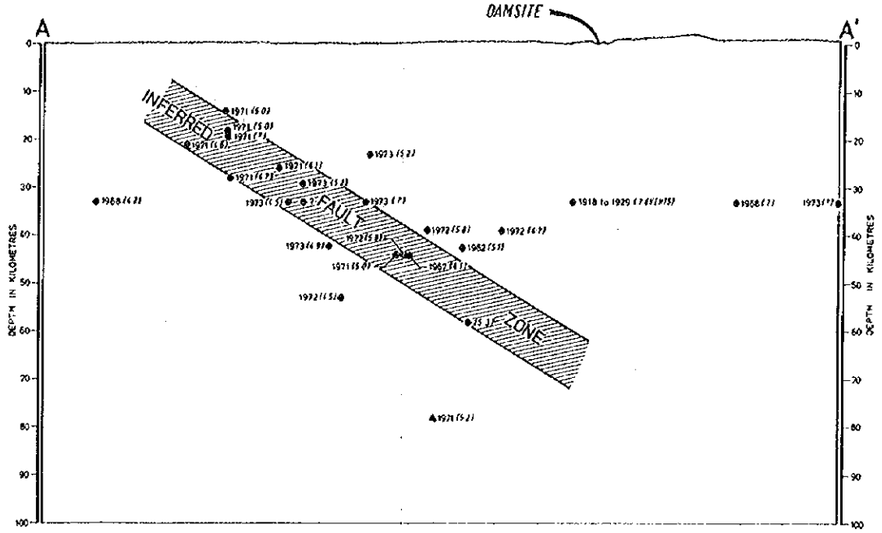
WABO POWER PROJECT

GENERAL GEOLOGY

[3] 2



PLAN



SECTION A-A'
Natural Scale

NOTE : Epicentres projected normal to section line.

LEGEND

- Epicentre Shallow (0-69km)
- ▲ Epicentre Intermediate (70-299km)
- ✱ Epicentre Deep (>299km)
- 23 January 1967 M=5, d=44 — Epicentre showing date, magnitude and depth

0 5 10 20 30 40 50 km

WABO POWER PROJECT

REGIONAL SEISMICITY

Fig 3

INTAKE STRUCTURE

DIVERSION TUNNEL

POWER STATION

RIVER

PURARI MAIN DAM

No.2 DIVERSION No.3 TUNNEL

SPILLWAY

LEGEND

- ALLUVIUM
- ALLUVIUM - High Level
- SLIDE DEBRIS, TALUS (> 2m thick)
- OUTCROP, SUB-OUTCROP, LOCAL OR SHALLOW SLIDE DEBRIS AND TALUS.

- Major rock outcrops within Alluvium
- Strike and dip of bedding
- DD/VP● Drill hole, vertical
- BH8 ●—◀ Drill hole, sloped
- A210 ◆ Hand Auger hole
- T210 Trench
- SL/0 SL/32 Seismic traverse line
- g g Location of geological section

GEOLOGICAL BOUNDARIES

- Accurate
- Approximate
- Inferred

0 20 100 200m

20 Contour Interval 5m

REFERENCE DRAWINGS

Wabo Power Project -

Geological Sections and Summary Logs of Drill Holes ..... FIGURES 9-22 (1429-S3099/1-14)

Summary Logs of Miscellaneous Drill Holes ..... FIGURE 23 (1429-S3099/15)

Geological Logs of Trenches T201 to T214 ..... FIGURES 24-26 (1429-S3047/1-3)

Geological Logs of Hand Auger Holes A201 to A236 ..... FIGURE 27 (1429-S3044)

Time-distance and Seismic Sections, Traverses S1 to S6 ..... FIGURE 28 (1429-S3097)

WABO POWER PROJECT
MAIN DAM AREA

GEOLOGICAL PLAN

4

INTAKE STRUCTURE

DIVERSION

TUNNEL

POWER STATION

RIVER

PURARA

MAIN DAM

OUTLINE OF ZONE 1

No. 1 DIVERSION

No. 3 DIVERSION

SPILLWAY

0 20 100 200m

Contour Interval 5 m

LEGEND

- ALLUVIUM
- ALLUVIUM - High Level
- SLIDE DEBRIS, TALUS (> 2m thick)
- OUTCROP, SUB-OUTCROP, LOCAL OR SHALLOW SLIDE DEBRIS AND TALUS.

Major rock outcrops within Alluvium
Strike and dip of bedding
Drill hole, vertical
Drill hole, sloped
Hand Auger hole
Trench
Seismic traverse line
Location of geological section
Strata Rock Unit

GEOLOGICAL BOUNDARIES
- Accurate
- Approximate
- Inferred

REFERENCE DRAWINGS

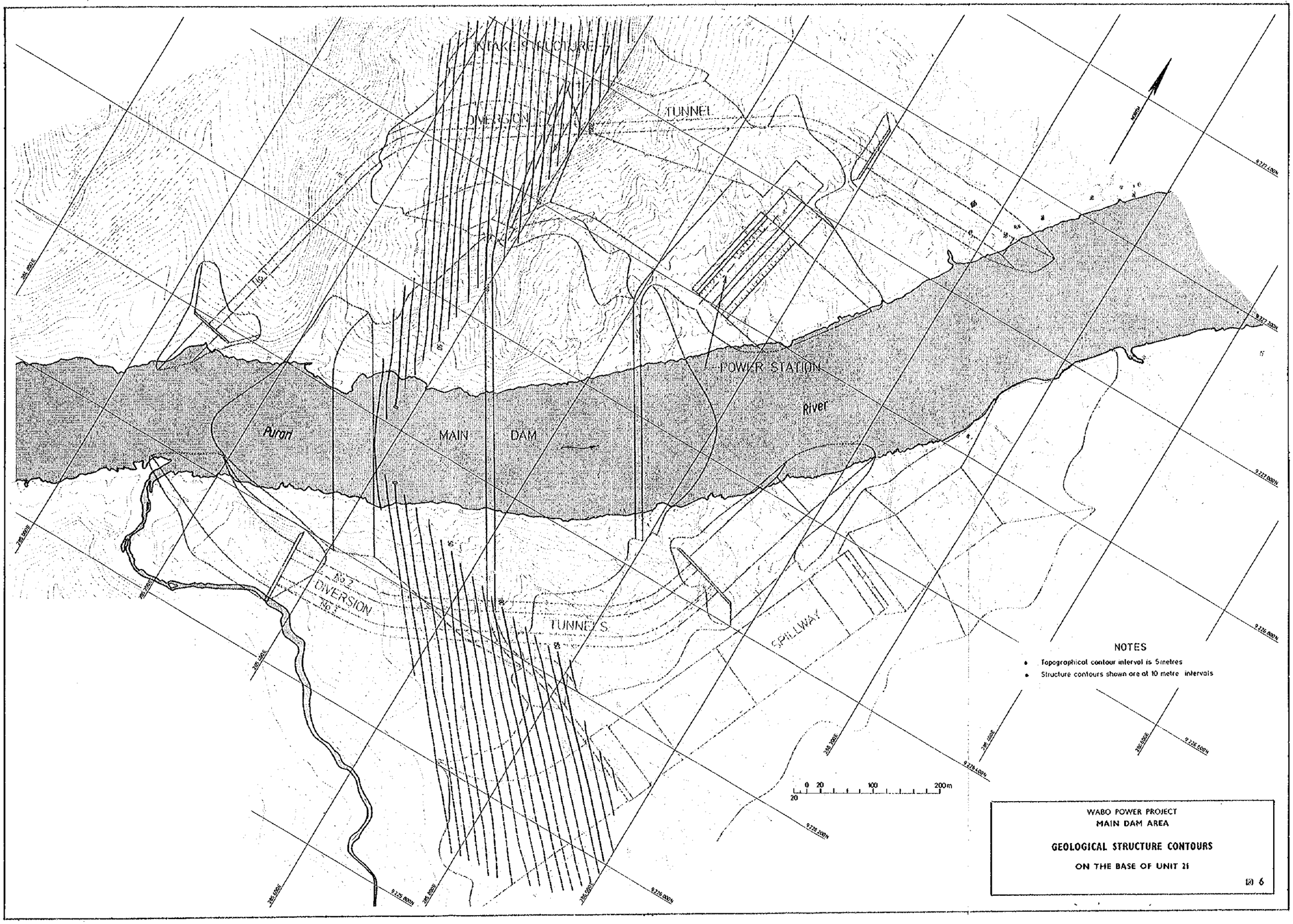
Wabo Power Project -

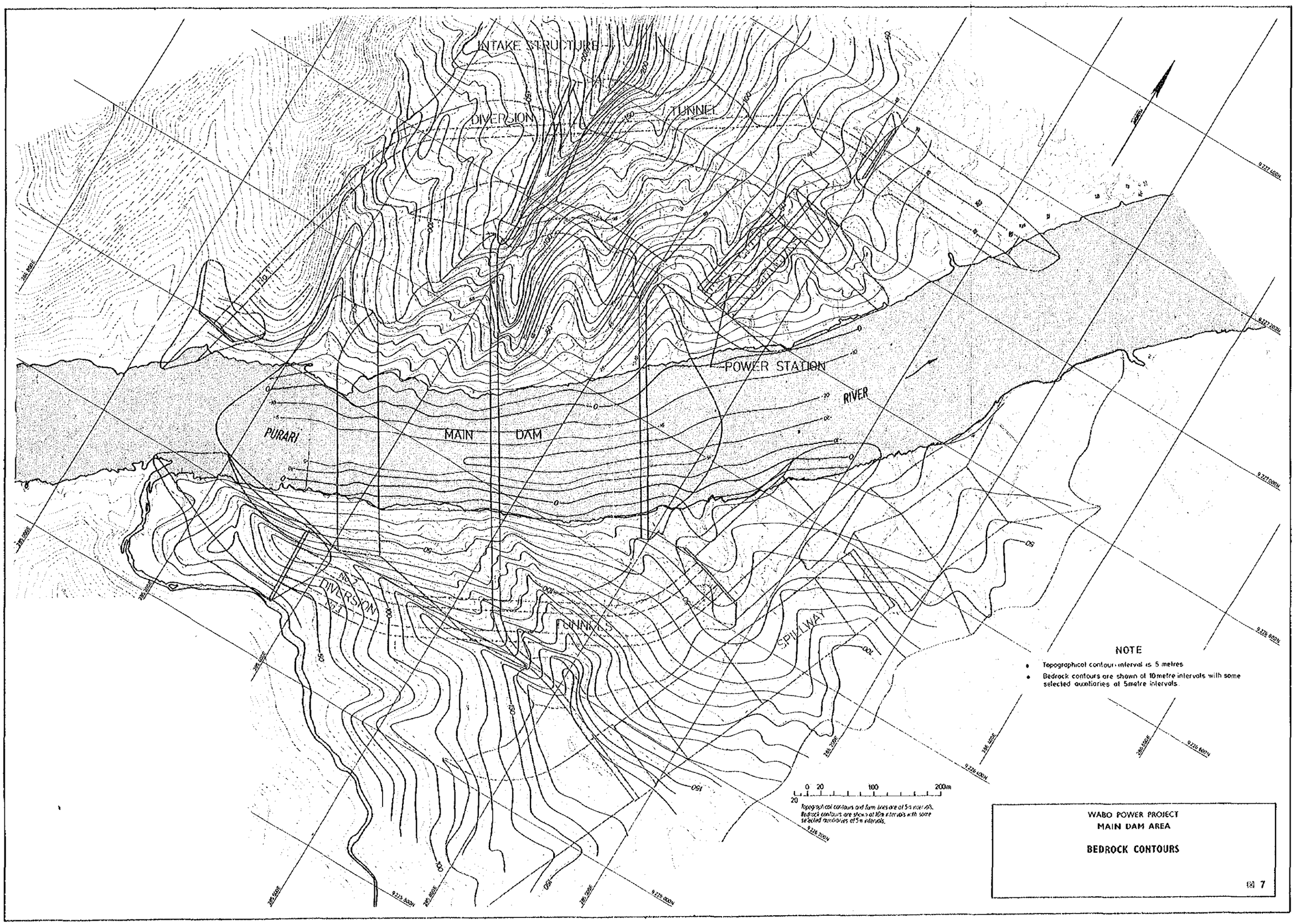
Geological Sections and Summary Logs of Drill Holes ..... FIGURES 9-22 (1429-S3099/1-14)
Summary Logs of Miscellaneous Drill Holes ..... FIGURE 23 (1429-S3099/15)
Geological Logs of Trenches T201 to T214 ..... FIGURES 24-26 (1429-S3047/1-3)
Geological Logs of Hand Auger Holes A201 to A236 ..... FIGURE 27 (1429-S3044)
Time-distance and Seismic Sections, Traverses S1 to S6 ..... FIGURE 28 (1429-S3097)

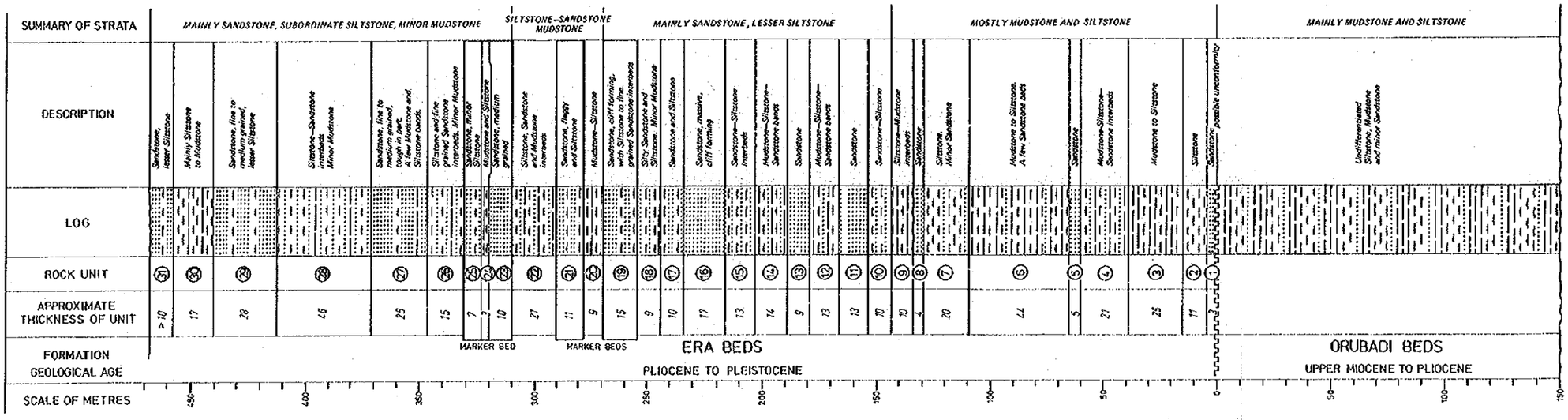
WABO POWER PROJECT

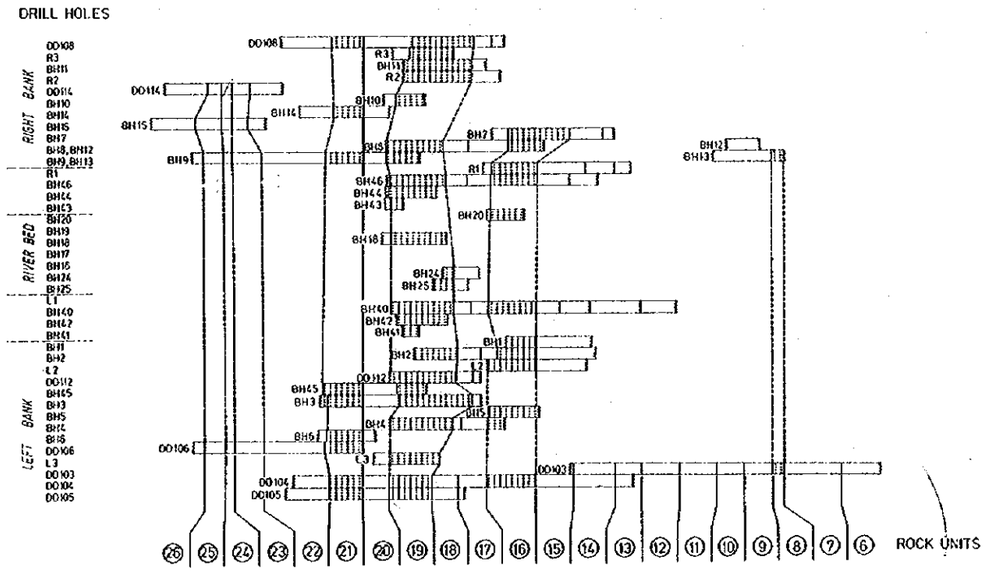
GEOLOGICAL PLAN
SUBSURFACE GEOLOGY

図 5


INTAKE STRUCTURES
DIVERSION
TUNNEL
POWER STATION
River
Purari
MAIN
DAM
R.2
DIVERSION
TUNNELS
SPILLWAY
NORTH
NOTES
Topographical contour interval is 5 metres
Structure contours shown are at 10 metre intervals
0 20 100 200m
WABO POWER PROJECT
MAIN DAM AREA
GEOLOGICAL STRUCTURE CONTOURS
ON THE BASE OF UNIT 2i
Fig 6


INTAKE STRUCTURE
DIVERSION TUNNEL
POWER STATION
RIVER
PURARI
MAIN DAM
No 2 DIVERSION No 1
TUNNELS
SPILLWAY
NOTE
Topographical contour interval is 5 metres
Bedrock contours are shown at 10 metre intervals with some selected auxiliaries at 5metre intervals
0 20 100 200m
Topographical contours and form lines are at 5m intervals. Bedrock contours are shown at 10m intervals with some selected auxiliaries at 5m intervals.
WABO POWER PROJECT
MAIN DAM AREA
BEDROCK CONTOURS
fig 7

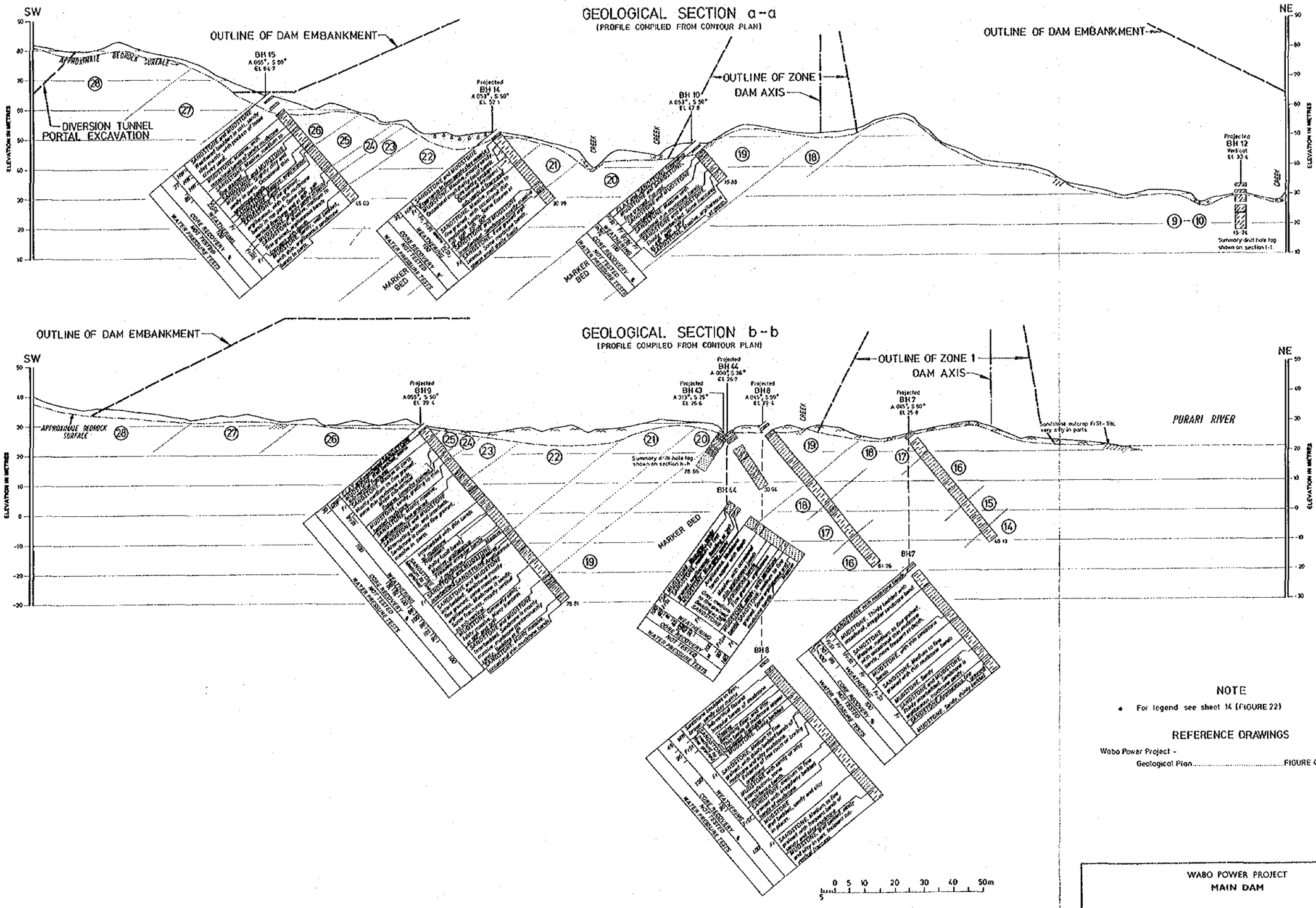




WABO POWER PROJECT
MAIN DAM

STRATIGRAPHIC COLUMN

8



NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... FIGURE 4 (1429-S3097)

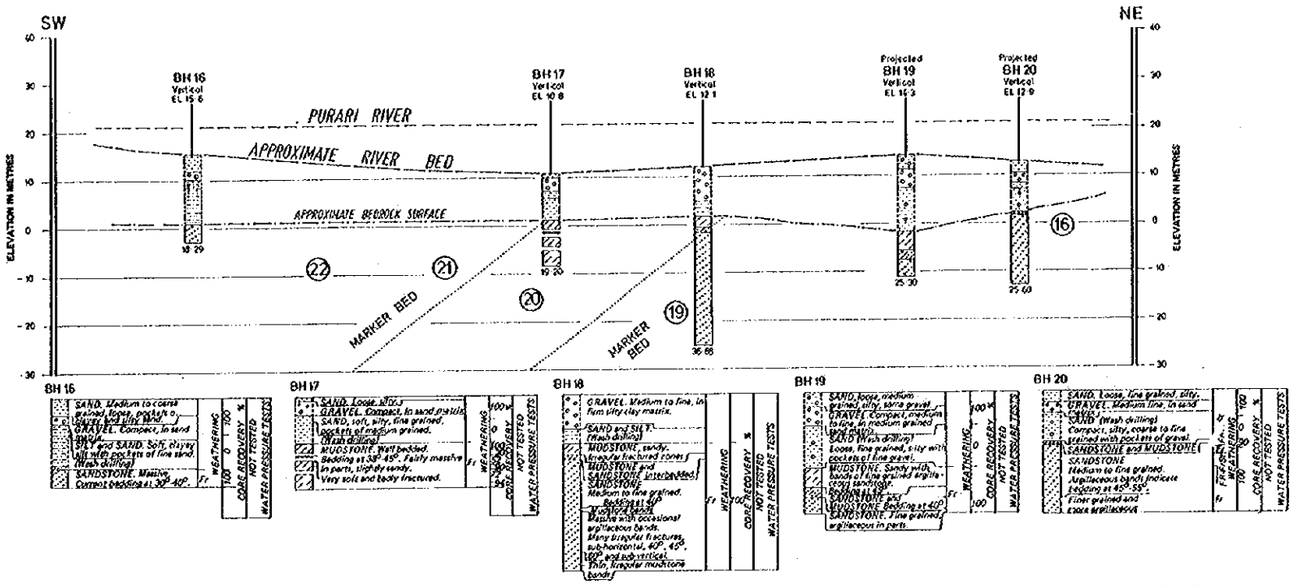
WABO POWER PROJECT
MAIN DAM

**GEOLOGICAL SECTIONS a-a and b-b
AND SUMMARY LOGS OF DRILL HOLES**

SHEET 1 OF 15

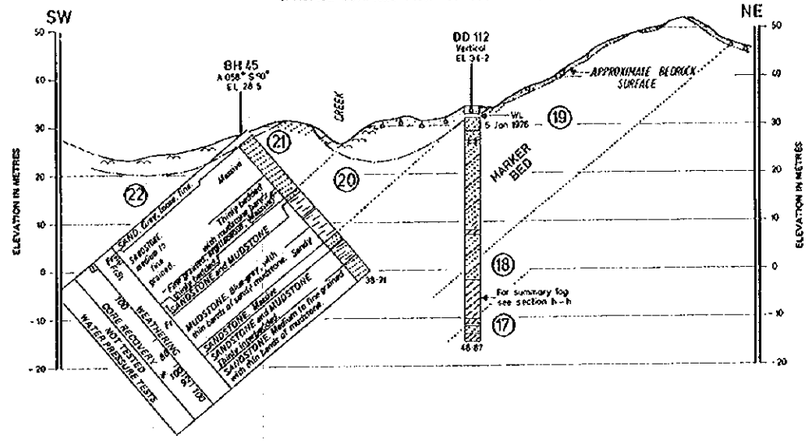
☒ 9

GEOLOGICAL SECTION c-c



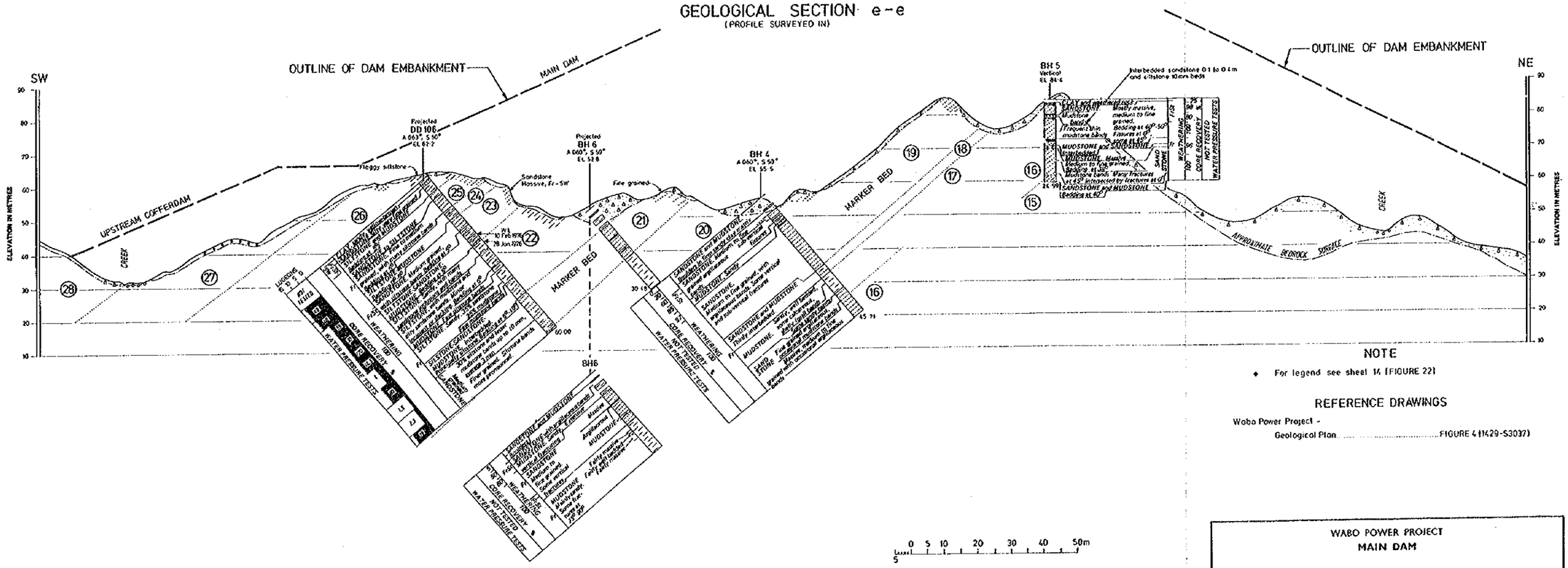
GEOLOGICAL SECTION d-d

(PROFILE COMPILED FROM CONTOUR PLAN)



GEOLOGICAL SECTION e-e

(PROFILE SURVEYED IN)



NOTE

◆ For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan ..... FIGURE 4 (11429-S3037)

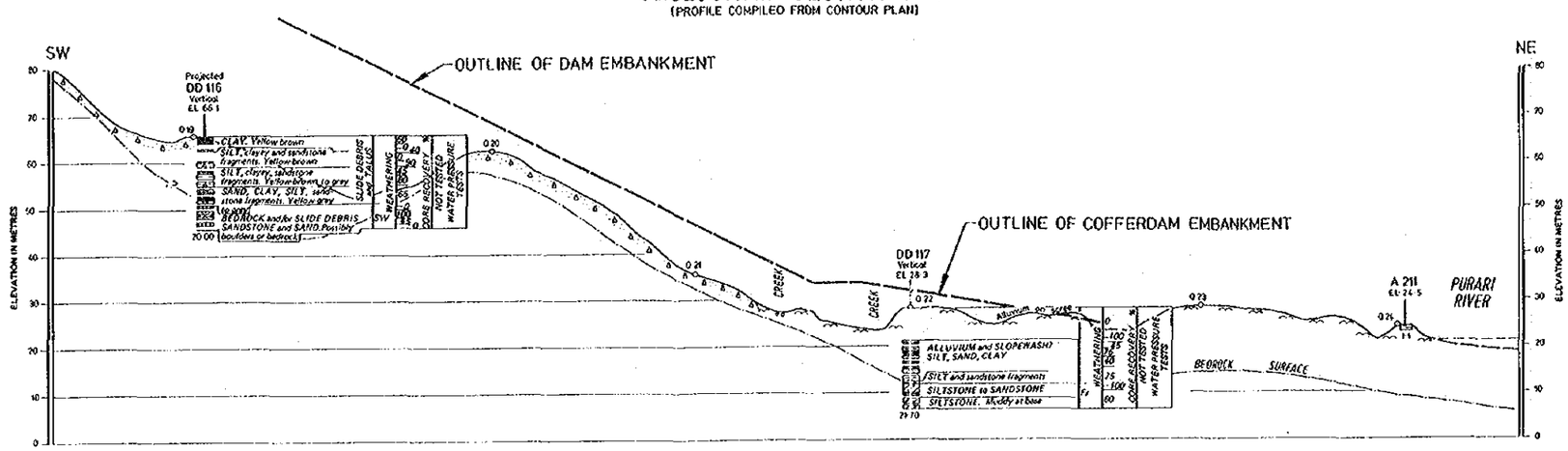
WABO POWER PROJECT
MAIN DAM

GEOLOGICAL SECTIONS c-c, d-d and e-e AND SUMMARY LOGS OF DRILL HOLES

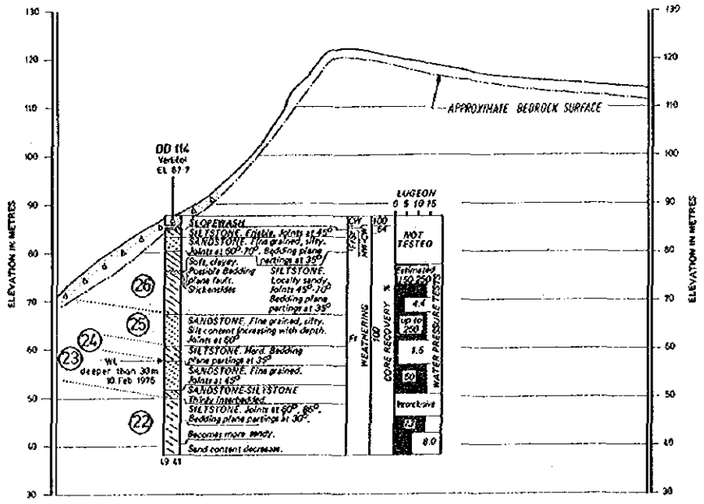
SHEET 2 OF 15

[2] 10

GEOLOGICAL SECTION f-f
(PROFILE COMPILED FROM CONTOUR PLAN)



GEOLOGICAL SECTION g-g
(PROFILE COMPILED FROM CONTOUR PLAN)



DIVERSION TUNNEL No. 2 DIVERSION TUNNEL No. 3

0 5 10 20 30 40 50m
S

NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan.....FIGURE 4 (1429-S3037)

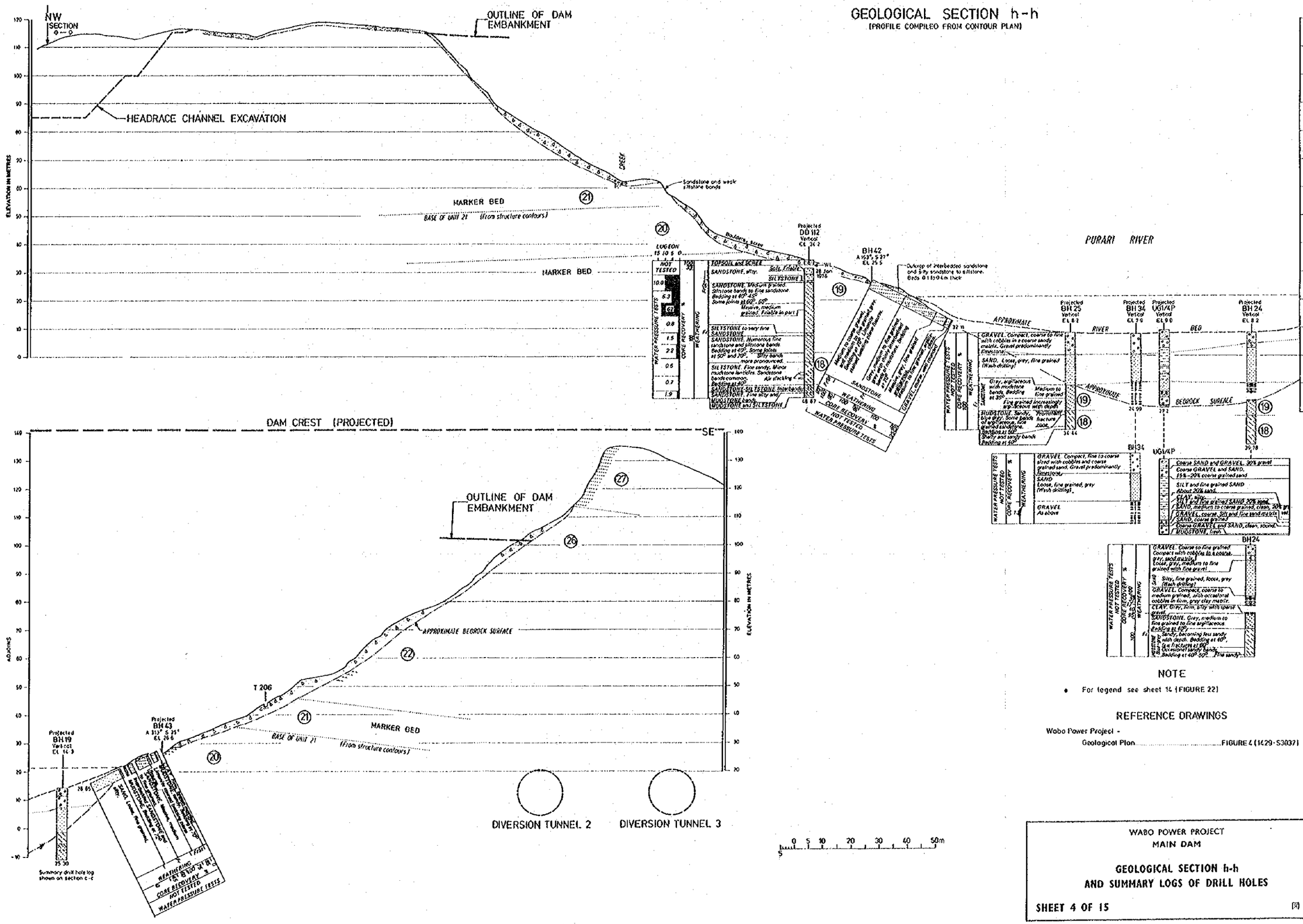
WABO POWER PROJECT
MAIN DAM

GEOLOGICAL SECTIONS f-f and g-g AND SUMMARY LOGS OF DRILL HOLES

SHEET 3 OF 15 ☒ 11

GEOLOGICAL SECTION h-h

(PROFILE COMPILED FROM CONTOUR PLAN)



NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan ..... FIGURE 4 (1429-S3037)

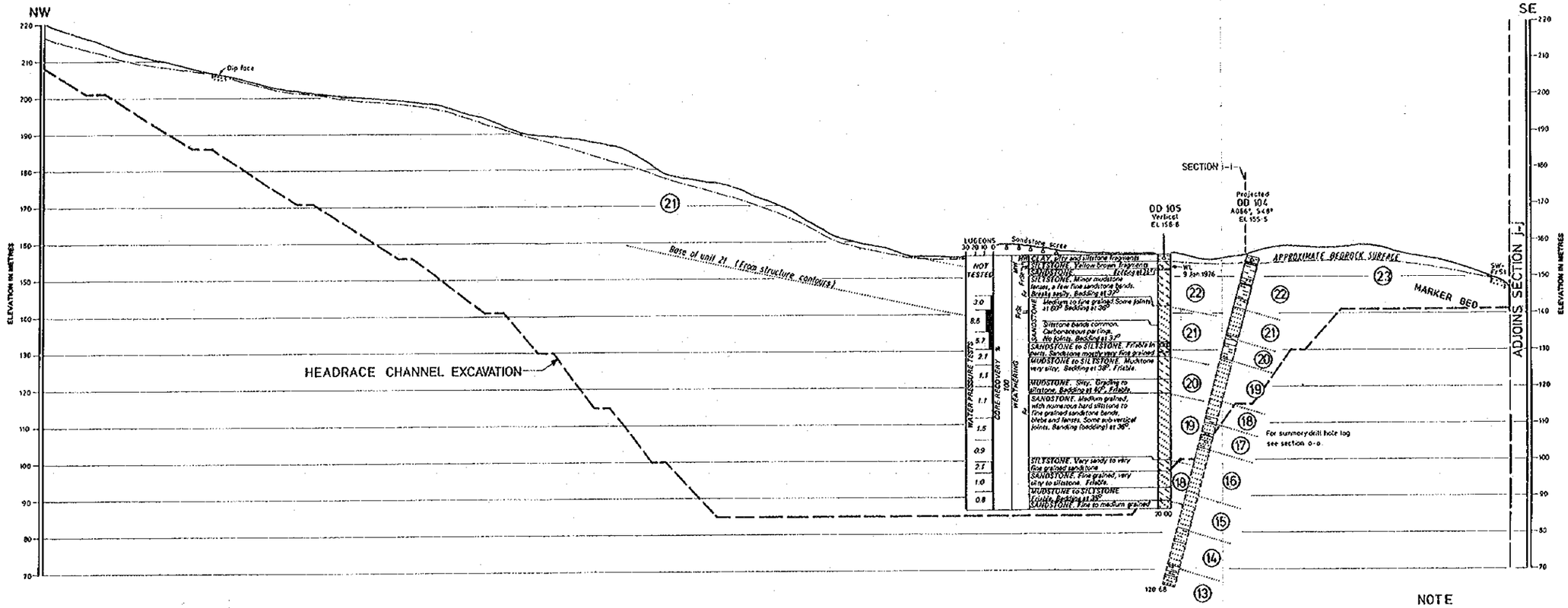
WABO POWER PROJECT
MAIN DAM

GEOLOGICAL SECTION h-h
AND SUMMARY LOGS OF DRILL HOLES

SHEET 4 OF 15 12

GEOLOGICAL SECTION I-I

(PROFILE COMPILED FROM CONTOUR PLANS)



NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan ..... FIGURE 4 (1429-S3037)

WABO POWER PROJECT
INTAKE STRUCTURE

GEOLOGICAL SECTION I-I
AND SUMMARY LOGS OF DRILL HOLES

SHEET 5 OF 15 — 13

GEOLOGICAL SECTION j-j

NW

CREST OF DAM

MARKER BED (21)
BASE OF UNIT 21
(From structure contours)

L3
Vertical
EL 97·1

ADJOINS SECTION j-i

ELEVATION IN METRES

MARKER BED (19)

Talus or rubble

Projected
L2
Vertical
EL 57·0

Projected
L1
A146°56'5"
EL 30·1

Projected
BH 1
A053°55'55"
EL 28·5

BH 1

Outcrop
Sandstone, Fr, hard with silty sandstone interbeds 0·15-0·3m wide.

PURARI RIVER

APPROXIMATE RIVER BED

APPROXIMATE BEDROCK SURFACE

Projected
R1
A322°56'5"
EL 97·4

Projected
BH 7
A065°55'55"
EL 75·8

Sand stone outcrop

For summary log of drill hole see section a-a

ADJOINS

BH 11

SE

SECTION k-k

ADJOINS

Projected
BH 11
A065°55'50"
EL 61·3

R2
Vertical
EL 67·0

R3
Vertical
EL 72·4

MARKER BED

Creek

Creek

R2

L1

NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan. ..... FIGURE 4 (1129-S3037)

0 5 10 20 30 40 50m

WABO POWER PROJECT
MAIN DAM

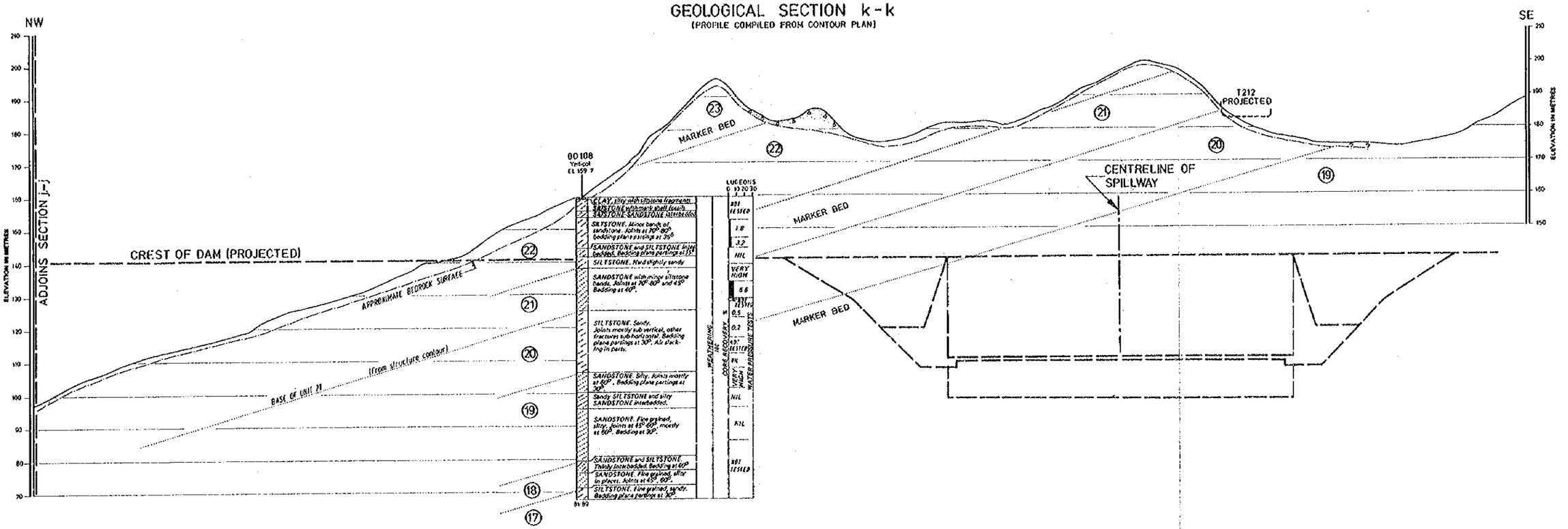
**GEOLOGICAL SECTION j-j
AND SUMMARY LOGS OF DRILL HOLES**

SHEET 6 OF 15

14

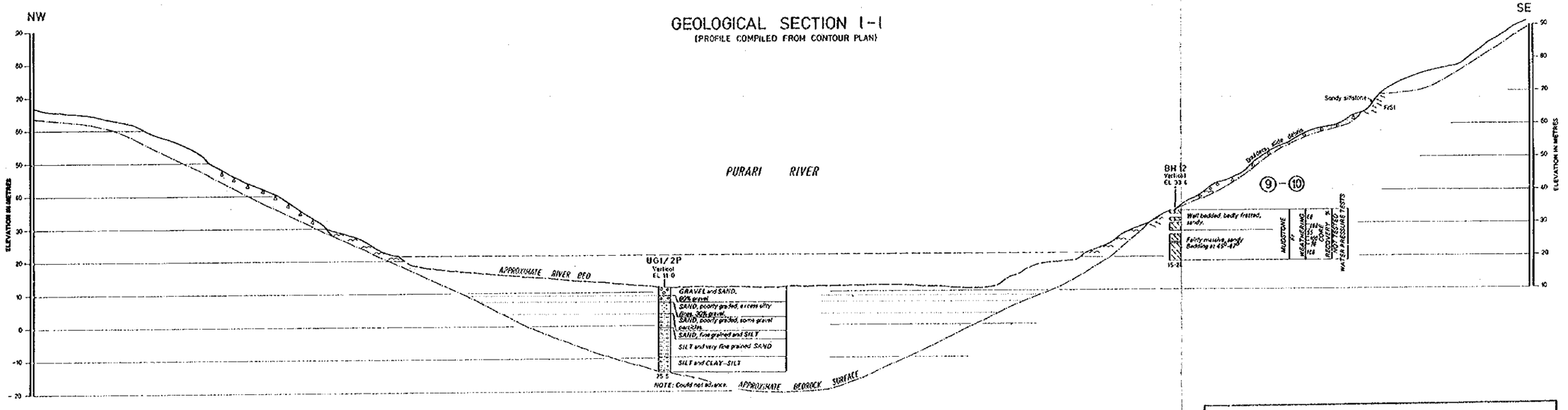
GEOLOGICAL SECTION k-k

(PROFILE COMPILED FROM CONTOUR PLAN)



GEOLOGICAL SECTION l-l

(PROFILE COMPILED FROM CONTOUR PLAN)



NOTE

- For legend see sheet 14 (FIGURE 22)

0 5 10 20 30 40 50m

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan ..... FIGURE 4 (1429-S3037)

WABO POWER PROJECT
SPILLWAY AND MAIN DAM

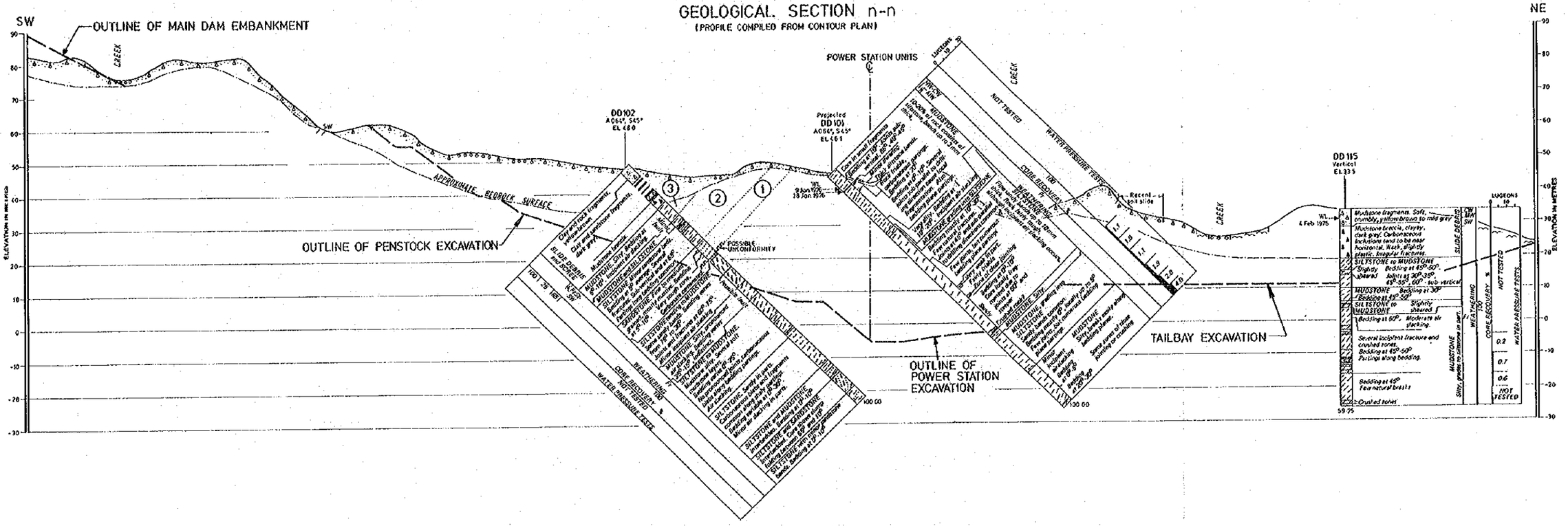
GEOLOGICAL SECTIONS k-k and l-l AND SUMMARY LOGS OF DRILL HOLES

SHEET 7 OF 15

15

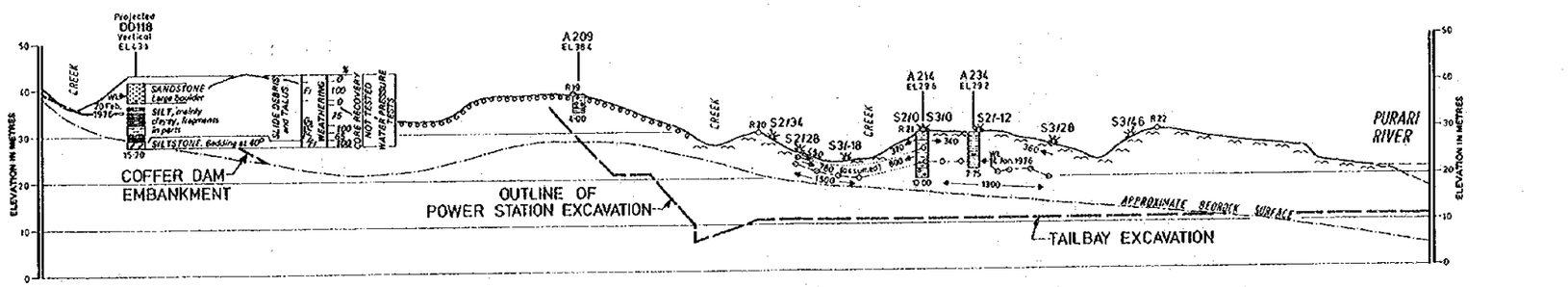
GEOLOGICAL SECTION n-n

(PROFILE COMPILED FROM CONTOUR PLAN)



GEOLOGICAL SECTION m-m

(PROFILE COMPILED FROM CONTOUR PLAN)



0 5 10 20 30 40 50m

NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project - Geological Plan ..... FIGURE 4 (1429-S3097)

WABO POWER PROJECT
POWER STATION

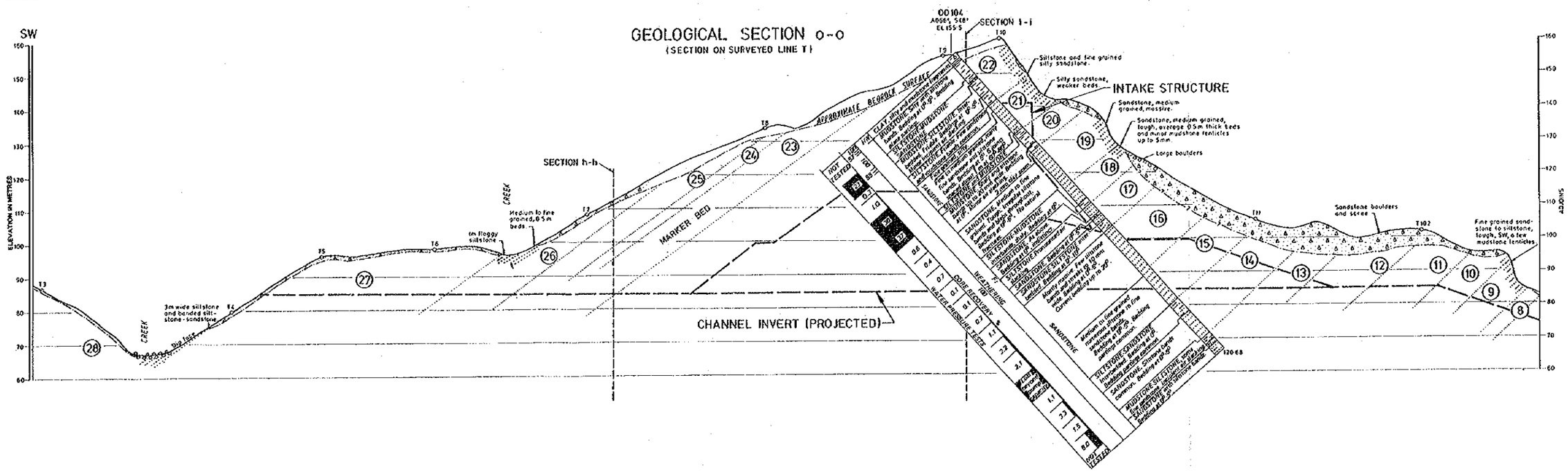
GEOLOGICAL SECTIONS m-m and n-n AND SUMMARY LOGS OF DRILL HOLES

SHEET 8 OF 15

図 16

GEOLOGICAL SECTION o-o

(SECTION ON SURVEYED LINE T)



NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan.....FIGURE 4 (1429-53037)

WABO POWER PROJECT
INTAKE STRUCTURE — PENSTOCK — POWER STATION

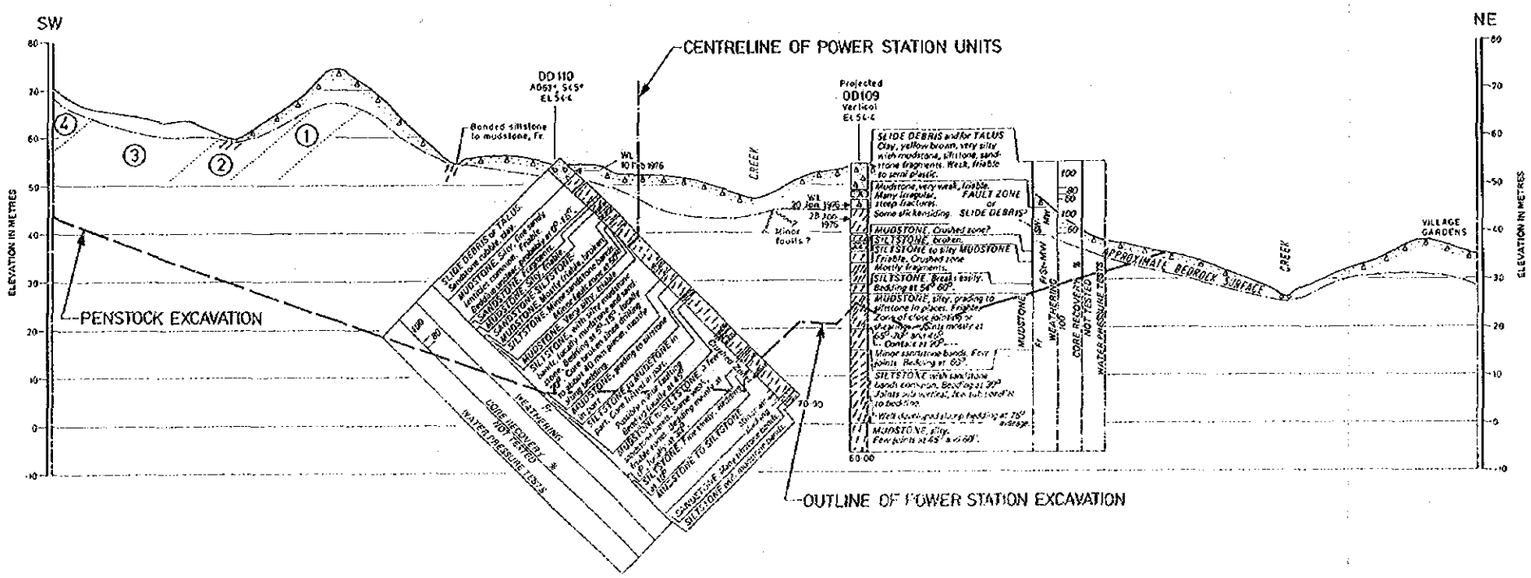
GEOLOGICAL SECTION o-o
AND SUMMARY LOGS OF DRILL HOLES

SHEET 9 OF 15

17

GEOLOGICAL SECTION p-p

(PROFILE COMPILED FROM CONTOUR PLAN)



NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... FIGURE 4 (1429-S3037)

WABO POWER PROJECT
POWER STATION

GEOLOGICAL SECTION p-p
AND SUMMARY LOGS OF DRILL HOLES

SHEET 10 OF 15 ☒ 18

GEOLOGICAL SECTION q - q

(SECTION ALONG SURVEYED LINE W)
(PROFILE COMPILED FROM CONTOUR PLAN)

SW

ELEVATION IN METRES

Mainly sandstone with many mudstone and siltstone interbeds.

Siltstone with mudstone and fine grained sandstone bands

Sandstone, medium to fine grained, massive.

Sandstone, fine grained with silty bands

DD 103
Vertical
EL 151·6

Fine grained silty sandstone

W1 9 Jan 1976
W1 28 Jan 1976

OUTLINE OF INTAKE STRUCTURE

MARKER BED

MARKER BED

MARKER BED

OUTLINE OF HEADRACE CHANNEL EXCAVATION

CHANNEL INVERT (PROJECTED)

APPROXIMATE BEDROCK SURFACE

CREEK

SLIDE DEBRIS ON TALUS
Sandy, clayey silt and sandstone pieces. Boulders

SANDSTONE, with siltstone bands, locally silty

SANDSTONE - SILTSTONE - MUDSTONE, Interbedded. Bedding at 40°. Minor air slacking

MUDSTONE, with sandstone and siltstone bands. Incipient air slacking

MUDSTONE - SANDSTONE - SILTSTONE, Interbedded. Carbonaceous fragments common. Bedding at 40°. Incipient air slacking. No joints.

SANDSTONE. Alternating bands of medium grained, light grey and fine grained, dark grey, silty sandstone. Bedding at 40°.

SANDSTONE - MUDSTONE. Interbedded. Bedding at 40°. Air slacking

MUDSTONE, with thin fine sandstone and siltstone bands. Incipient air slacking

MUDSTONE, SANDSTONE, SILTSTONE. Interbedded. Bedding at 40°, partings along bedding common. Slight air slacking in part.

MUDSTONE to SILTSTONE, minor sandstone bands. Weak and friable, incipient air slacking. Bedding at 40°

MUDSTONE, SANDSTONE Interbedded

SILTSTONE and MUDSTONE. Interbedded. Bedding at 40°

SANDSTONE. Minor siltstone to mudstone lenticles. No joints.

SANDSTONE-SILTSTONE Interbedded, minor mudstone lenticles. Bedding at 40°

SILTSTONE and MUDSTONE

SILTSTONE-MUDSTONE-SANDSTONE. Interbedded

SILTSTONE. Friable, incipient air slacking

SILTSTONE-MUDSTONE. Finely interbedded. Bands of fine sandstone common. Bedding at 35°-40°. Weak, incipient air slacking

SANDSTONE-SILTSTONE. Interbedded. Few friable siltstone bands.

MUDSTONE. Very silty, friable. Partially air slacked.

SILTSTONE. Partially air slacked.

SILTSTONE-SANDSTONE. Interbedded

SILTSTONE. Few fine, sandy bands. Thin mudstone lenticles common. Bedding at 40°. Air slacking

SILTSTONE-SANDSTONE. Interbedded. Bedding partings at 40°

SILTSTONE. Core shared along bedding planes. Minor air slacking and fretting

MUDSTONE to SILTSTONE. Minor sandy bands. Bedding at 40°. Partings along bedding

MUDSTONE. Silty, mostly weak, friable

MUDSTONE and SANDSTONE. Bedding at 40°. Minor incipient air slacking.

WATER PRESSURE TESTS
CORE RECOVERY %
WEATHERING

ADJOINS 'W'

OUTLINE OF PENSTOCK EXCAVATION

Slide debris, talus and rubble

GULLY

APPROXIMATE BEDROCK SURFACE

WATER PRESSURE TESTS NOT TESTED
CORE RECOVERY %
WEATHERING
WATER STRIKES

SILTSTONE. Joints at 20°, 60°, 80°
Bedding at 55°

Projected
DD 119
Vertical
EL 69·8

A 230
RL 67·7

Sandy clay with wood

Sandstone and Siltstone fragments

BRECCIA

WL 18 Dec 1975

Thick slide debris, talus, rubble, possibly 15 m thick

ADJOINS 'B'

A 231
EL 52·3

A 232
EL 49·2

A 233
EL 40·9

CREEK

Slide debris and talus

APPROXIMATE BEDROCK SURFACE

DOWNSTREAM PORTAL

DIVERSION TUNNEL No. 1

CHANNEL INVERT (PROJECTED)

NE

Residual silty clay, probably on mudstone

ELEVATION IN METRES

0 5 10 20 30 40 50m

NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... FIGURE 4 (1429-S3037)

WABO POWER PROJECT
INTAKE STRUCTURE — PENSTOCK

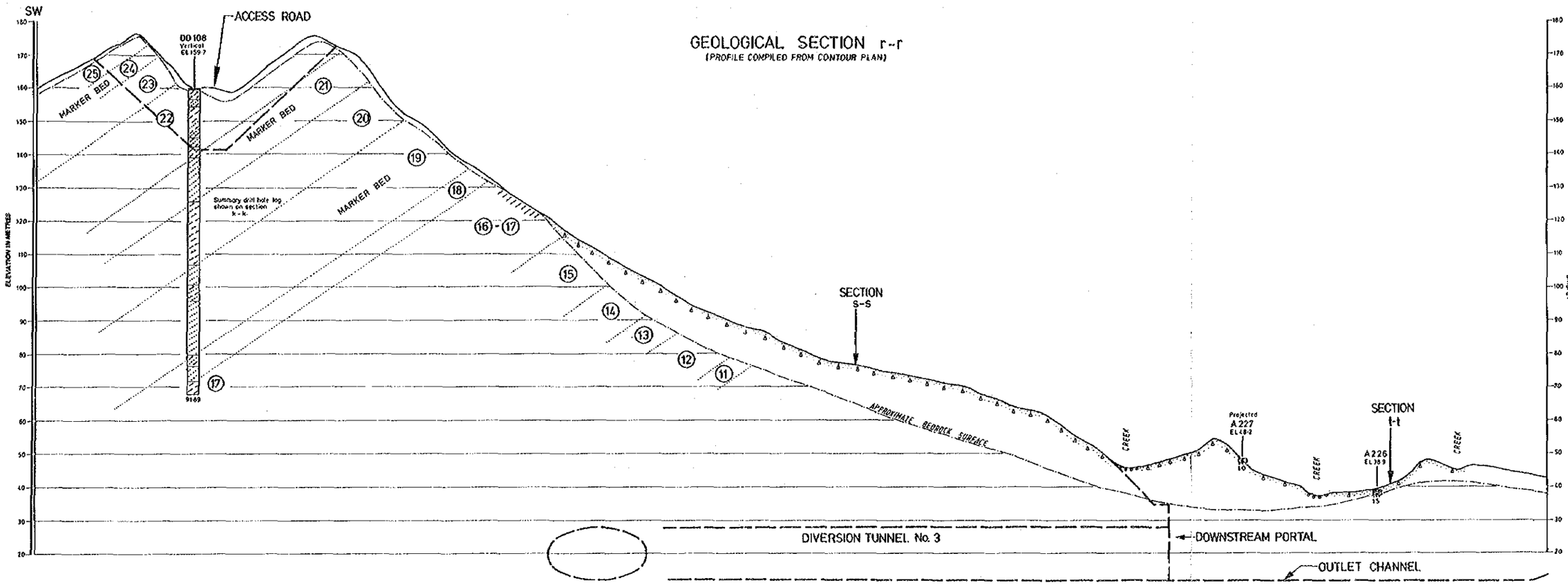
GEOLOGICAL SECTION q-q AND SUMMARY LOGS OF DRILL HOLES

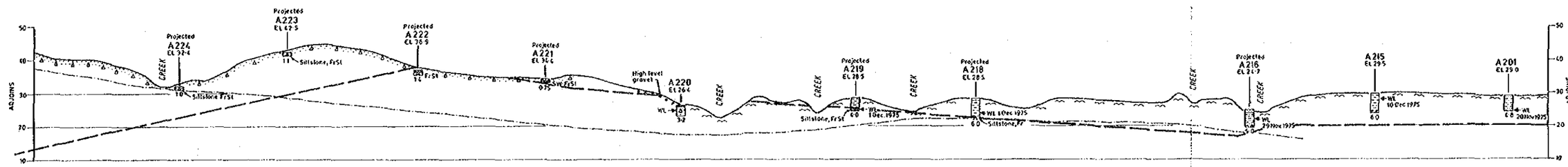
SHEET 11 OF 15

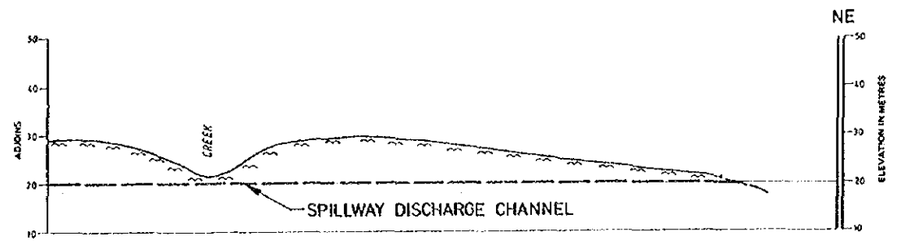
19

GEOLOGICAL SECTION r-r

(PROFILE COMPILED FROM CONTOUR PLAN)







0 5 10 20 30 40 50m

NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan.....FIGURE 4 (1429-S3037)

WABO POWER PROJECT

DIVERSION TUNNEL AND SPILLWAY

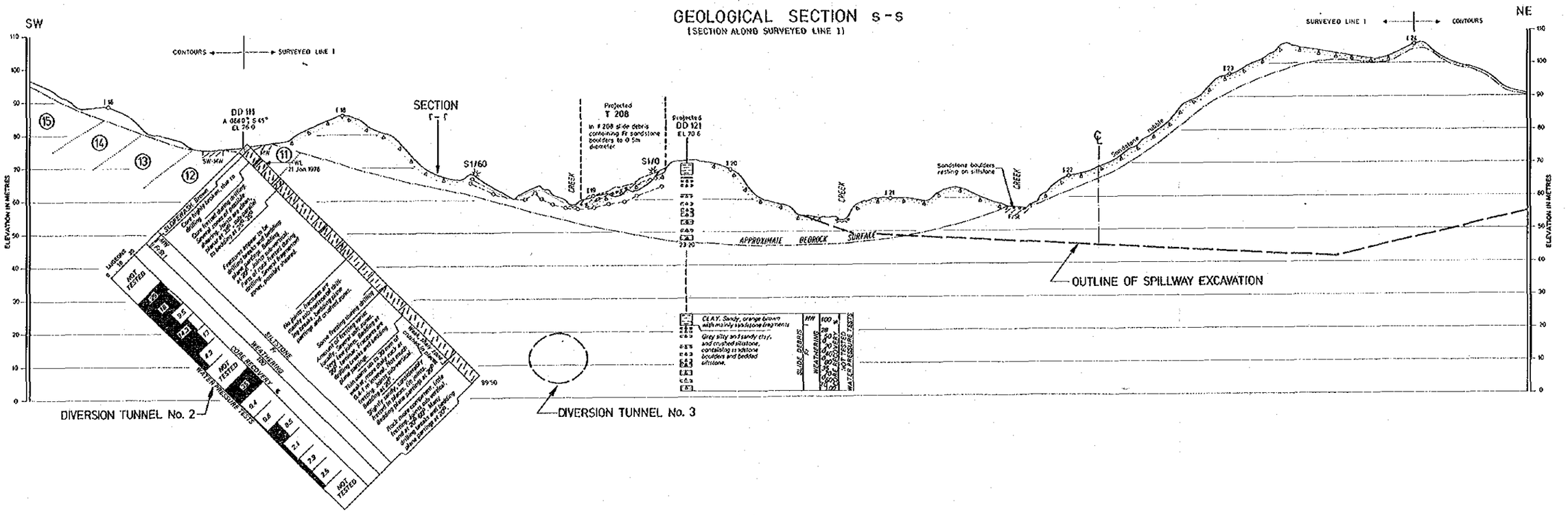
GEOLOGICAL SECTION r-r

AND SUMMARY LOGS OF DRILL HOLES

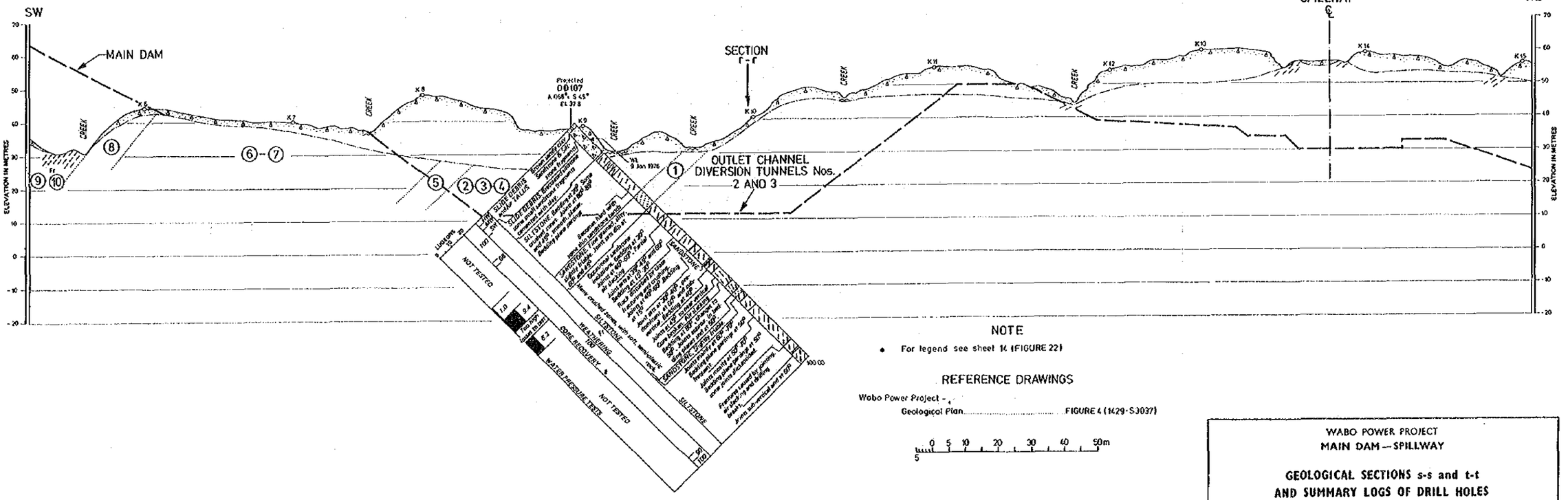
SHEET 12 OF 15

図 20

GEOLOGICAL SECTION s-s
(SECTION ALONG SURVEYED LINE 1)



GEOLOGICAL SECTION t-t
(SECTION ALONG SURVEYED LINE K)



NOTE

- For legend see sheet 14 (FIGURE 22)

REFERENCE DRAWINGS

Wabo Power Project –
Geological Plan ..... FIGURE 4 (1429-S3037)

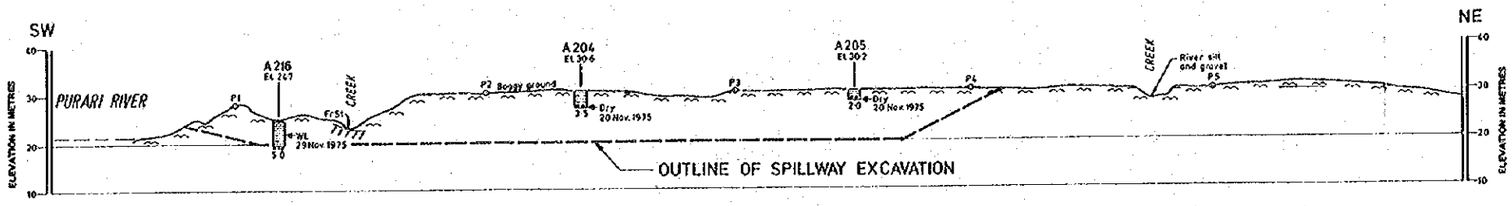
0 5 10 20 30 40 50m

WABO POWER PROJECT
MAIN DAM — SPILLWAY

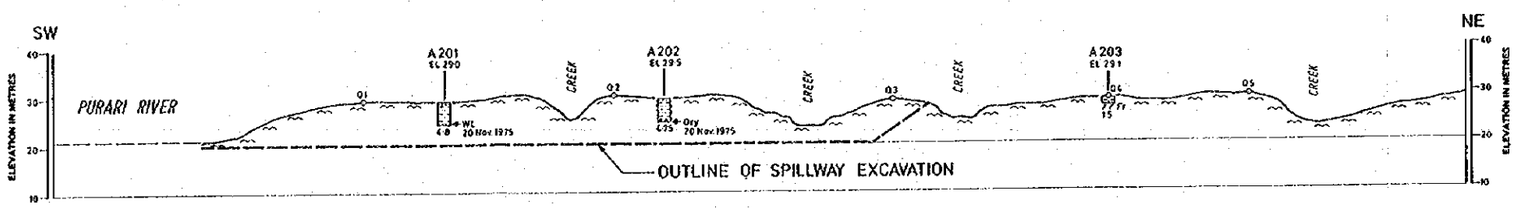
GEOLOGICAL SECTIONS s-s and t-t AND SUMMARY LOGS OF DRILL HOLES

SHEET 13 OF 15 | 21

GEOLOGICAL SECTION u-u
(SECTION ON SURVEYED LINE P)



GEOLOGICAL SECTION v-v
(SECTION ON SURVEYED LINE Q)



NOTES

- Description of material in drill holes refers only to core recovered.
- Where breaks are shown in drill hole logs, core was not recovered.
- Dip of joints, bedding, sheared zones is the angle between the planes of these features and the plane perpendicular to the axis of the drill hole.

LEGEND

- SLIDE DEBRIS, TALUS SOIL AND ROCK FRAGMENTS
- ALLUVIUM
- GRAVEL, BOULDER BEDS
- SANDSTONE
- SILTSTONE
- MUDSTONE

DD 110 — Drill hole 110.
A 062° ∠ S 45° — Slope, angle from horizontal, Azimuth.
EL 54.46 — Elevation in metres.
WL 10 Feb 1976 — Water level at date.
NO CORE — Summary bore log showing rock types, main core losses and sheared or crushed zones.
70.00 — Depth of hole in metres.

A 214 — Auger hole 214.
EL 29.6 — Elevation in metres.
Summary bore log showing rock types.
WL 20 Nov 1975 — Water level at date.
10.0 — Depth of hole in metres.

S3/0 S3/46 — Distances along seismic traverse S3/ metres. Geophone positions.
Seismic boundary (probable)
Seismic boundary (interpolated)
Depth point (calculated)
400 — Apparent seismic velocity (m/s)
1400 — Mean seismic velocity (m/s)

(17) (16) (15) — Rock Units.

DEGREE OF WEATHERING

CW — Completely weathered
HW — Highly weathered
MW — Moderately weathered
SW — Slightly weathered
FrSt — Fresh with limonite stained joints
Fr — Fresh

GEOLOGICAL BOUNDARIES

- Accurate
- Approximate
- Inferred

P3 P4 — Survey peg along surveyed line P.

0 5 10 20 30 40 50m
S

REFERENCE DRAWINGS

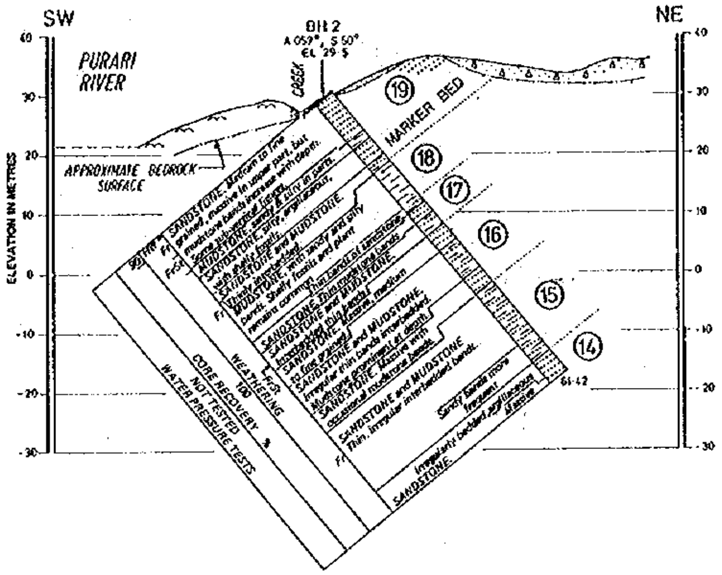
Wobo Power Project -

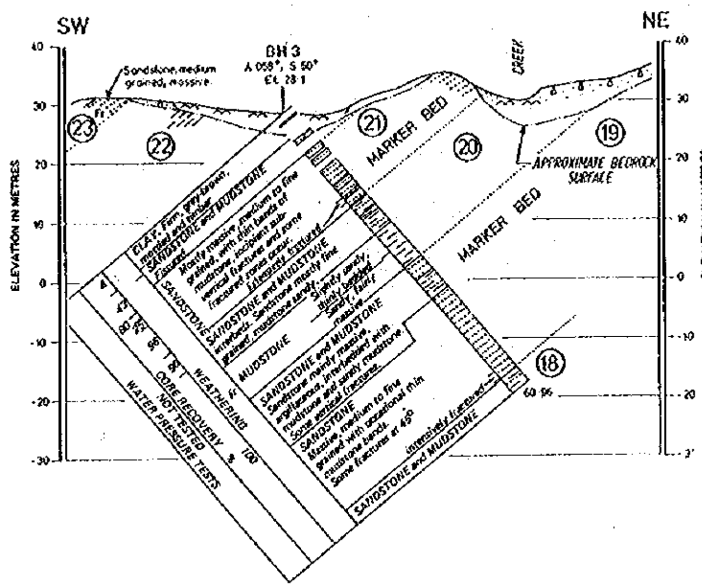
Geological Plan	FIGURE 4 (1429-S3037)
Subsurface Geology	FIGURE 5 (1429-S3038)
Stratigraphic Column	FIGURE 8 (1429-S3102)
Geological Logs of Hand Auger Holes A201 to A236	FIGURE 27(1429-S3044)
Time-distance graphs and Seismic Sections, Traverses S1 to S6	FIGURE 28(1429-S3097)

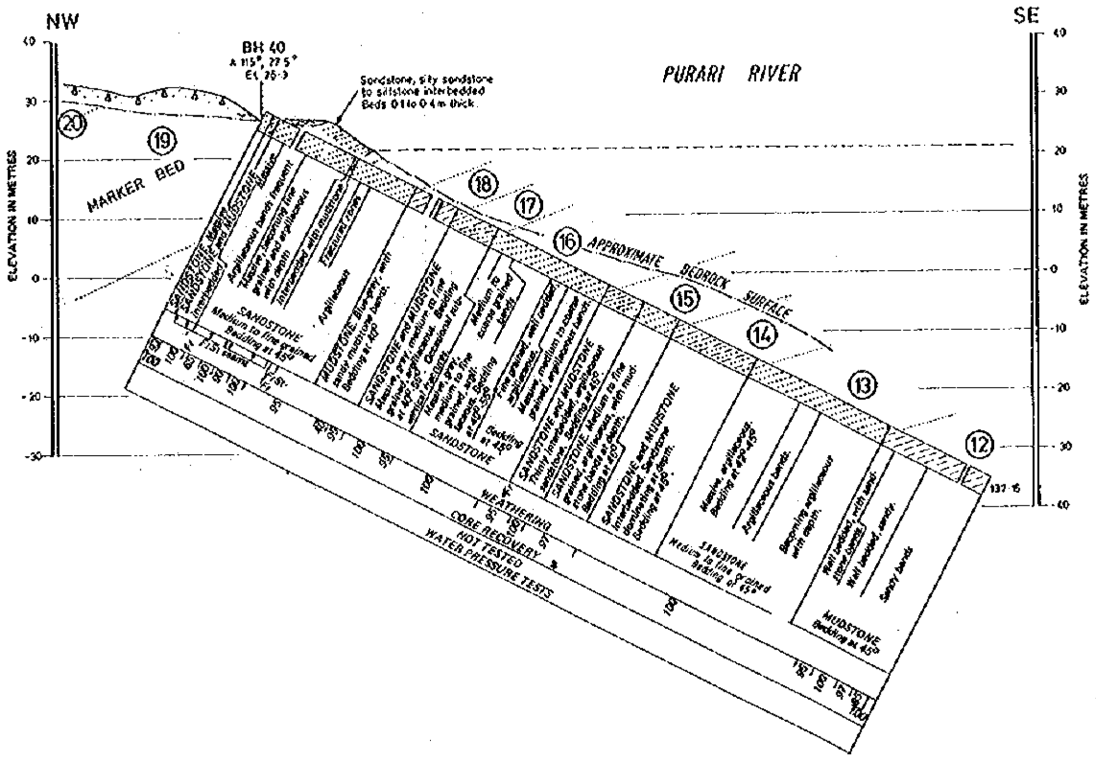
WABO POWER PROJECT
POWER STATION

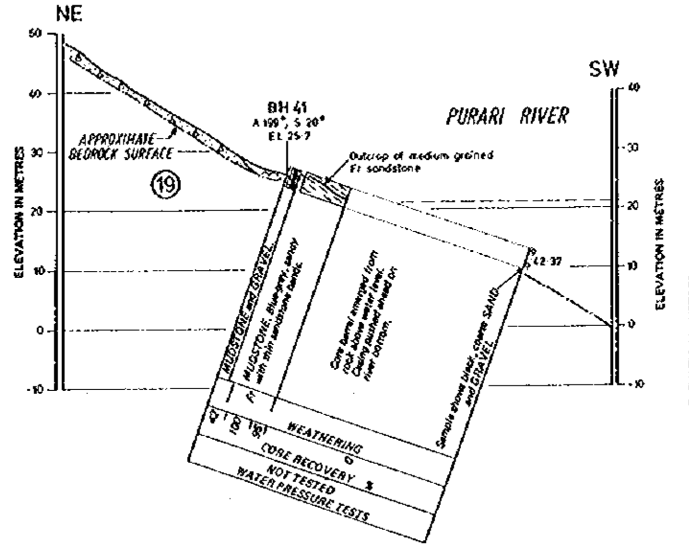
GEOLOGICAL SECTIONS u-u and v-v AND SUMMARY LOGS OF DRILL HOLES

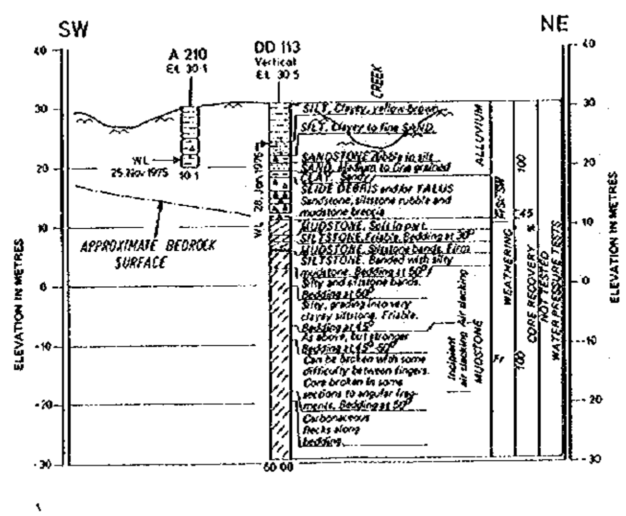
SHEET 14 OF 15 — 22

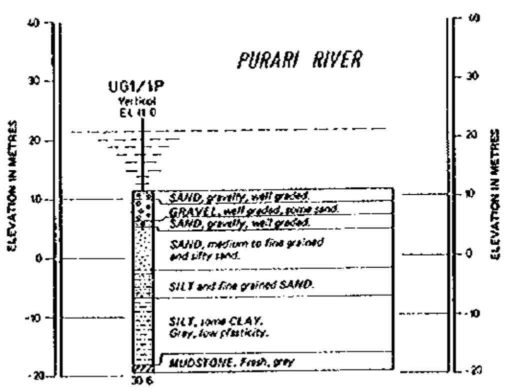


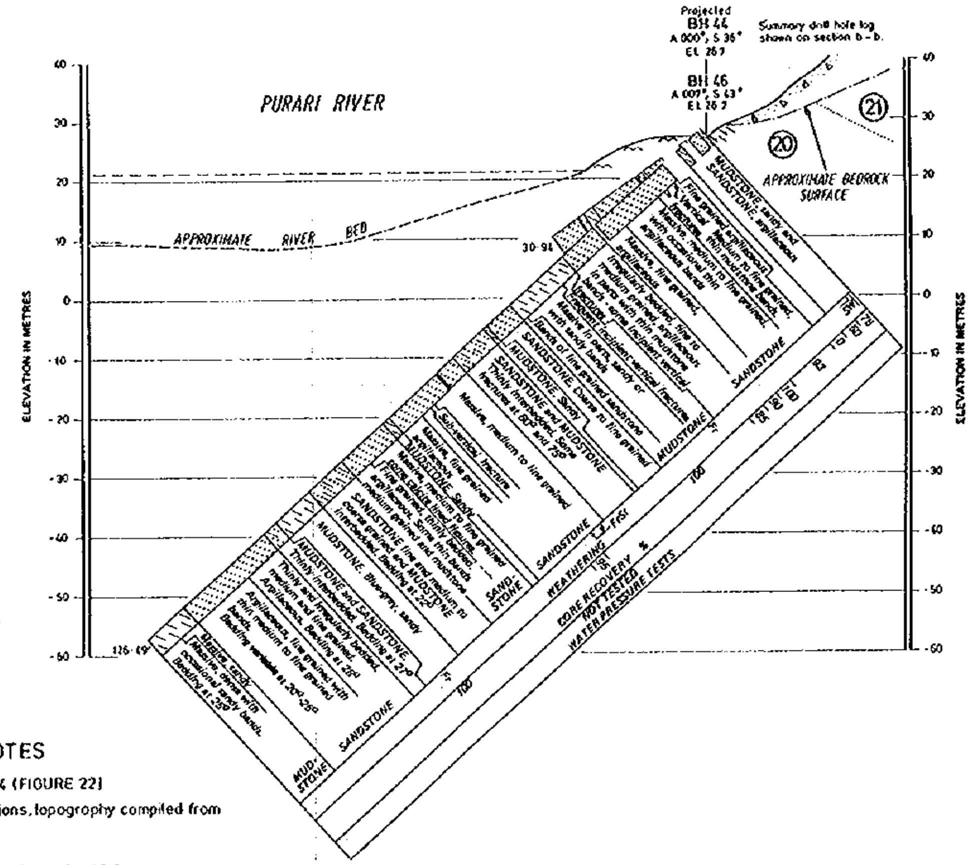


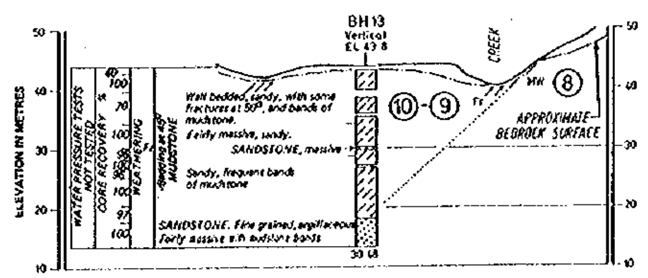


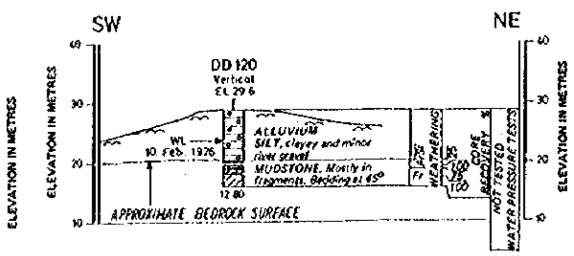












NOTES

- For legend see sheet 14 (FIGURE 22)
- Holes not shown on sections, topography compiled from contour plans.

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan .... FIGURE 4 (1429-S3037)

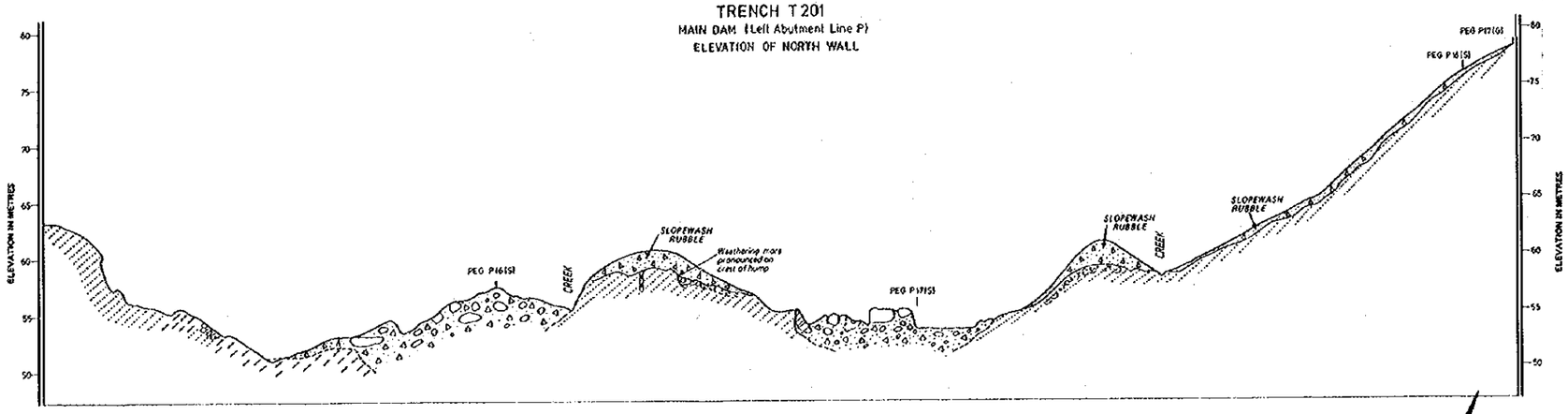
0 5 10 20 30 40 50m

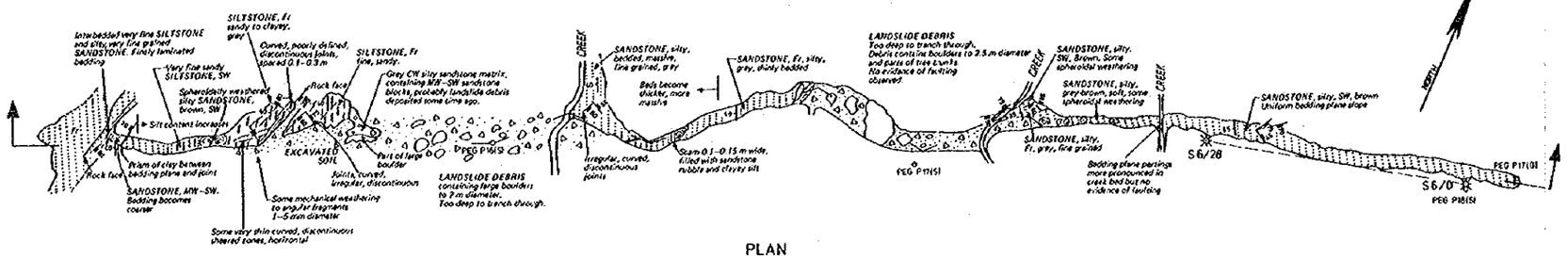
WABO POWER PROJECT
MAIN DAM AREA

SUMMARY LOGS OF MISCELLANEOUS DRILL HOLES

SHEET 15 OF 15 — 23

TRENCH T 201
MAIN DAM (Left Abutment Line P)
ELEVATION OF NORTH WALL





PLAN

LEGEND

- Joint strike and dip, inclined, vertical.
- Bedding strike and dip, inclined, vertical.
- Fault strike and dip.
- Anticlinal axis.
- A207 — Hand auger hole.
- S6/0 S6/28 — Distances along seismic traverse S6/metres.
- Geophone positions.

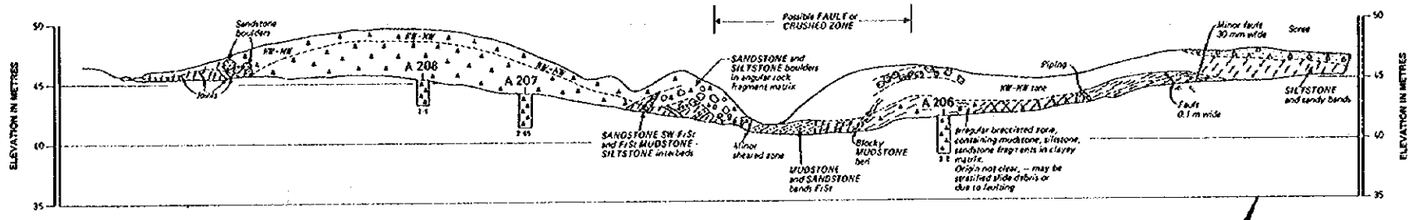
GEOLOGICAL BOUNDARIES

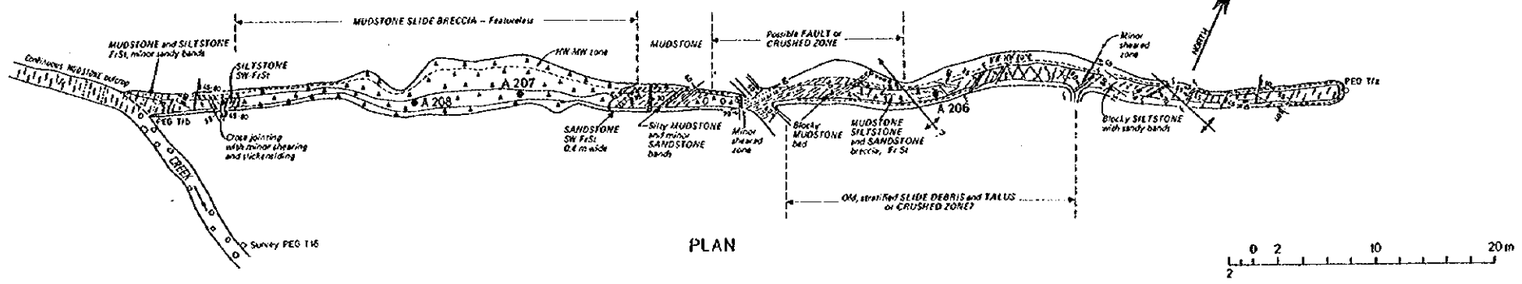
- ———— Accurate.
- - - - - - - - Approximate.

DEGREE OF WEATHERING

- cw – Completely weathered.
- hw – Highly weathered.
- mw – Moderately weathered.
- sw – Slightly weathered.
- fsi – Fresh, with limonite stained joints.
- fr – Fresh.

TRENCH T 202
POWER STATION
ELEVATION OF NORTH WALL





PLAN

0 2 10 20 m

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... FIGURE 4 (1429-S3037)
Geological Logs of Hand Auger Holes A201 to A236 ..... FIGURE 27 (1429-S3044)

WABO POWER PROJECT
MAIN DAM

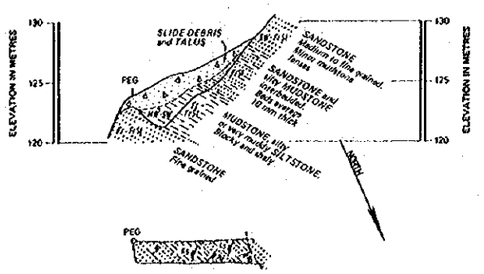
GEOLOGICAL LOGS OF TRENCHES

TRENCH T201 — T202

SHEET 1 OF 3

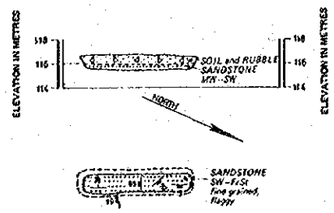
図 24

TRENCH T 203
MAIN DAM - LEFT ABUTMENT
ELEVATION OF SOUTH WALL



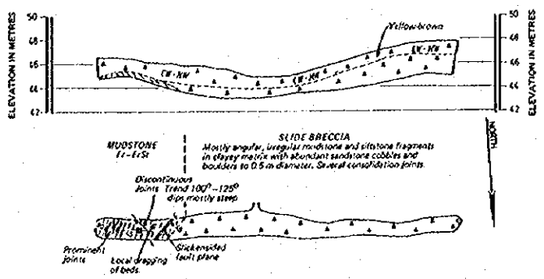
PLAN

TRENCH T 204
MAIN DAM - LEFT ABUTMENT
ELEVATION OF WEST WALL



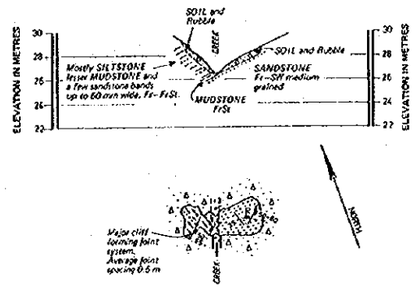
PLAN

TRENCH T 205
POWER STATION
ELEVATION OF SOUTH WALL



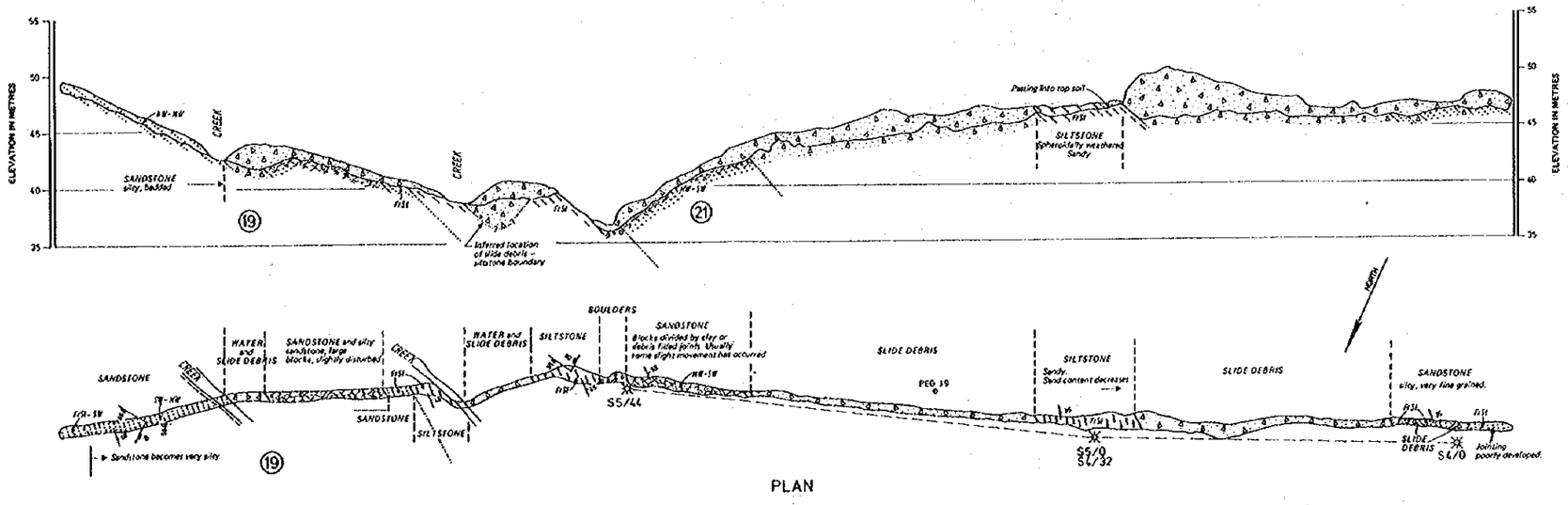
PLAN

TRENCH T 207
MAIN DAM (Left Bank Diversion Tunnel Inlet)
ELEVATION OF NORTH WALL



PLAN

TRENCH T 206
MAIN DAM - RIGHT ABUTMENT
ELEVATION OF SOUTH WALL



PLAN

0 2 10 20m

REFERENCE DRAWINGS

Wabo Power Project -
- Geological Plan ..... FIGURE 4 (1429-S3032)
- Geological Logs of Trenches T201 - T202, Sheet 1 ..... FIGURE 24 (1429-S3047/1)

WABO POWER PROJECT
MAIN DAM

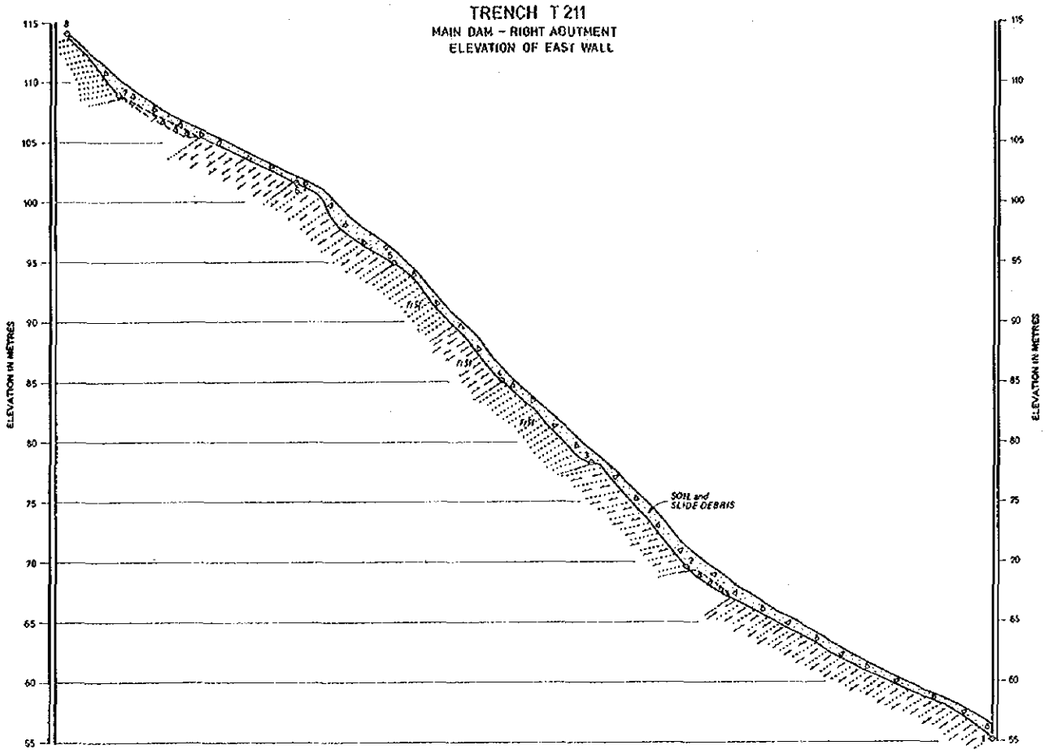
GEOLOGICAL LOGS OF TRENCHES

TRENCHES T203 to T207

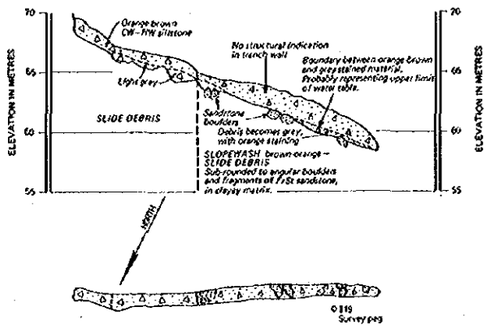
SHEET 2 OF 3

FIG 25

TRENCH T 211
MAIN DAM – RIGHT ABUTMENT
ELEVATION OF EAST WALL

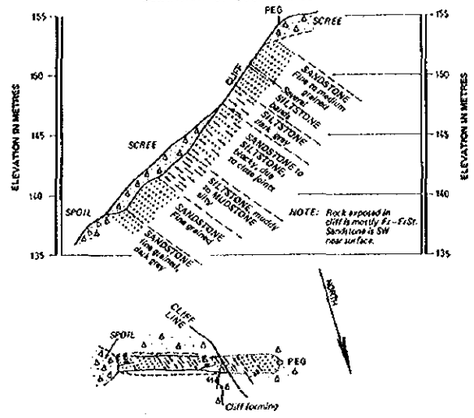


TRENCH T 208
SPILLWAY
ELEVATION OF SOUTH WALL



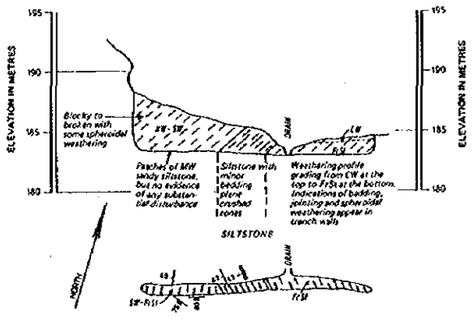
PLAN

TRENCH T 209
MAIN DAM – LEFT ABUTMENT
ELEVATION OF SOUTH WALL



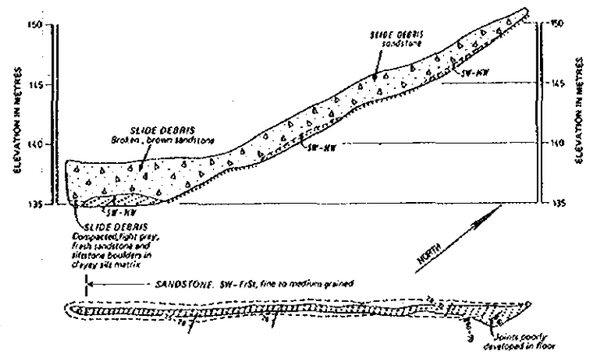
PLAN

TRENCH T 212
SPILLWAY
ELEVATION OF NORTH WALL



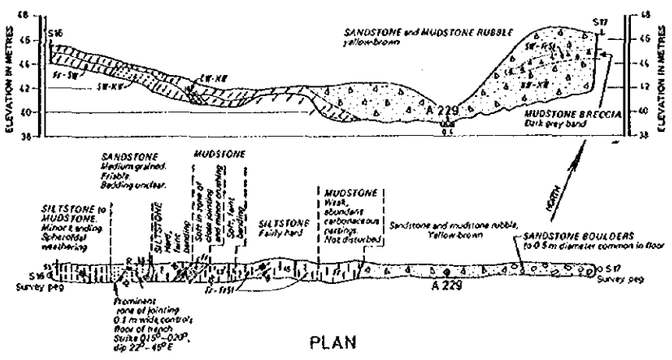
PLAN

TRENCH T 213
MAIN DAM – LEFT ABUTMENT
ELEVATION OF NORTH-WEST WALL



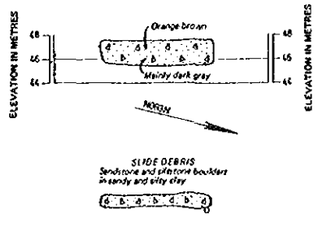
PLAN

TRENCH T 210
POWER STATION
ELEVATION OF NORTH WALL



PLAN

TRENCH T 214
SPILLWAY
ELEVATION OF WEST WALL



PLAN

TRENCH T 212
SPILLWAY
ELEVATION OF NORTH WALL

PLAN

REFERENCE DRAWINGS

Wabo Power Project –

Geological Plan	FIGURE 4 (1429-S3037)
Geological logs of Trenches T201 to T202, sheet 1	FIGURE 26 (1429-S3047/1)
Geological logs of Hand Auger Holes A201 to A236	FIGURE 27 (1429-S3044)

0 2 10 20 m

WABO POWER PROJECT
MAIN DAM

GEOLOGICAL LOGS OF TRENCHES

TRENCHES T208 to T214

SHEET 3 OF 3

26

SPILLWAY

A201 EL 29·0
ALLUVIUM
Grey to brown river silt and sand
20 Nov 1975 Wt
4·6
Stopped by water

A202 EL 29·5
ALLUVIUM
River silt and sand
20 Nov 1975 Dry
4·75
Rounded pebbles
Stopped by gravel

A203 EL 29·1
ALLUVIUM
River silt and sand
1·5
Bedrock Siltstone Fr

A204 EL 30·5
ALLUVIUM
River silt and sand
20 Nov 1975 Dry
3·5
Rounded pebbles
Stopped by gravel

A205 EL 30·0
ALLUVIUM
River silt and sand
20 Nov 1975 Dry
2·0
Rounded pebbles
Stopped by gravel

POWER STATION (TRENCH 1202)

A206 EL 42·0
MUDSTONE and SANDSTONE.
Fresh, angular fragments to 60 mm diameter in soft clay matrix. Possible slide debris or highly fractured mudstone and sandstone
18 Nov 1975 Wt
3·2
Hole stopped
Auger will not retain sample

A207 EL 44·1
MUDSTONE and SILTSTONE.
Fresh fragments to 30 mm diameter in silty clay matrix. Probably slide debris
10 Dec 1975 Wt
2·85
Hole stopped, – Auger will not retain sample
Approximate boundary

A208 EL 45·3
MUDSTONE and SILTSTONE.
Fresh fragments to 30 mm diameter in silty clay matrix. Probably slide debris
18 Nov 1975 Wt
3·1

POWER STATION

A209 EL 38·4
ALLUVIUM (HIGH LEVEL)
River gravel in clayey silt matrix. Yellow brown
ALLUVIUM
Silt, dark grey, clayey.
4·0
Hole stopped, – Auger will not retain sample

A210 EL 30·1
ALLUVIUM
Silt, dark grey, clayey.
ALLUVIUM
Silt, dark grey, clayey, with angular Sandstone pebbles. One rounded limestone pebble
25 Nov 1975 Wt
ALLUVIUM
Silt, dark grey, clayey
10·1
Hole stopped, – Auger will not retain sample, due to water

A211 EL 24·5
ALLUVIUM
Silt, dark grey, clayey
24 Nov 1975 Wt
1·1
1·3
Hole stopped – Auger will not retain sample, due to water

A212 EL 30·0
ALLUVIUM
Silt, dark grey, clayey
SILT and ROCK FRAGMENTS
Possible talus or slope wash
CLAY, Very silty, mid grey to yellow brown, mottled. Bedrock not reached.
8·0
Hole stopped. Auger will not retain sample

A213 EL 28·5
ALLUVIUM
Silt, dark grey, clayey
25 Nov 1975 Wt
ALLUVIUM
Silt and clay
CLAY, silty. Possibly CW rock
4·75
MUDSTONE Fr

A214 EL 29·6
ALLUVIUM
Sand, medium grained, yellow brown, silty
ALLUVIUM
Silt, sandy, dark grey, minor clay
ALLUVIUM
Sand and gravel. Medium grained, dark grey sand, minor silt. Limestone gravel to 50 mm diameter, well rounded
19·0

SPILLWAY

A215 EL 29·5
ALLUVIUM
Silt, brown, dry
10 Dec 1975 Wt
ALLUVIUM
Silt, sandy, blue grey, brown
ALLUVIUM
Silt, more sandy than above
River gravel
6·0
Stopped by gravel

A216 EL 25·0
ALLUVIUM
Sand, brown, slightly moist
ALLUVIUM
Sand, fine grained and silt, blue grey to brown
29 Nov 1975 Wt
ALLUVIUM
Sand, fine grained and brown, clayey silt
ALLUVIUM
Silt, clayey, blue brown and sandy, fine grained. River gravel
5·0
Stopped by gravel

SPILLWAY

A217A EL 29·4
ALLUVIUM
Silt, brown
25 Nov 1975 Wt
ALLUVIUM
Silt, clayey, blue.
6·0
Material from bottom of hole lost without identification

A217B EL 28·5
10 Dec 1975 Wt
ALLUVIUM Silt, clayey, brown.
ALLUVIUM Silt, clayey, brown-grey-blue
ALLUVIUM Silt, clayey, blue grey
ALLUVIUM Silt
3·5
Auger will not retain sample

A218 EL 28·5
TOPSOIL. Brown, medium moist
ALLUVIUM
Silt, grey
ALLUVIUM
Silt, sandy, grey.
10 Dec 1975 Wt
SILTSTONE Fr, much softer than normal. Slickensided, broken to completely crushed
6·0
Auger will not retain sample

A219 EL 28·5
ALLUVIUM
Clay, silty, brown
2 Dec 1975 Wt
SILT, dark grey with some bedrock
SILTSTONE Fr, soft, dark grey. Broken and slickensided.
4·0

A220 EL 26·4
CLAY, silty, brown
SLOPEWASH
Silt, clayey, sandy, containing rounded sandstone pebbles. Brown grey
Sand content increases
Bedrock?
2 Dec 1975 Wt
3·2
Very hard to auger
Auger will not retain sample

A221 EL 34·4
TOPSOIL
SILTSTONE SW–FrSt. Brown grey. Fairly soft, but brittle
0·75
Auger will not retain sample

A222 EL 36·9
ALLUVIUM–HIGH LEVEL?
SOIL, brown, containing rounded sandstone pebbles
SILTSTONE FrSt
1·5

A223 EL 42·5
TOPSOIL – SLOPEWASH
SILTSTONE FrSt
1·1
Refusal

SPILLWAY

A224 EL 32·4
CLAY, Brown with small crushed fragments of rock, brown and dark grey
SILTSTONE FrSt
1·0
Refusal

A225 EL 44·7
SLOPEWASH with Mill sandstone pebbles and cobbles
6
CLAY, silty, blue grey with Fr sandstone pebbles and cobbles ?
3 Dec 1975 Wt
ALLUVIUM (HIGH LEVEL?)
CLAY, silty, grey with Fr sandstone cobbles and pebbles. Fr siltstone fragments
Bedrock (Sandstone ?)
4·0
Refusal

A226 EL 38·9
TOPSOIL, orange brown
ALLUVIUM (HIGH LEVEL?)
CLAY, sandy, grey with sandstone pebbles Fr grey, which show signs of rounding.
Bedrock? (Sandstone?)
4 Dec 1975 Wt
1·5

A227 EL 48·2
TOPSOIL–SLOPEWASH
Clay, brown with rock fragments
Sandstone pebbles, FrSt, (bedrock?)
1·0
Too hard to auger

A228 EL 50·2
TOPSOIL–SLOPEWASH Brown
Sandstone pebbles
In grey brown silty sand
0·75
Auger will not retain sample

POWER STATION (TRENCH 1210)

A229 EL 39·2
SLIDE DEBRIS
Sandstone and mudstone fragments
10 Dec 1975 Wt
0·4
Unable to penetrate boulder

DIVERSION OUTLET CHANNEL

A230 EL 67·7
SLIDE DEBRIS or TALUS
Sandstone rubble in yellow brown clay matrix
Sandstone and mudstone rubble, dark grey
11 Dec 1975 Wt
3·0
Hole stopped. Auger will not retain sample

A231 EL 52·3
SLIDE DEBRIS or TALUS
Sandstone rubble in yellow-brown clay matrix
Sandstone and mudstone rubble, dark grey
3·25
Hole stopped, auger will not retain sample

DIVERSION OUTLET CHANNEL

A232 EL 49·2
SLIDE DEBRIS or TALUS
Mudstone fragments in clay matrix, yellow-brown
Mudstone pieces, dark grey. (Possible bedrock ?)
2·75
Hole stopped. Auger will not retain sample, or penetrate

A233 EL 40·9
SLIDE DEBRIS or TALUS
Sandstone and mudstone fragments in clay matrix, yellow-brown
SLIDE DEBRIS
Sandstone and mudstone rubble in clay matrix, dark grey.
Coalified wood recovered
9·2
Auger will not penetrate

POWER STATION

A234 EL 29·5
ALLUVIUM
Sand and silt grading into silty clay at depth
ALLUVIUM
Sand and silty sand, containing some partly decomposed plant remains and wood
12 Jan 1976 Wt
7·75

SPILLWAY

A235 EL 31·6
SILT, clayey, orange to grey, crumbly
SILTSTONE Dark grey
SILTSTONE, Fr, dark grey, bedded
11 Feb 1976 Wt
2·25

A236 EL 28·5
CLAY, sandy, mottled, low plasticity
SAND, clayey, silty, grey
SAND, fine grained, silty
SAND, clayey with Fr sandstone pebbles
ALLUVIUM
CLAY, fine sandy with Fr sandstone pebbles
12 Feb 1976 Wt
4·75

LEGEND

A216 EL 25·0 — Auger hole number, Elevation in metres

Summary log showing rock types

Water level at date shown

5·0 — Depth of hole in metres

REFERENCE DRAWINGS

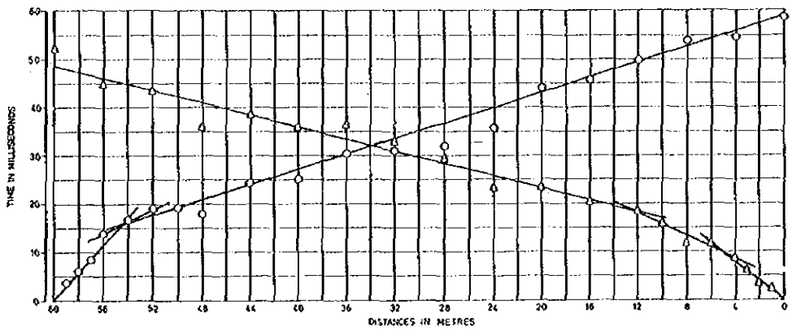
Wabo Power Project -
Geological Plan ..... FIGURE 4 (1429-S3037)

WABO POWER PROJECT
MAIN DAM

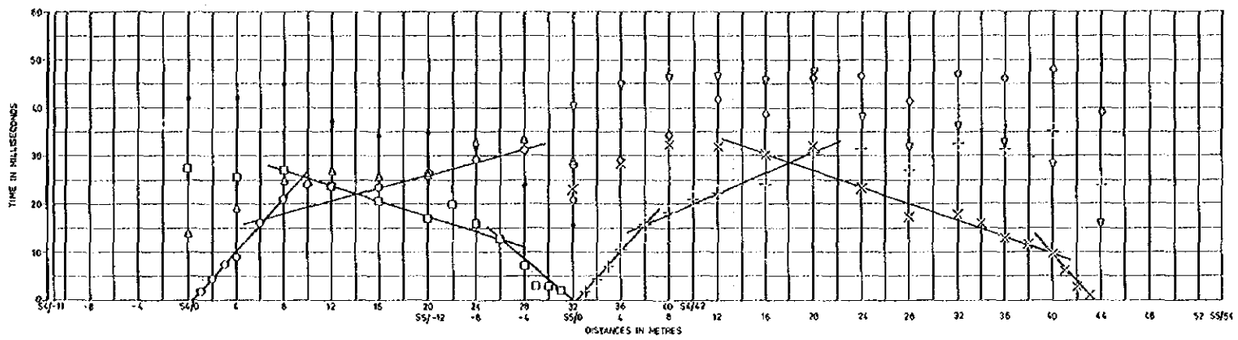
GEOLOGICAL LOGS OF HAND AUGER HOLES

27

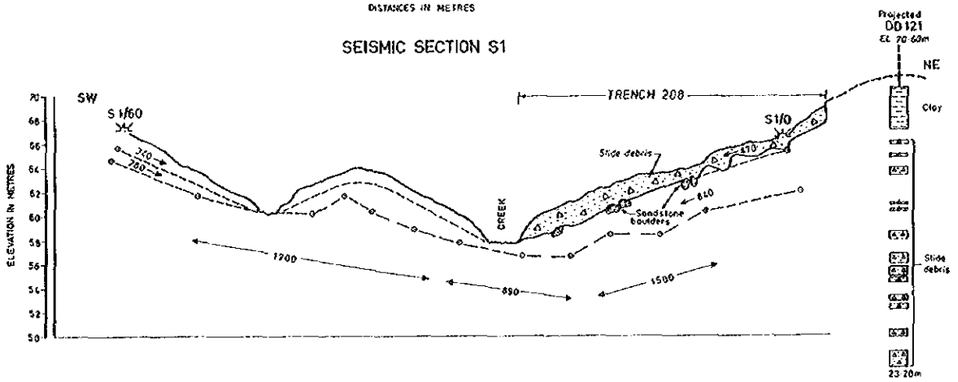
TIME-DISTANCE GRAPH, TRAVERSE S1



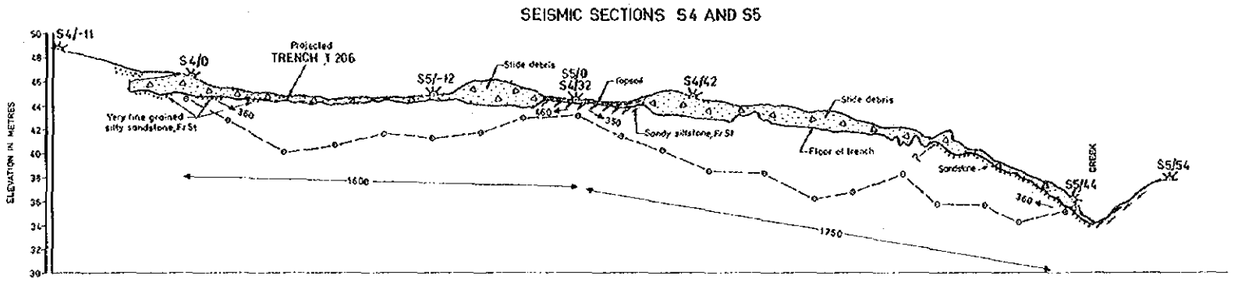
TIME-DISTANCE GRAPH, TRAVERSES S4 AND S5



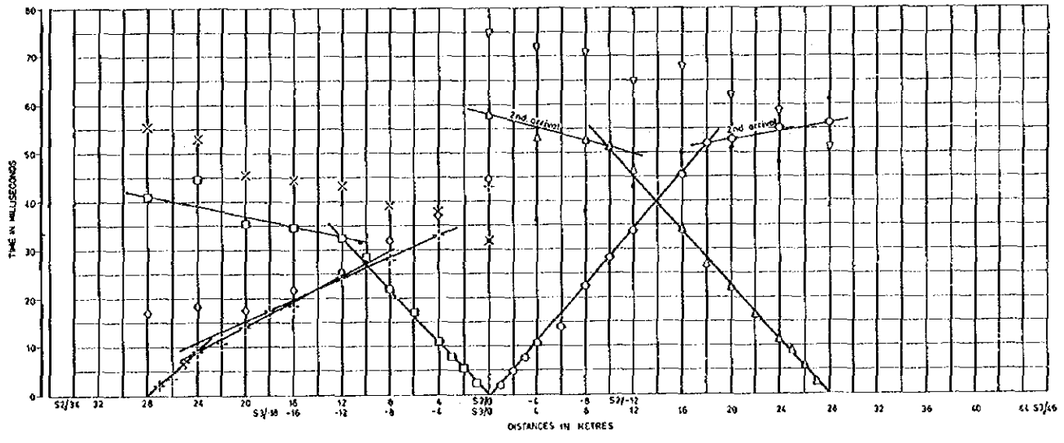
SEISMIC SECTION S1



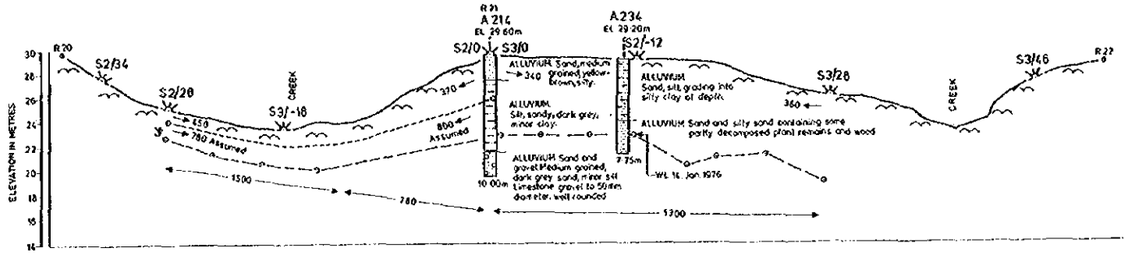
SEISMIC SECTIONS S4 AND S5



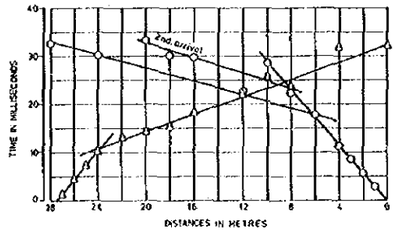
TIME-DISTANCE GRAPH, TRAVERSES S2 AND S3



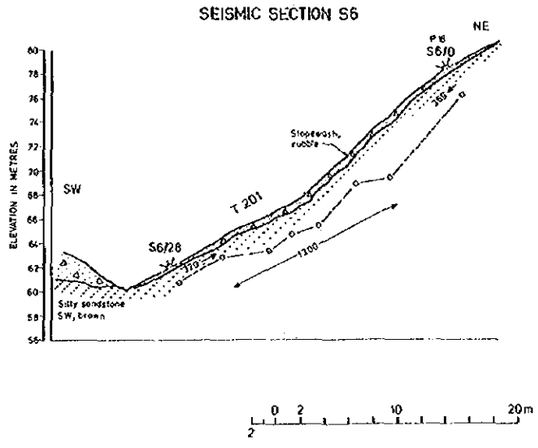
SEISMIC SECTIONS S2 AND S3



TIME-DISTANCE GRAPH, TRAVERSE S6



SEISMIC SECTION S6



LEGEND

S4/0 S4/42 — Distances along seismic traverse S4/metres

Geophone positions

Seismic boundary (probable)

Time distance graph (established)

Depth point (calculated)

Recorded travel times

369 — Apparent seismic velocity (m/s)

1300 — Mean seismic velocity (m/s)

R22 6 Survey peg

NOTE • Only the upper surface of the highest velocity layer is shown. The thickness of this layer is not known and there may be material with different velocities below it.

♦ Seismic survey was carried out with a "Bison 1570B, signal Enhancement" hammer seismograph

DIAMOND DRILL HOLE

DD121 — Hole number

EL 70·60m — Elevation in metres

No core

23·20m — Depth of hole

Summary log of hole showing rock types and core losses

AUGER HOLE

A210 — Hole number

EL 29·60m — Elevation in metres

WL 16 Jan 1976 — Water level at date

10·00m — Depth of hole

Summary log of hole showing rock types

REFERENCE DRAWINGS

Wabo Power Project -

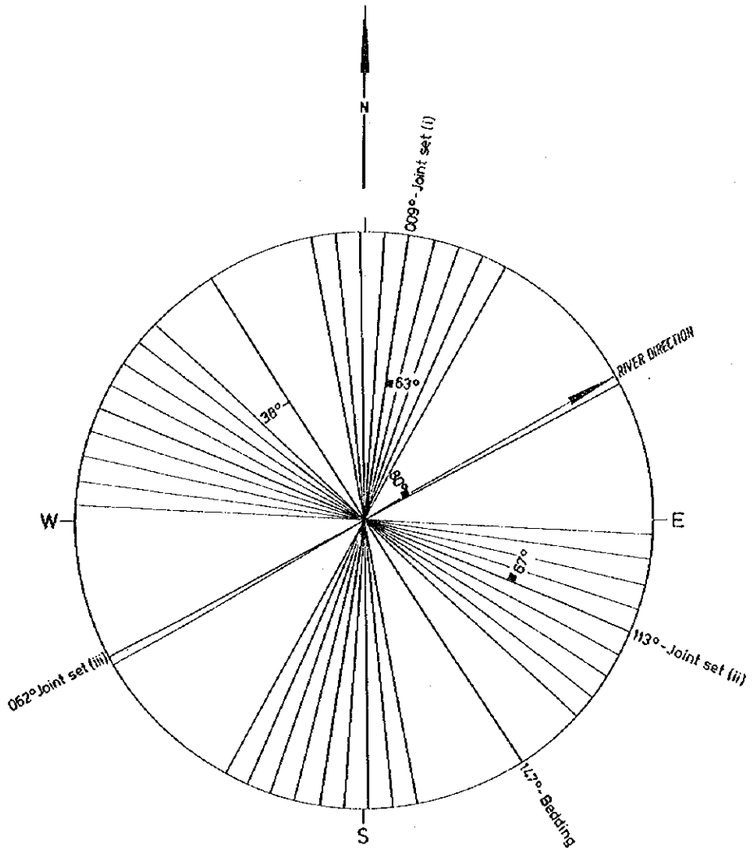
Geological Plan ..... FIGURE 4 (14·29 - S 3037)

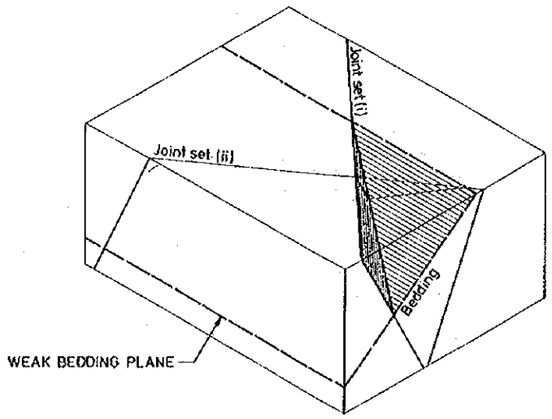
WABO POWER PROJECT
MAIN DAM

TIME-DISTANCE GRAPHS & SEISMIC SECTIONS

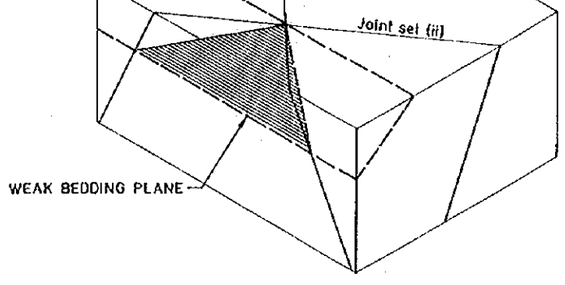
TRAVERSES S1,S2,S3,S4,S5 AND S6

28

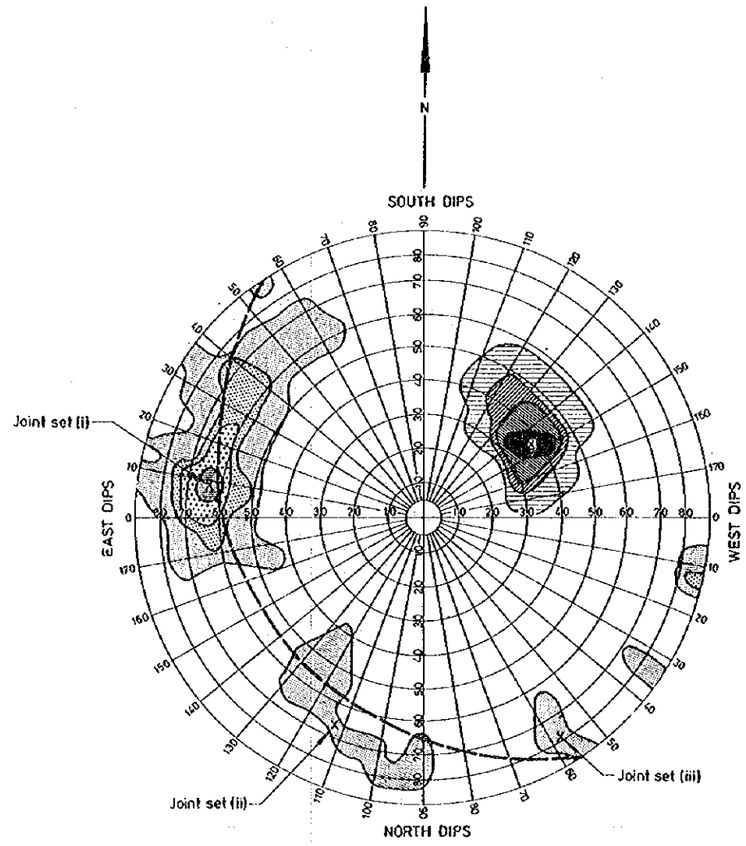




WEDGE TYPE FAILURE ON BEDDING PLANES
AND JOINT SET (i)



WEDGE TYPE FAILURE ON JOINT SETS (i) AND (ii)
WHERE BEDDING IS UNDERCUT



LEGEND

JOINTS - 210 POINTS	BEDDING - 140 POINTS
< 1.5% PER 1% AREA	< 8% PER 1% AREA
1.5% - 3% PER 1% AREA	8% - 15% PER 1% AREA
3% - 4.5% PER 1% AREA	15% - 24% PER 1% AREA
4.5% - 6% PER 1% AREA	24% - 32% PER 1% AREA
> 6% PER 1% AREA	> 32% PER 1% AREA

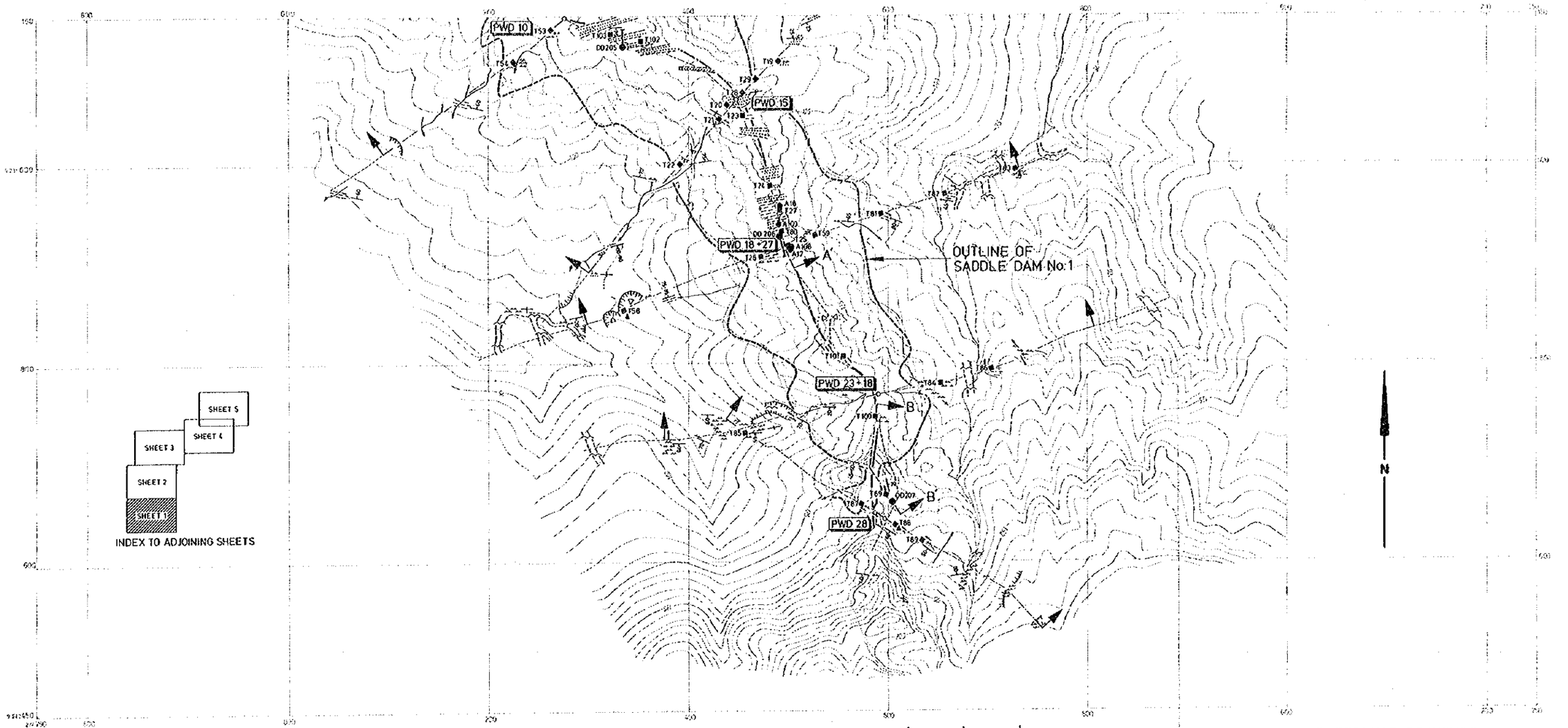
SCHMIDT NET LOWER HEMISPHERE
GRADUATED FOR POLES OF PLANAR ELEMENTS

- Read strike of plane along circumference in degrees east of north.
- Read dip of plane along diameter

WABO POWER PROJECT
MAIN DAM

POLAR DIAGRAM OF JOINTS & BEDDING PLANES

29



LEGEND

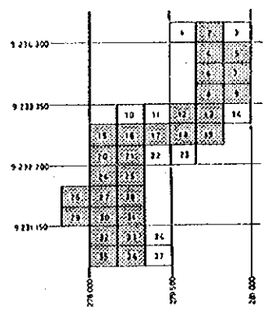
- ALLUVIUM.
- SCREE, TALUS.
- SLIDE DEBRIS and BRECCIA.
- SANDSTONE.
- SANDSTONE, rubbly outcrop.
- SILTSTONE.
- MUDSTONE.

- Strike and dip of bedding
- Strike of vertical bedding
- Strike and dip of fault or sheared zone.
- Strike of vertical fault or sheared zone.
- Anticline
- Syncline.
- Lineament.
- Fault or sheared zone.
- Stump scarp.

GEOLOGICAL BOUNDARIES

- Approximate
- Inferred

- T135 ■ T130 Trench.
- DD207 ● Diamond drill hole, vertical.
- DD 208 ● Diamond drill hole, sloped.
- A21 ● Auger hole.
- PWD 55 — Geological sections.
- B B' — Geological sections.
- S01/0 S01/45 — Seismic traverse line.
- Surveyed line.



Index to 1:500 Series map coverage. Shading indicates maps with detailed geology.

0 20 100 200m

Contour Interval 5m

REFERENCE DRAWINGS

Wabo Power Project

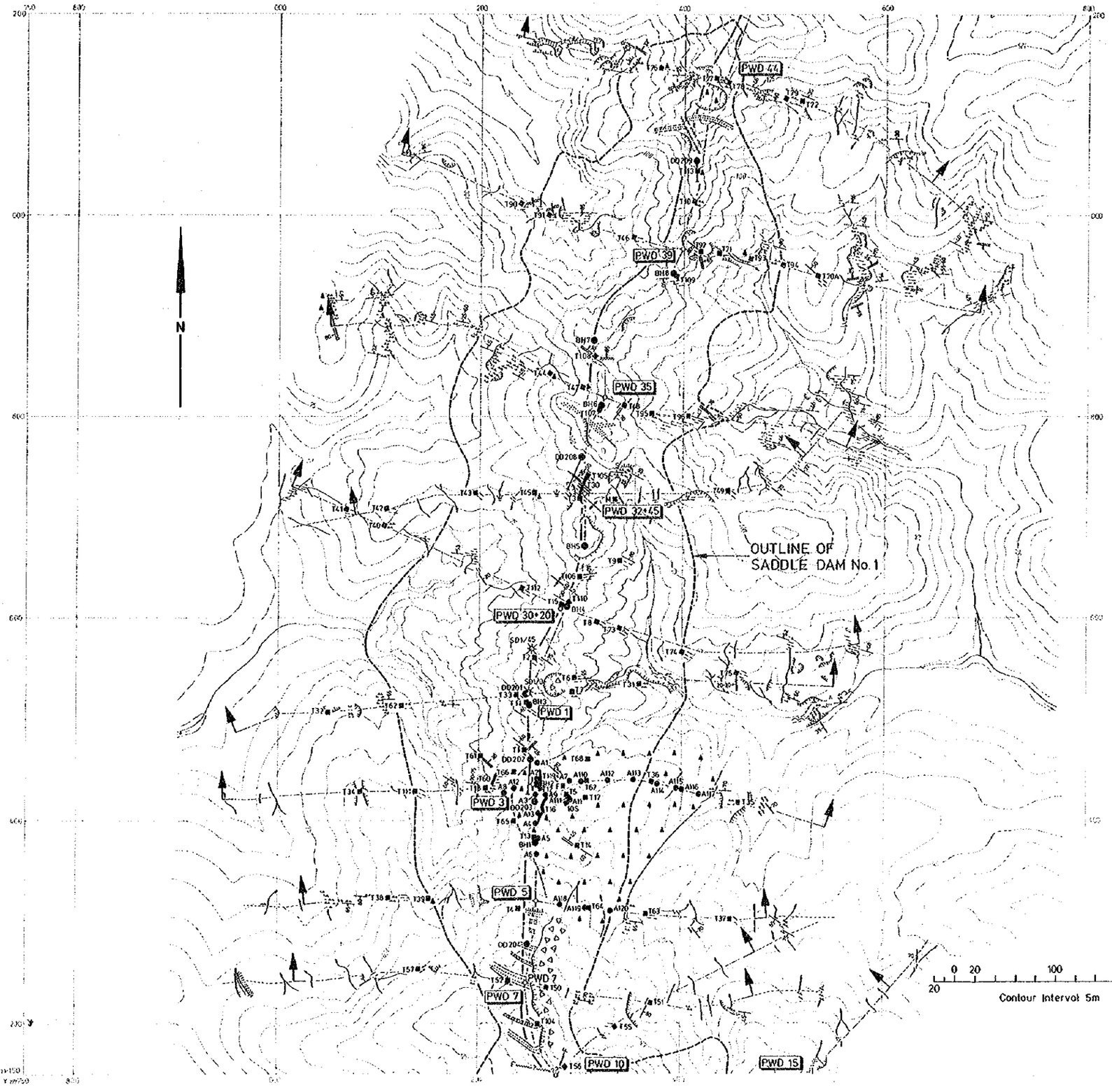
Geological sections and summary logs of drill holes.	Figures 36-51 (1429-S3158/1-16)
Geological logs of trenches	Figures 52-61 (1429-S3045/1-10)
Geological logs of hand auger holes	Figure 62 (1429-S3159)
Time-distance graph and seismic section, Traverse S01	Figure 63 (1429-S3160)
Polar diagram - bedding planes	Figure 64 (1429-S3161)

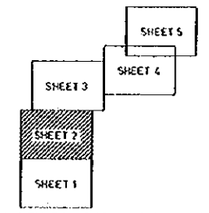
WABO POWER PROJECT
SADDLE DAMS

GEOLOGICAL PLAN

SHEET 1 OF 5

Fig 30





INDEX TO ADJOINING SHEETS

NOTE

- For legend see sheet 1 (figure 30).

WABO POWER PROJECT
SADDLE DAMS

GEOLOGICAL PLAN

SHEET 2 OF 5

図 31

N

OUTLINE OF SADDLE DAM No.2

PWD 63

PWD 58+20

PWD 55

PWD 50

PWD 72+29

PWD 69

PWD 78

FAULT ZONE

INDEX TO ADJOINING SHEETS

SHEET 5
SHEET 4
SHEET 3
SHEET 2
SHEET 1

NOTE

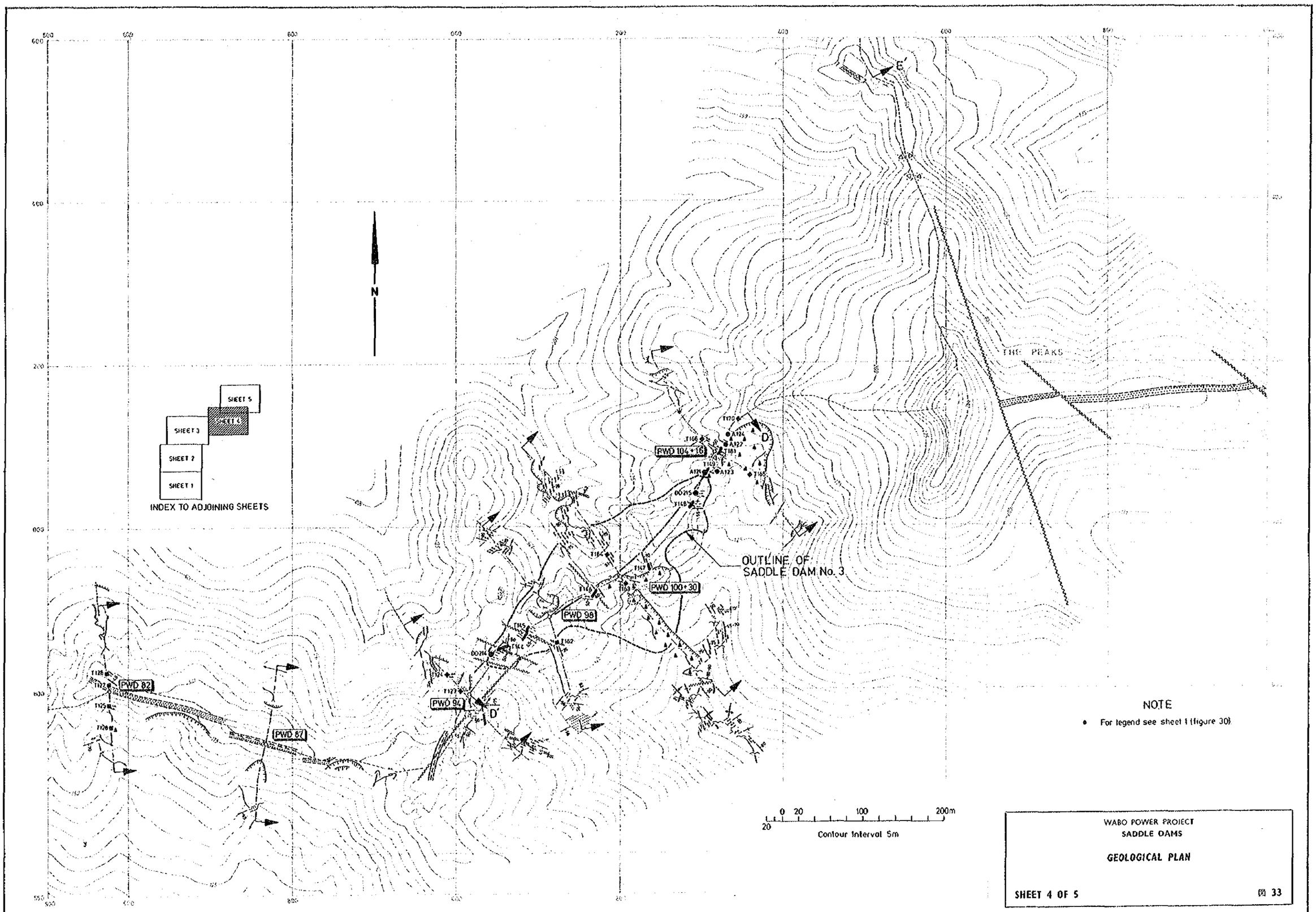
- For legend see sheet 1 (figure 30)

0 20 100 200m
20
Contour Interval 5m

WABO POWER PROJECT
SADDLE DAMS

GEOLOGICAL PLAN

SHEET 3 OF 5 32

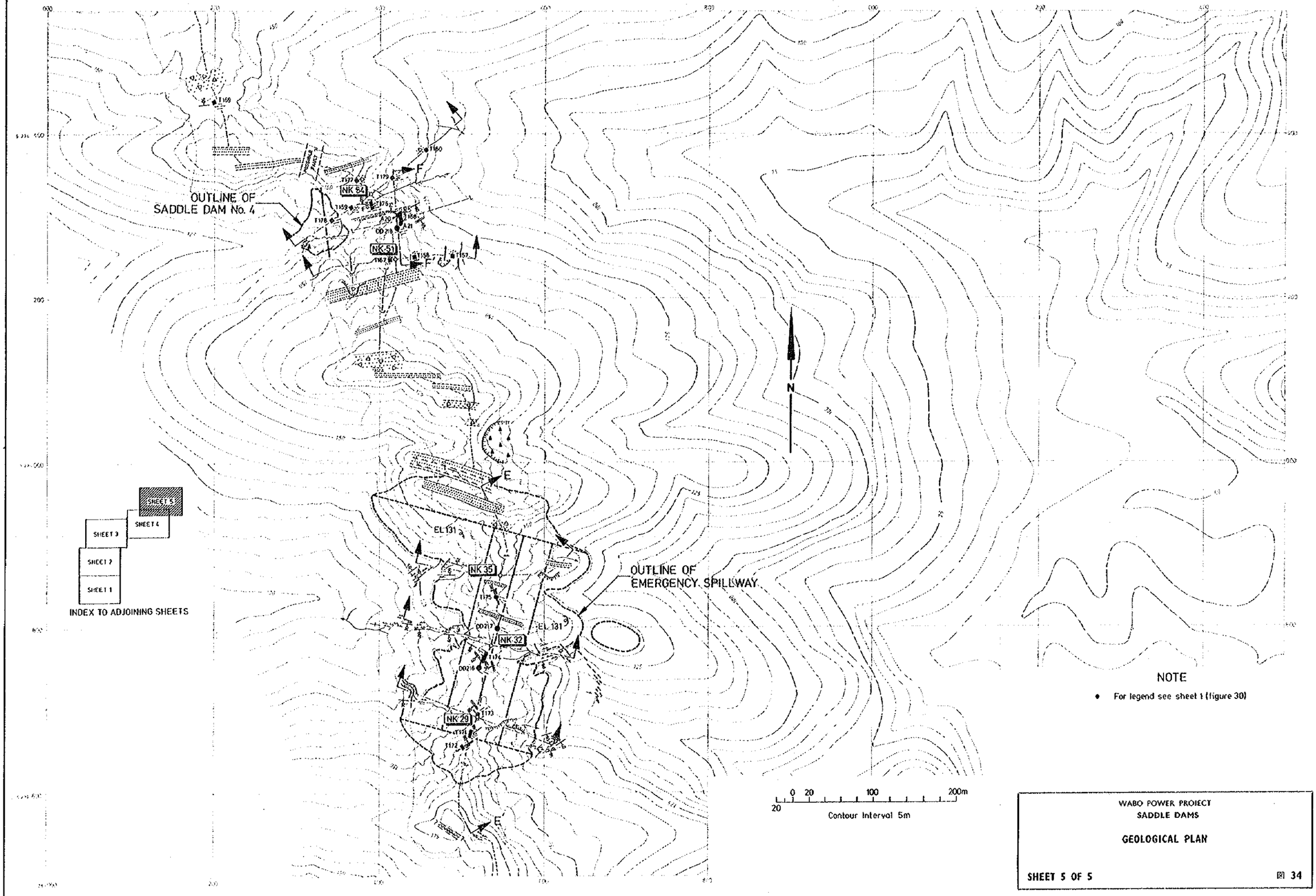


WABO POWER PROJECT
SADDLE DAMS

GEOLOGICAL PLAN

SHEET 4 OF 5

図 33



NOTE

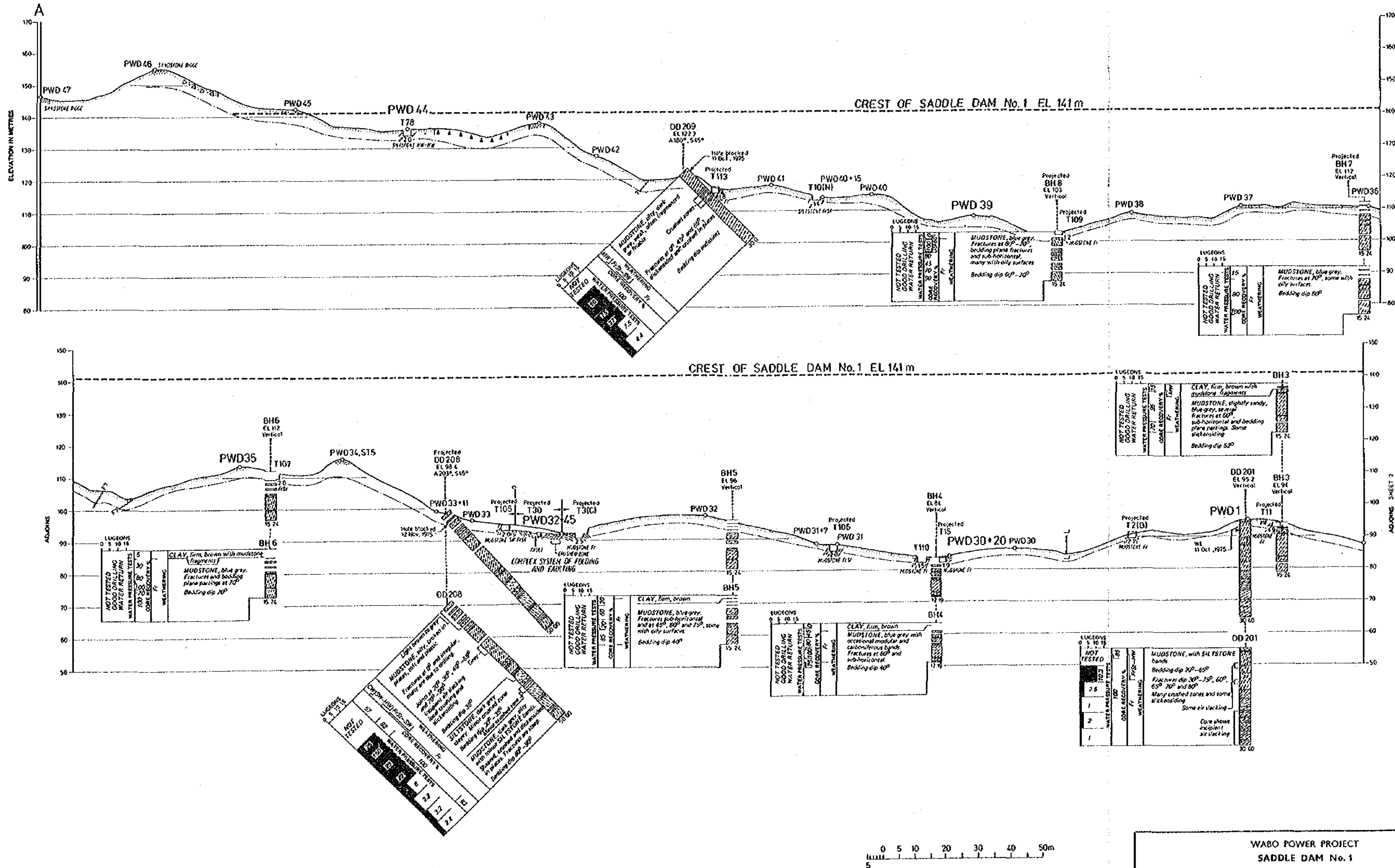
- For legend see sheet 1 (figure 30)

WABO POWER PROJECT
SADDLE DAMS

GEOLOGICAL PLAN

SHEET 5 OF 5

図 34



NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

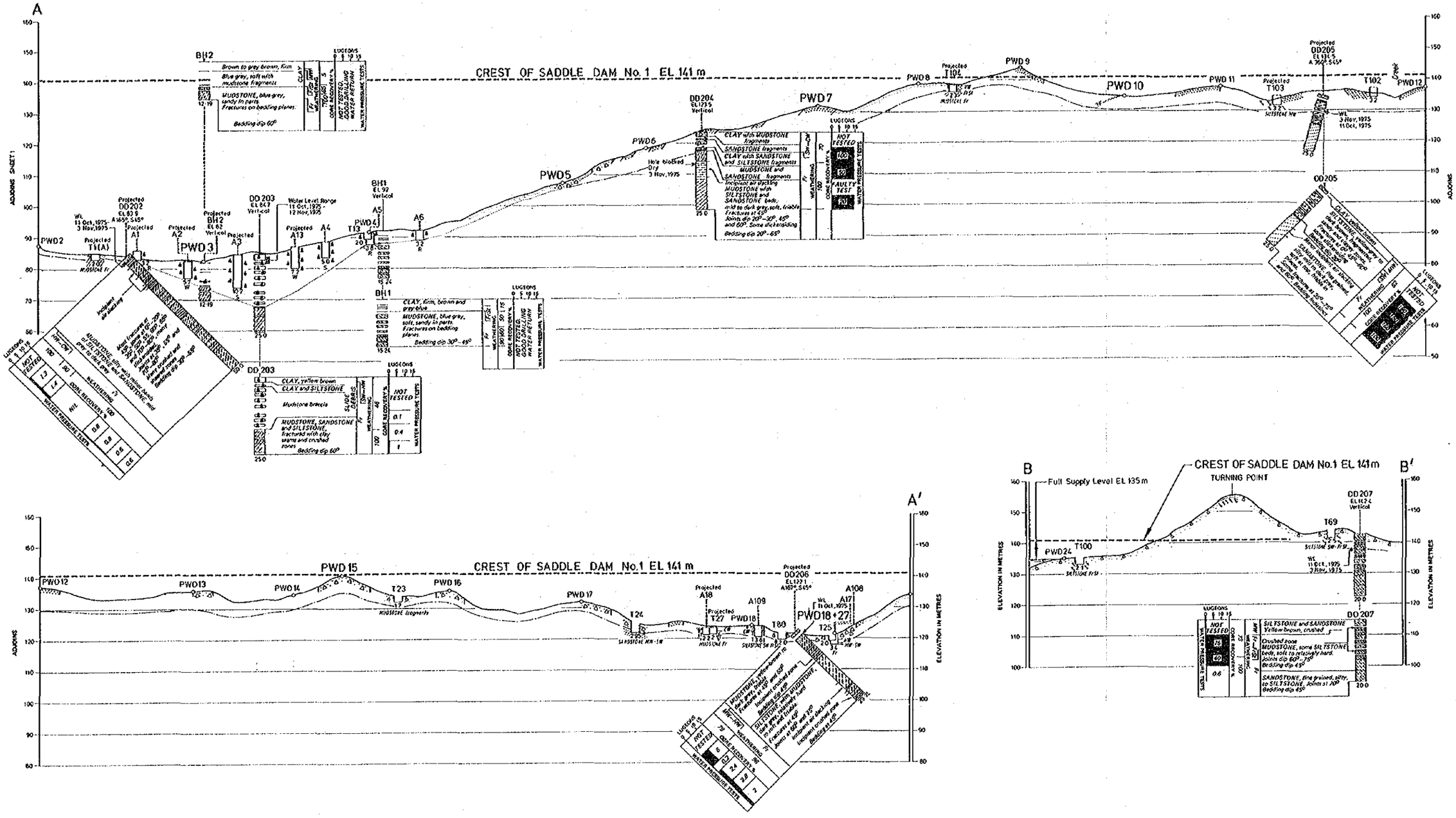
Wabo Power Project –
Geological Plan.................................Figure 31 (1429-53162/2)

WABO POWER PROJECT
SADDLE DAM No. 1

GEOLOGICAL SECTION
A-A′

SHEET 1 OF 16

図 35



NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project –

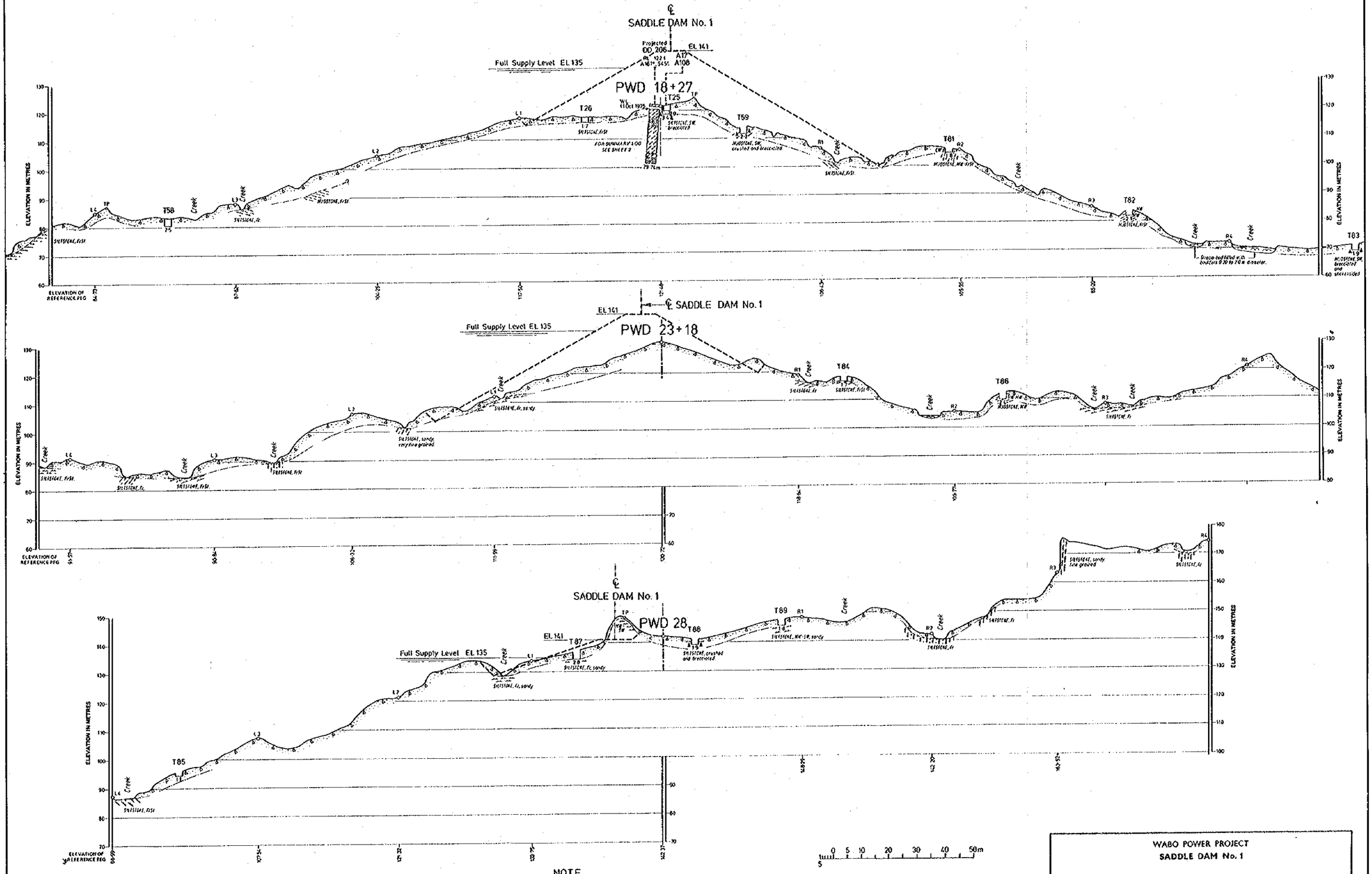
Geological Plans ..... Figures 30 & 31 (1429-S3162/1&2)

WABO POWER PROJECT
SADDLE DAM No. 1

GEOLOGICAL SECTIONS
A-A' and B-B'

SHEET 2 OF 16

36



NOTE

- For legend see sheet 16 (Figure 50)

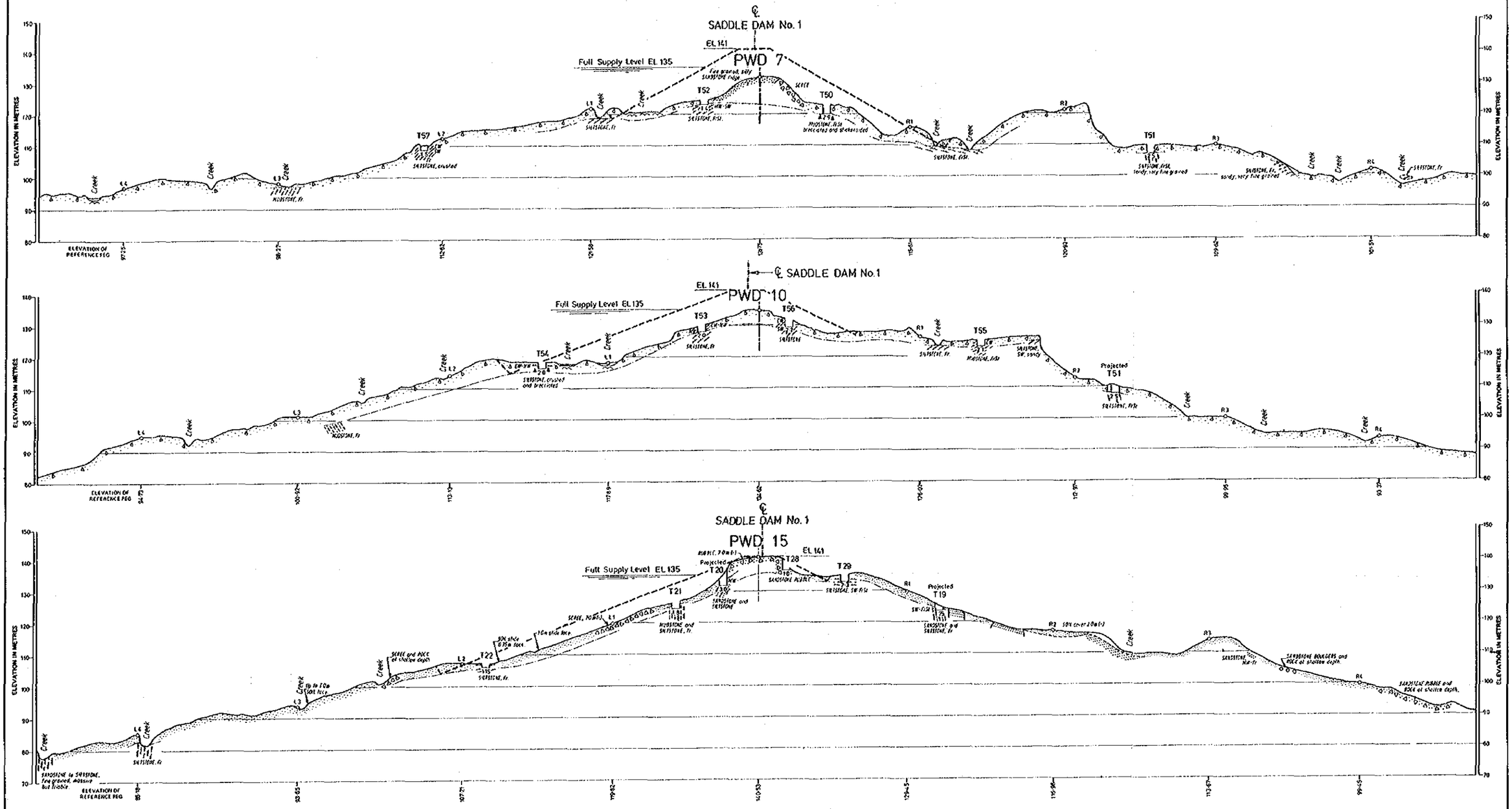
REFERENCE DRAWINGS

Wabo Power Project –
Geological Plan ..... Figure 30(1429-S3162/1)

WABO POWER PROJECT
SADDLE DAM No. 1

GEOLOGICAL SECTIONS
PWD 18+27, PWD 23+18 and PWD 28

SHEET 3 OF 16 ☒ 37



NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project –
Geological Plans ..... Figures 30831(1/29-S3162/1 & 2)

0 5 10 20 30 40 50m

WABO POWER PROJECT
SADDLE DAM No. 1

GEOLOGICAL SECTIONS
PWD 7, PWD 10 and PWD 15

SHEET 4 OF 16 ☒ 38

OUTLINE OF DAM EMBANKMENT

PWD 3

T34 T111 T18

ELEVATION IN METRES

ELEVATION OF REFERENCE PEG

ADJOINS

OUTLINE OF DAM EMBANKMENT

BH2 EL 82·0 Vertical

PWD 3

T119 Projected A7 A110 T67 A112 A113 T36 A114 A115 A116 A117 T35

12·19m FOR SUMMARY LOG SEE SHEET 3

ADJOINS

ELEVATION OF REFERENCE PEG

ELEVATION IN METRES

SADDLE DAM No. 1

EL 141

Full Supply Level EL 135

PWD 5

T38 T39 A118 A119 T64 A120 T63 T37

ELEVATION IN METRES

ELEVATION OF REFERENCE PEG

ELEVATION IN METRES

NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan ..... Figure 31 (1429-S3162/2)

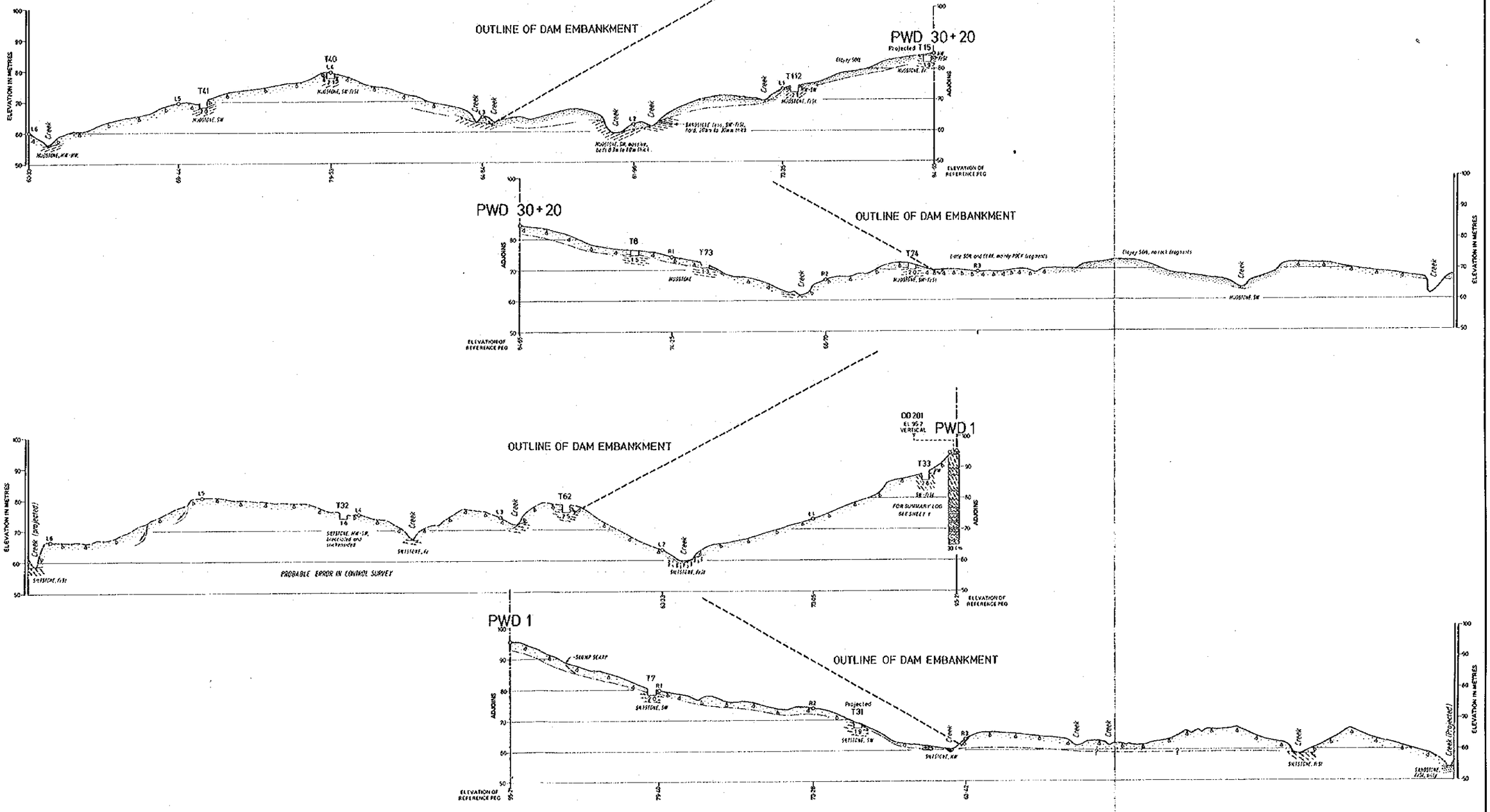
0 5 10 20 30 40 50m

WABO POWER PROJECT
SADDLE DAM No. 1

GEOLOGICAL SECTIONS
PWD 3 and PWD 5

SHEET 5 OF 16

39



NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... Figure 31 (1429-53152/2)

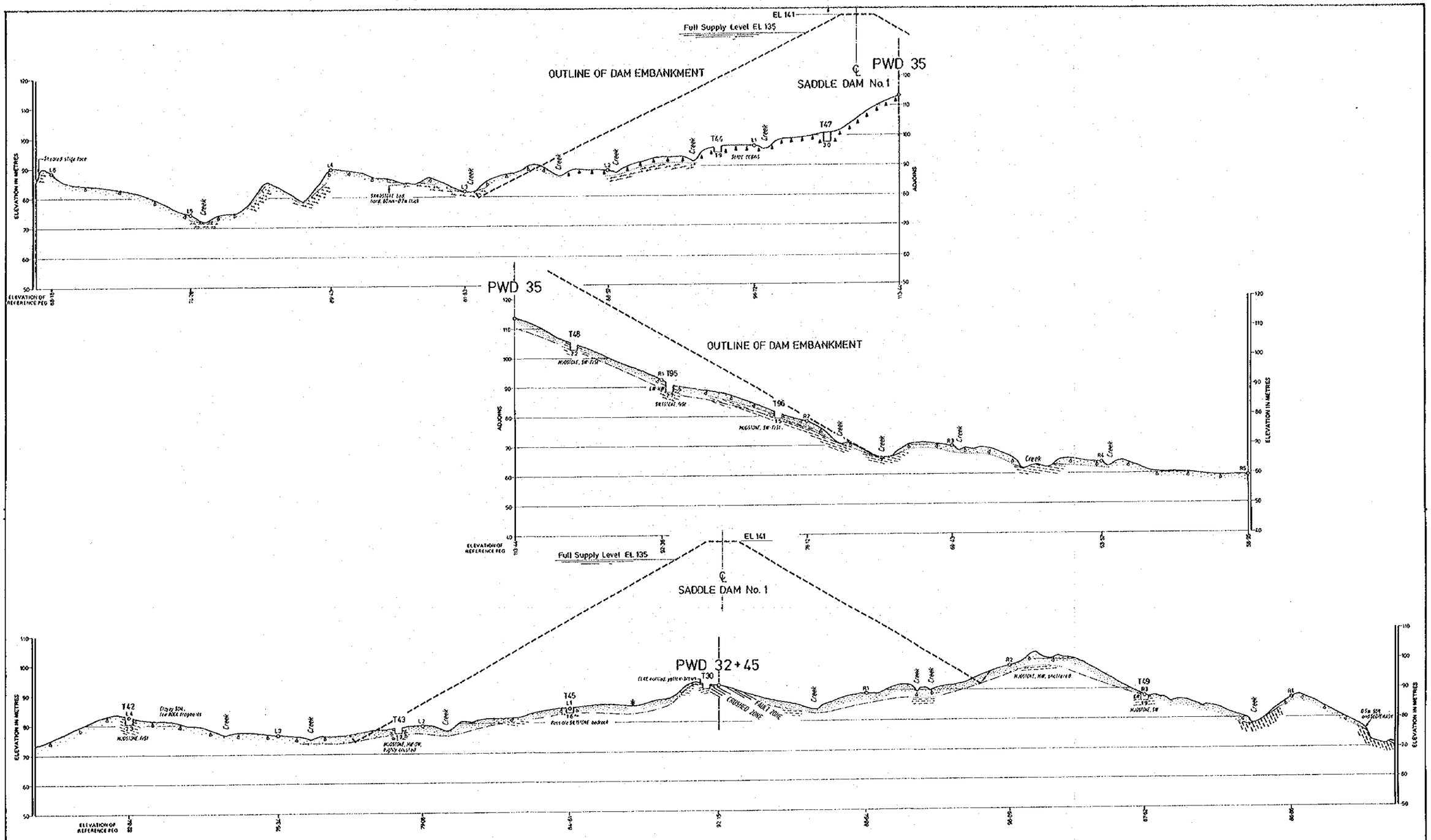
0 5 10 20 30 40 50m

WABO POWER PROJECT
SADDLE DAM No. 1

GEOLOGICAL SECTIONS
PWD 30+20 and PWD 1

SHEET 6 OF 16

40



NOTE

* For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project –
Geological Plan..... Figure 31 (1429-S3162/2)

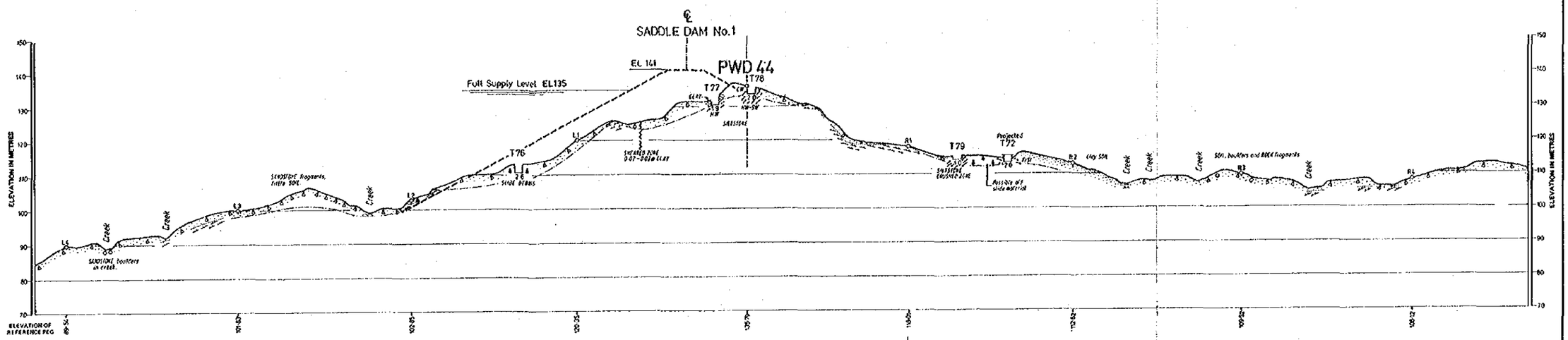
0 5 10 20 30 40 50m

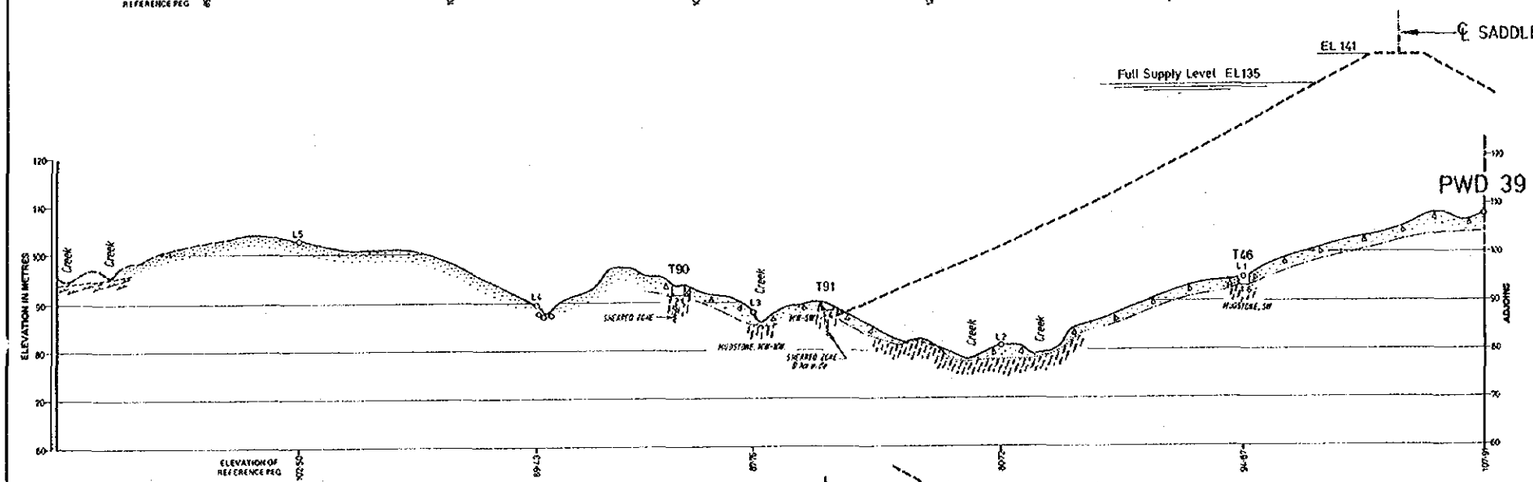
WABO POWER PROJECT
SADDLE DAM No. 1

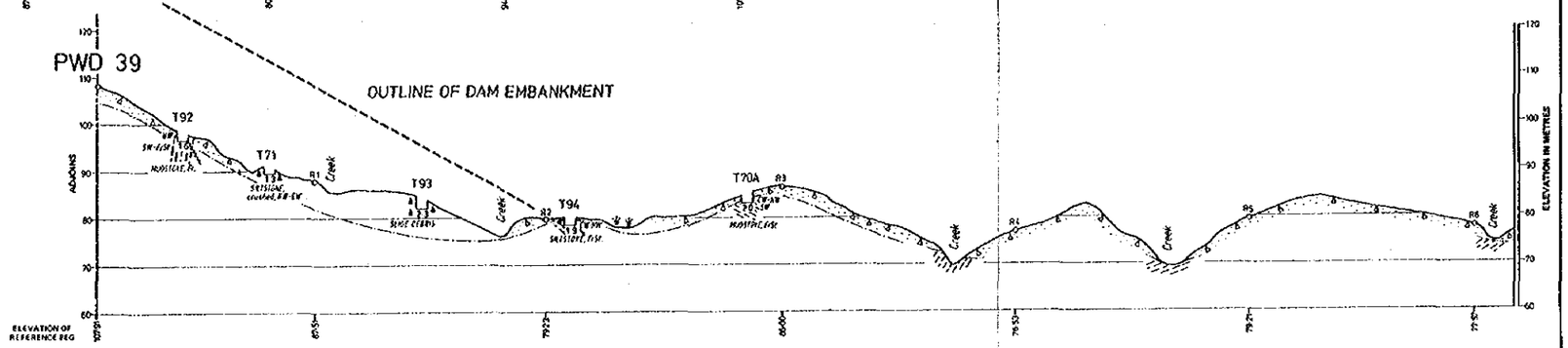
GEOLOGICAL SECTIONS
PWD 35 and PWD 32+45

SHEET 7 OF 16

⊠ 41







NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan.....Figure 31 (1429-S3162/2)

0 5 10 20 30 60 50m
5

WABO POWER PROJECT
SADDLE DAM No. 1

GEOLOGICAL SECTIONS
PWD 44 and PWD 39

SHEET 8 OF 16

☒ 42

C

CREST OF SADDLE DAM No.2 EL 141 m

PWD79 PWD78 PWD77 PWD76 PWD75 PWD74 PWD73 PWD72+29 PWD72 PWD71 PWD70 PWD69

Projected DD213 EL 1497 Vertical

DD213

MUDSTONE, yellow brown to dark grey
Crushed zone
Fractures dip 45° and 60° some slickensiding
Bedding dip 60°
SILTSTONE, very clayey

POSSIBLE SLIDE BLOCK

Projected DD212 EL 1518 A 242°, S45°

DD212

Projected T132 T133

ELEVATION IN METRES

ADJOINS

PWD68 PWD67 PWD66 PWD65 PWD64 PWD63 PWD62 ST 2 PWD61 PWD60 PWD59 PWD58+20 PWD58

CREST OF SADDLE DAM No.2 EL 141 m

Projected T134 T131 T130

Projected DD211 EL 1234 A 209°, S45°

DD211

PWD57 PWD56 PWD55 PWD52 PWD51 PWD50 PWD49 PWD48 PWD47

DD210 EL 1179 A 220°, S45°

TURNING POINT

Projected T118 T117 T116 T99 T114

C'

NOTE

• For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project –
Geological Plan ..... Figure 32 (1429-S3162/3)

0 5 10 20 30 40 50m

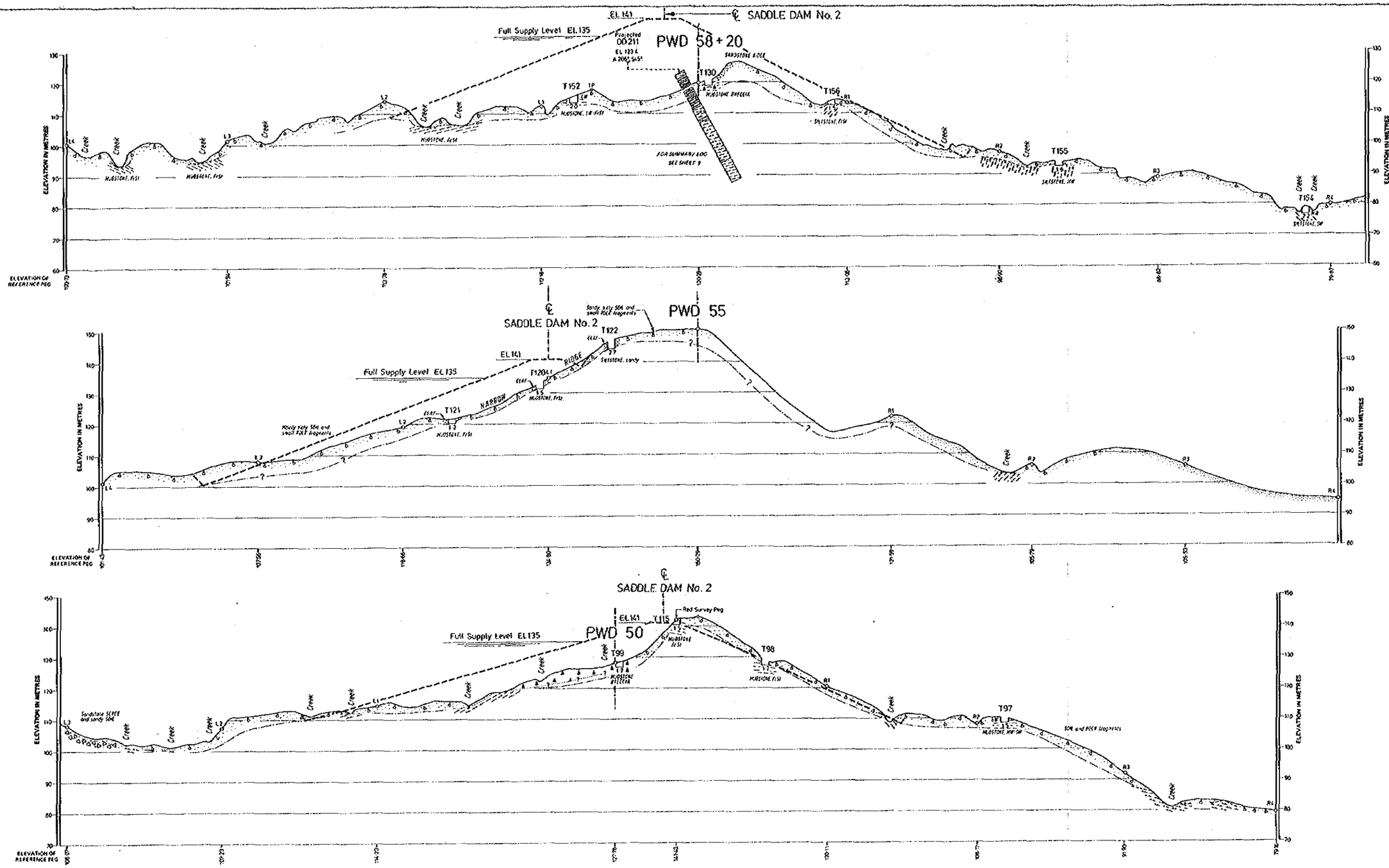
WABO POWER PROJECT
SADDLE DAM No. 2

GEOLOGICAL SECTION

C – C'

SHEET 9 OF 16

43



NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... Figure 32(1429-S3162/3)

0 5 10 20 30 40 50m

WABO POWER PROJECT
SADDLE DAM No. 2

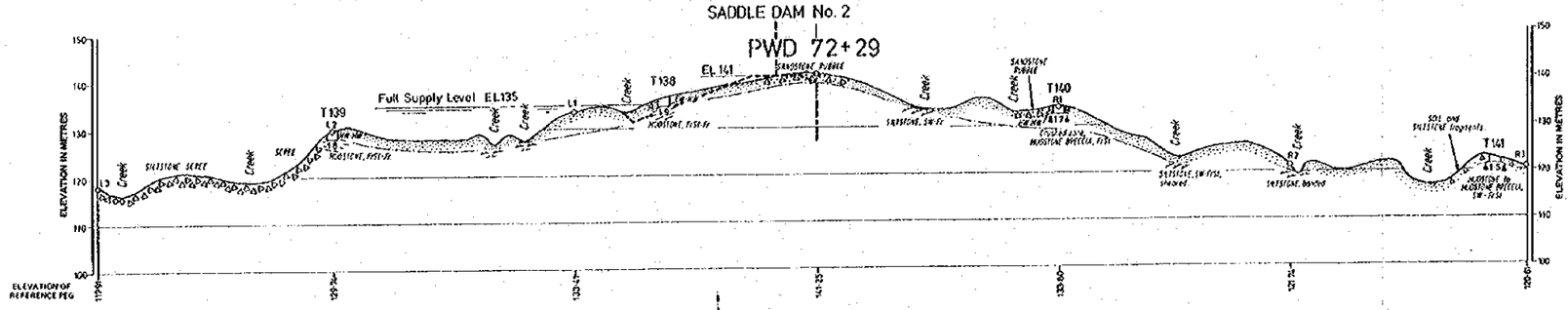
GEOLOGICAL SECTIONS
PWD 58+20, PWD 55 and PWD 50

SHEET 10 OF 16

⊠ 44

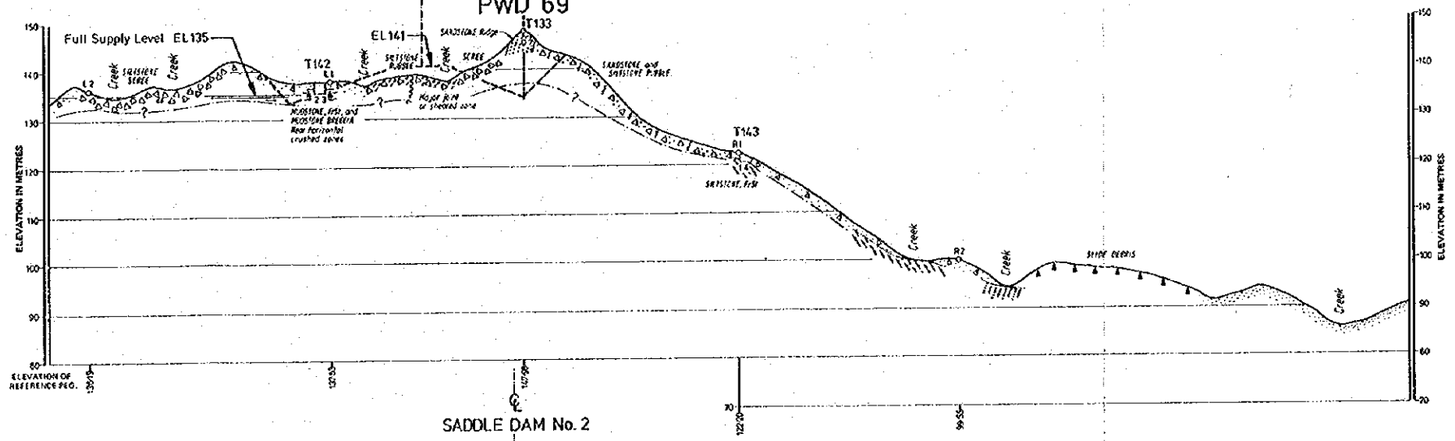
SADDLE DAM No. 2

PWD 72+29



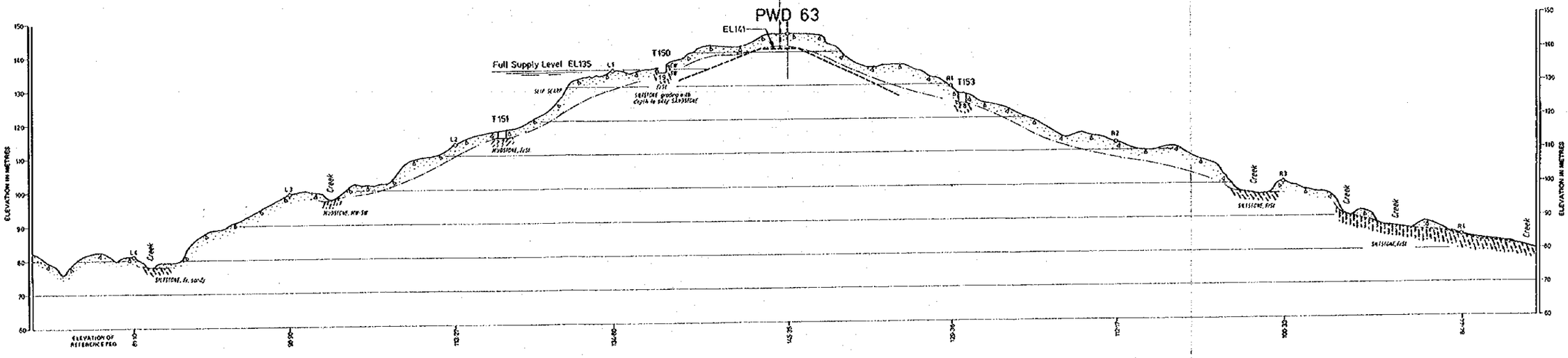
SADDLE DAM No. 2

PWD 69



SADDLE DAM No. 2

PWD 63



NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan.....Figure 32(1429-S3162/3)

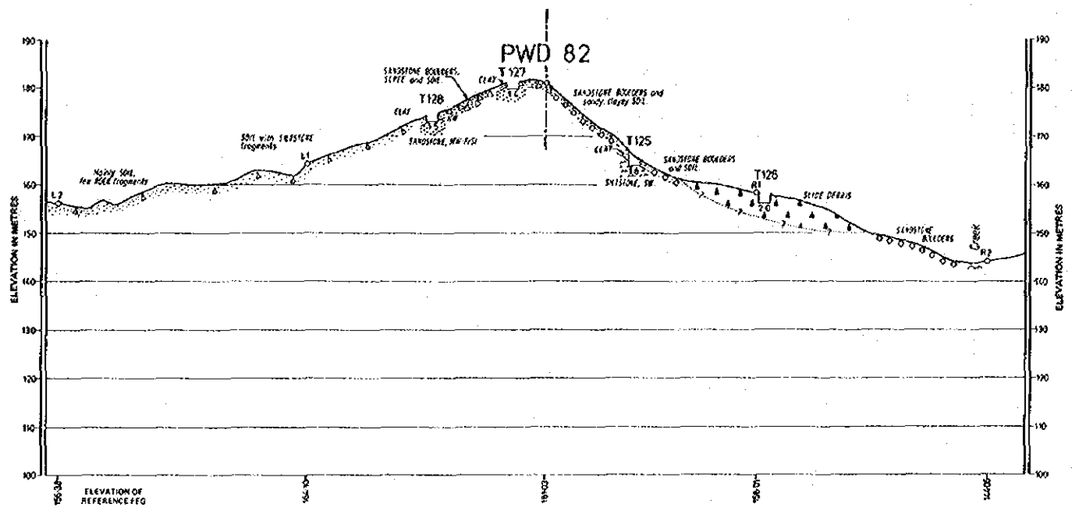
0 5 10 20 30 40 50m

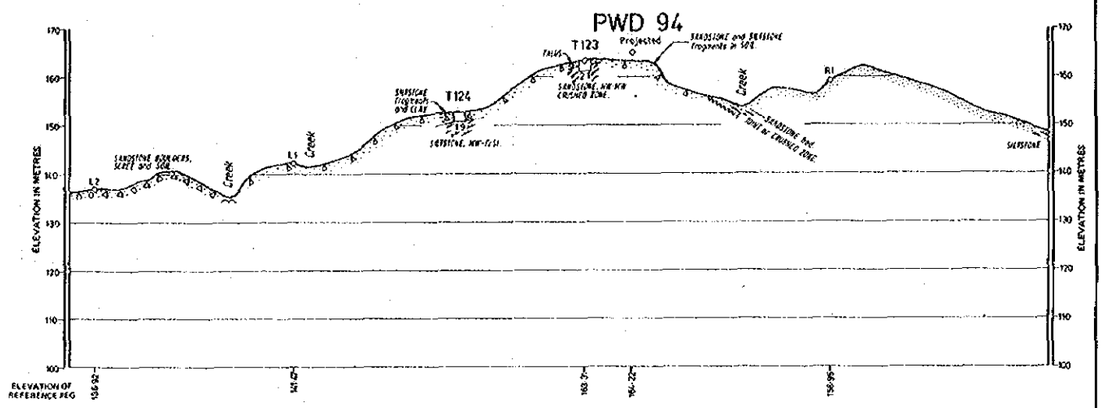
WABO POWER PROJECT
SADDLE DAM No. 2

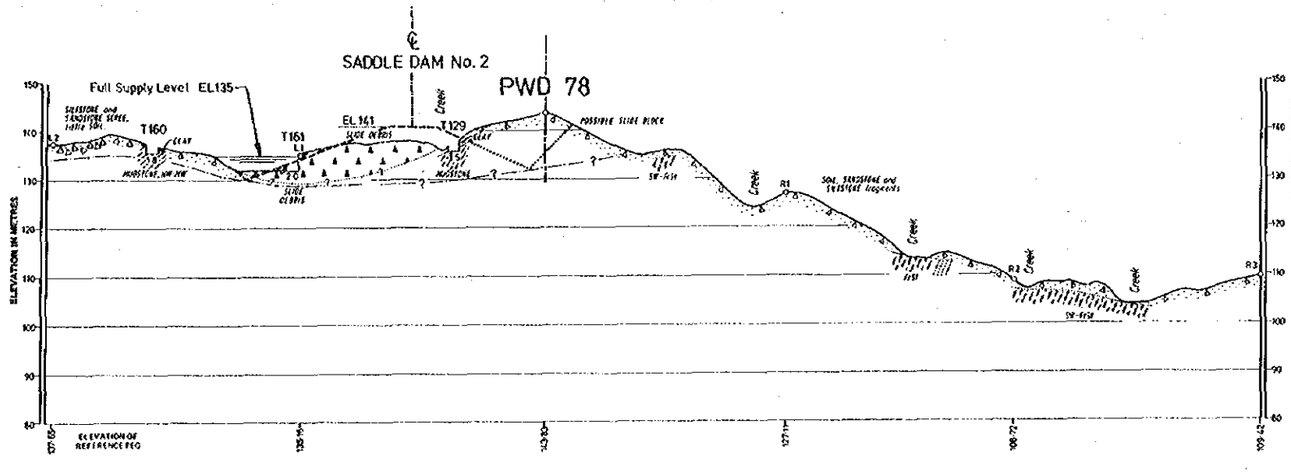
GEOLOGICAL SECTIONS
PWD 72+29, PWD 69 and PWD 63

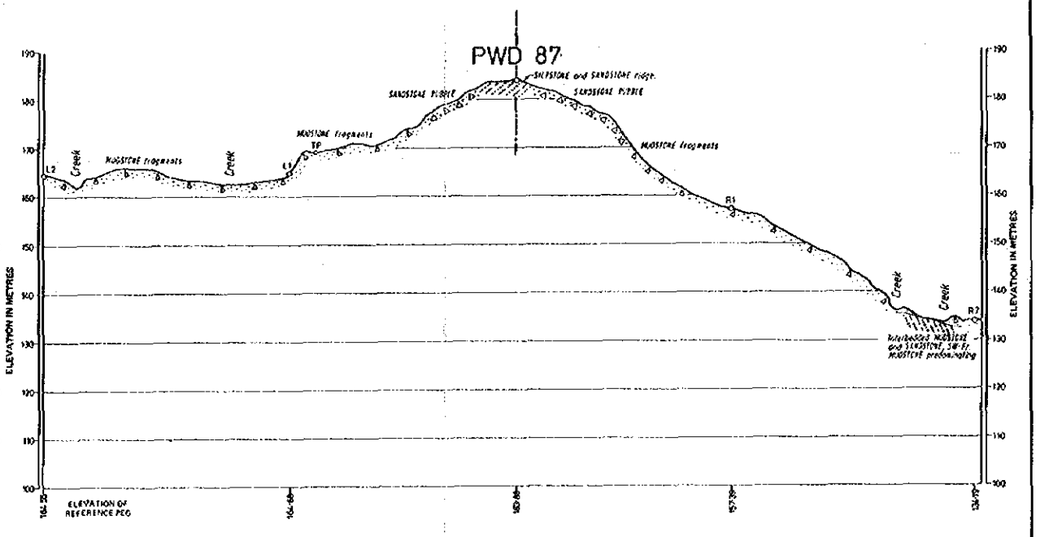
SHEET 11 OF 16

図 45









0 5 10 20 30 40 50m

NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

Wabo Power Project -

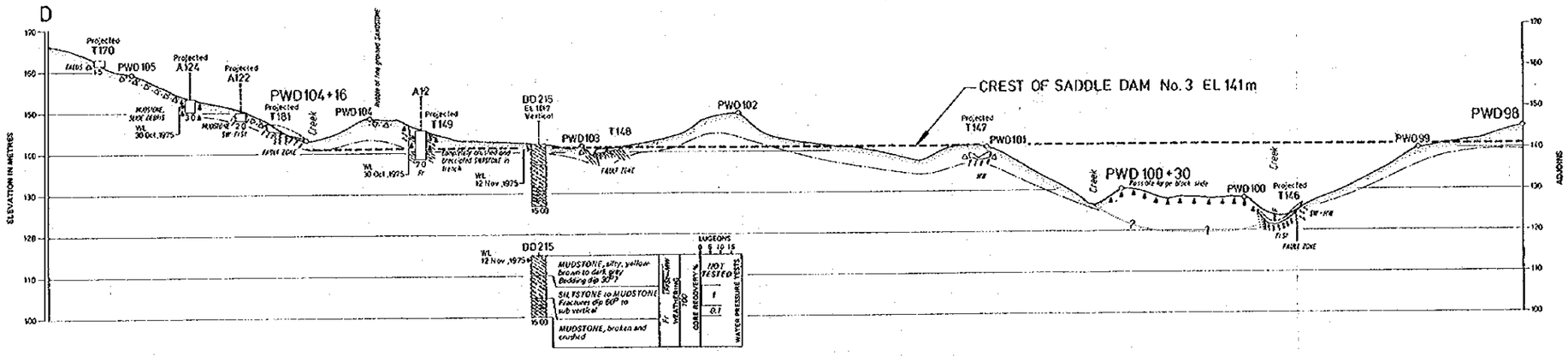
Geological Plans ..... Figures 32-33 (1429-S3162/3-4)

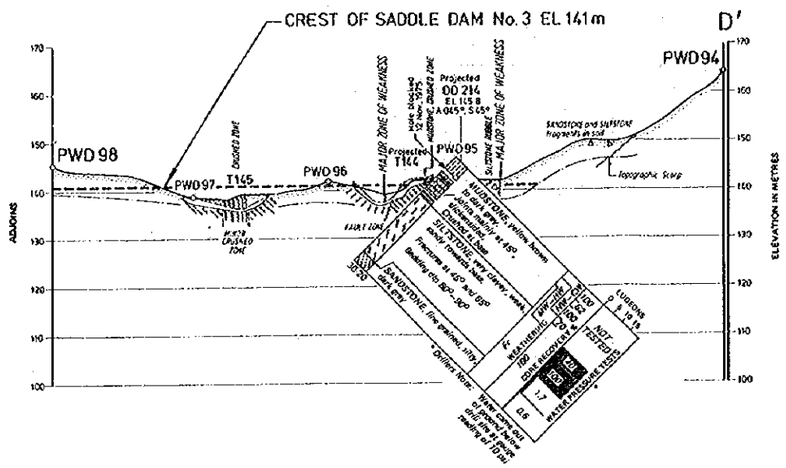
WABO POWER PROJECT
SADDLE DAM No. 2

GEOLOGICAL SECTIONS
PWD 82 PWD 78, PWD 94 and PWD 87

SHEET 12 OF 16

図 46





NOTE

- For legend see sheet 16 (Figure)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... Figure 3011429-S3162/4)

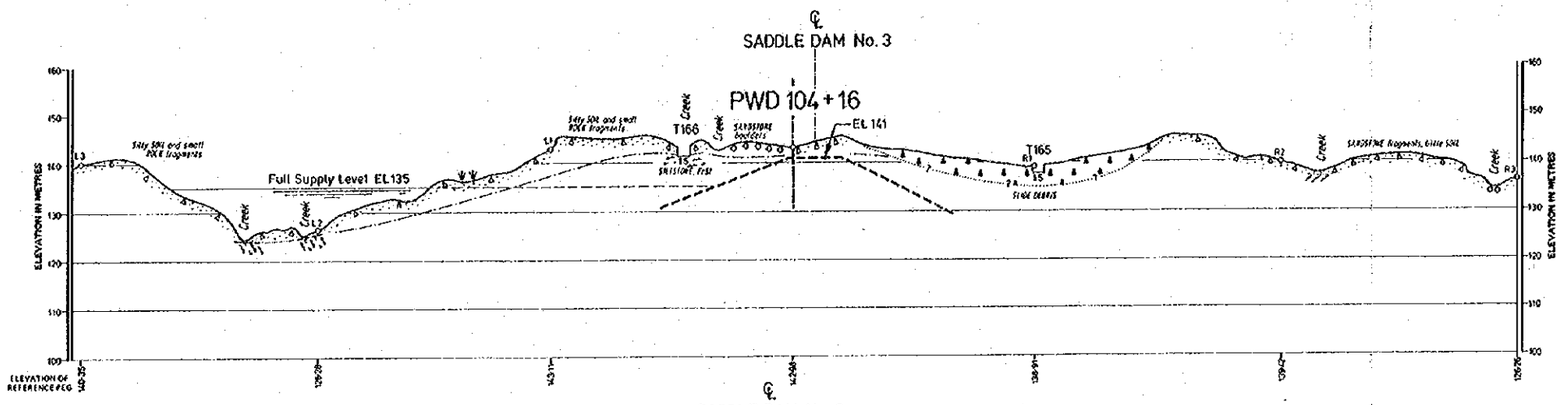
0 5 10 20 30 40 50m
5

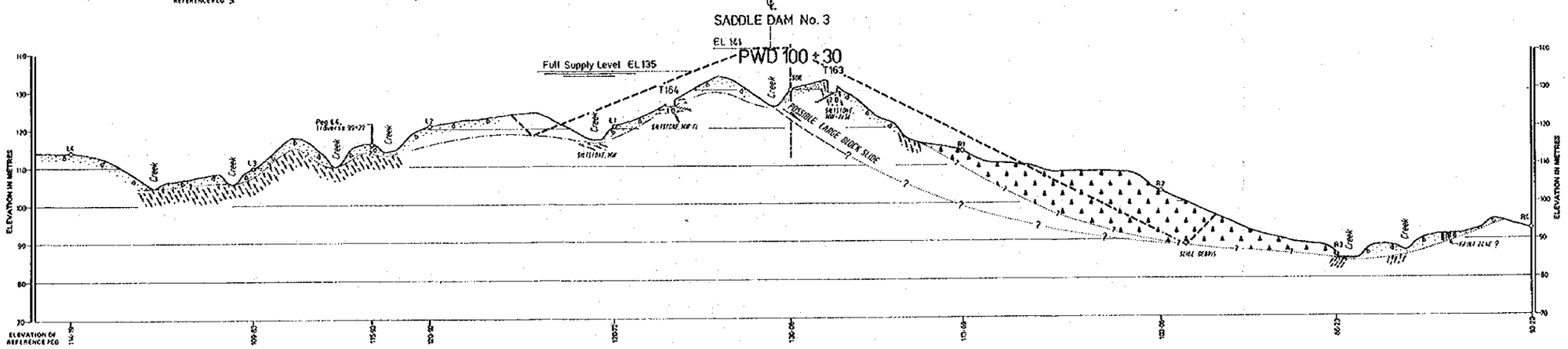
WABO POWER PROJECT
SADDLE DAM No. 3

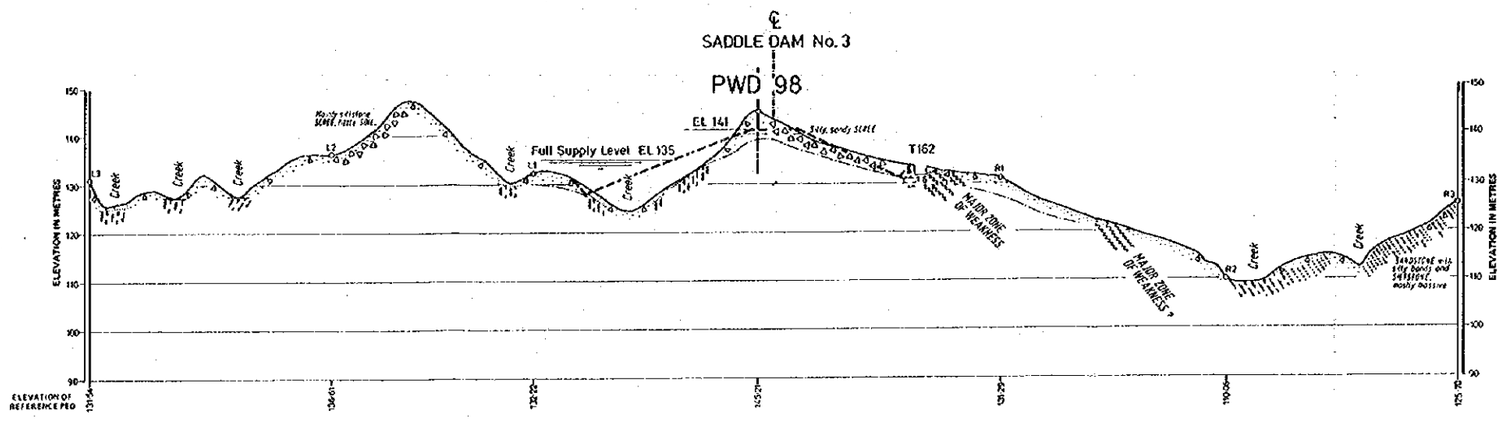
GEOLOGICAL SECTION
D-D'

SHEET 13 OF 16

図147







NOTE

- For legend see sheet 16 (Figure 50)

REFERENCE DRAWINGS

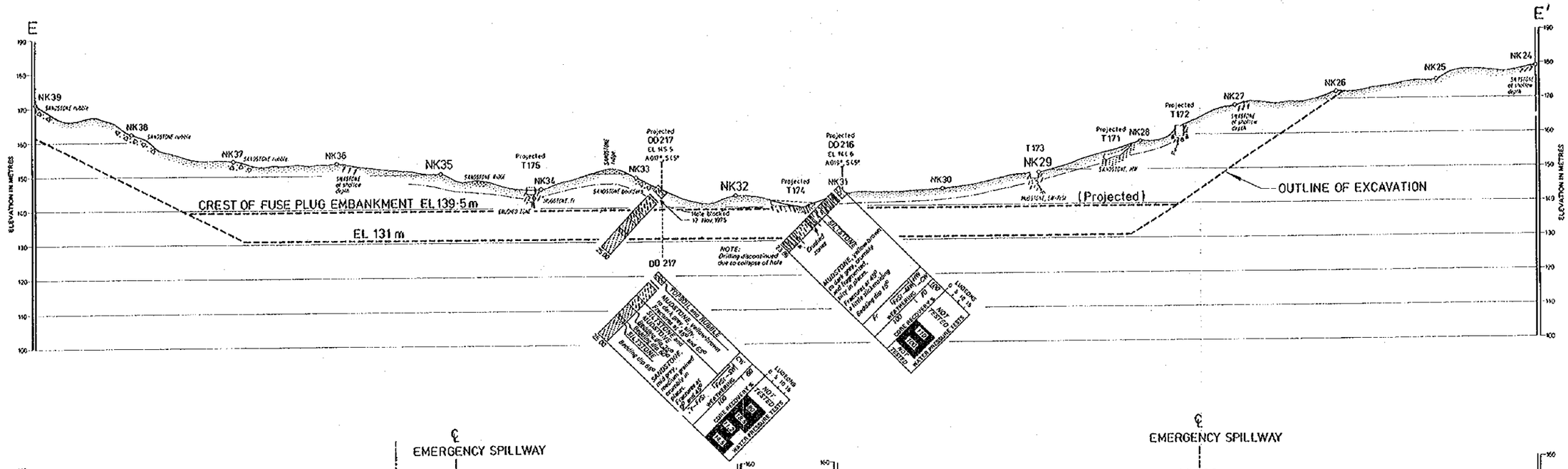
Wabo Power Project –
Geological Plan ..... Figure 33 (N29-S3162/4)

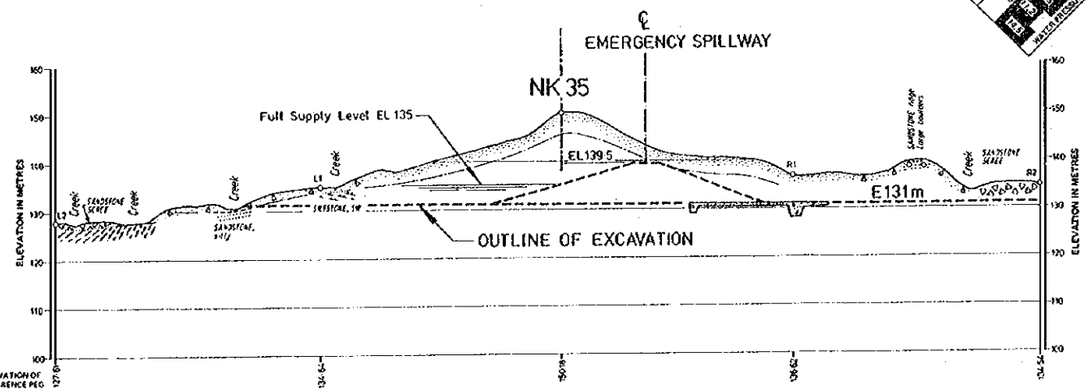
0 5 10 20 30 40 50m

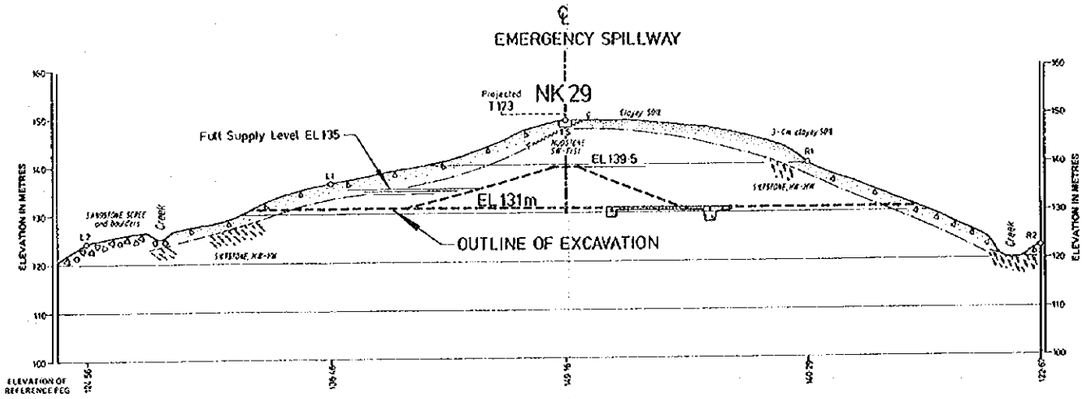
WABO POWER PROJECT
SADDLE DAM No. 3

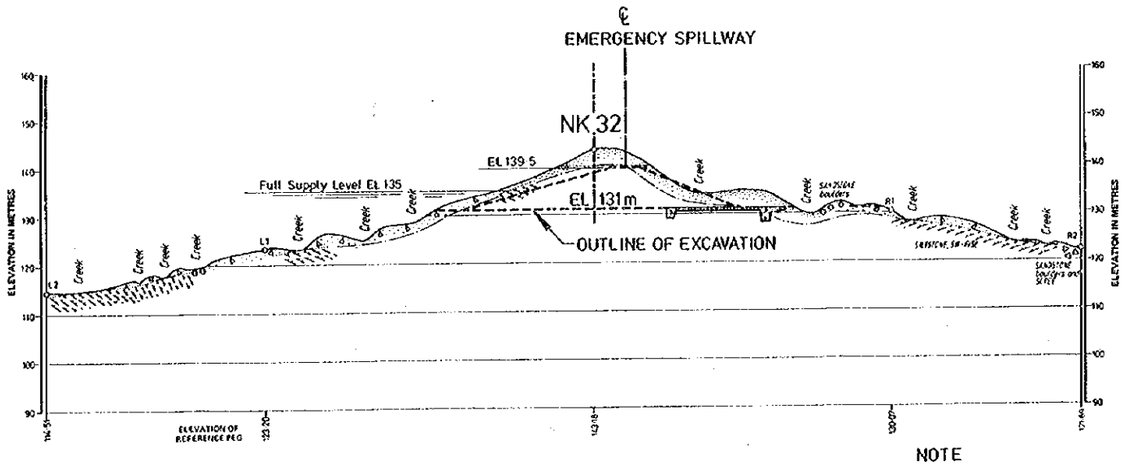
GEOLOGICAL SECTIONS
PWD 104+16, PWD 100+30 and PWD 98

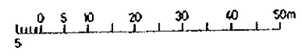
SHEET 14 OF 16 ☒ 48











NOTE

- For legend see sheet 16 (Figure 50)

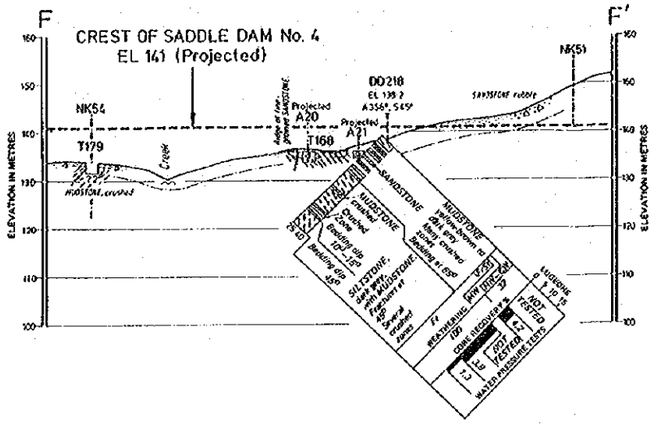
REFERENCE DRAWINGS

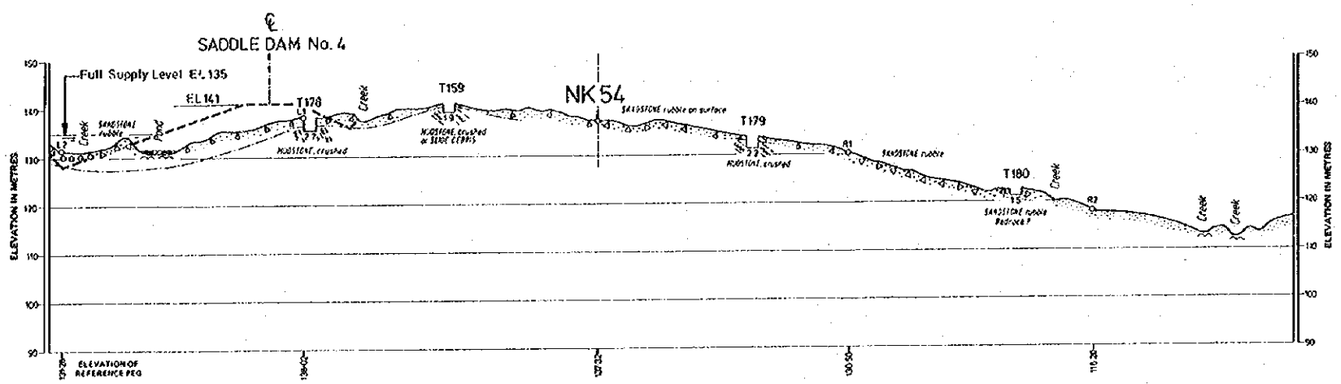
Wabo Power Project -
Geological Plan ..... Figure 34(1429-S3162/5)

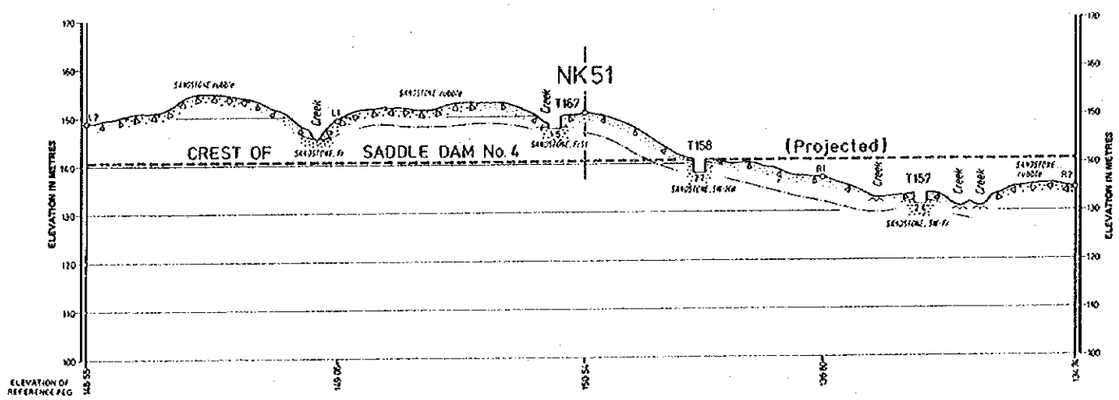
WABO POWER PROJECT
EMERGENCY SPILLWAY

GEOLOGICAL SECTIONS
E-E', NK 35, NK 32 and NK 29

SHEET 15 OF 16 ☒ 49







LEGEND

- SOIL
- SOIL and ROCK fragments
- ALLUVIUM
- GRAVEL, BOULDER beds
- SCREE, TALUS
- SLIDE DEBRIS and BRECCIA
- SANDSTONE
- SANDSTONE, rubbly outcrop
- SILTSTONE
- SILTSTONE, rubbly outcrop
- MUDSTONE

DD205 — Diamond drill hole 205
EL 134.9 — Elevation in metres
A 360°, 54.5° — Slope (angle from horizontal) Azimuth
No core
W.L. 3 Nov. 1975 — Water level, date
Summary log of diamond drill hole showing rock types, main core losses and sheared or crushed zones.
75.0 — Depth of hole in metres

A117 — Auger hole 117
Rock types
Depth of hole in metres
W — Stopped by water
R — Refusal
T — Stopped by tree root
S — Stopped by slow advancement in silt or clay

T179 — Trench 179
Rock types
Depth of trench in metres
MUDSTONE, crushed — Rock type in floor of trench

PWD71 — Control traverse survey peg
PWD78 NK54 — Control traverse survey peg indicating cross section
B1 — Survey peg on cross section
Assumed minimum stripping depth

GEOLOGICAL BOUNDARIES

- Accurate
- Approximate
- Inferred

DEGREE OF WEATHERING

CW - Completely weathered
HW - Highly weathered
MW - Moderately weathered
SW - Slightly weathered
FrSt - Fresh, with limonite stained joints
Fr - Fresh

0 5 10 20 30 40 50m
S

NOTES

- Description of material in drill holes refers only to core recovered.
- Where breaks are shown in drill hole logs, core was not recovered.
- In drill hole logs dip of joints, bedding and sheared zones is the angle between the planes of these features and the plane perpendicular to the axis of the drill hole.
- On sections A-A', B-B', C-C', D-D', E-E' and F-F', topography is derived from contour plans.

REFERENCE DRAWINGS

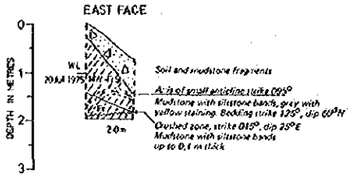
Wabo Power Project -
Geological Plan ..... Figures 30-34 (1429-S3162/1-5)
Geological logs of trenches ..... Figures 51-60 (1429-S3045/1-10)
Geological logs of hand auger holes ..... Figure 61 (1429-S3159)

WABO POWER PROJECT
SADDLE DAM No. 4

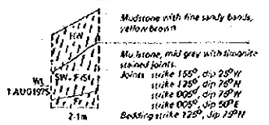
GEOLOGICAL SECTIONS
F-F', NK 54 and NK 51

SHEET 16 OF 16 — 50

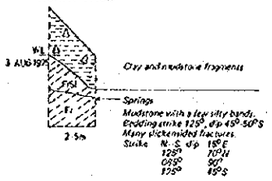
T1
EAST FACE



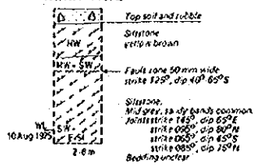
T2
EAST FACE



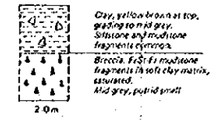
T3
NORTH FACE



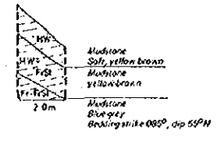
T4
NORTH FACE



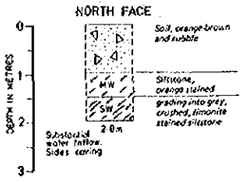
T5
NORTH FACE



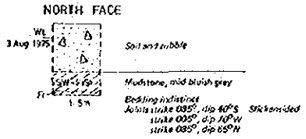
T6
NORTH FACE



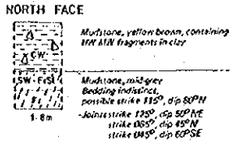
T7
NORTH FACE



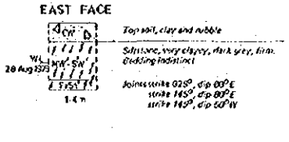
T8
NORTH FACE



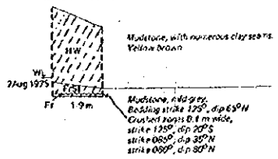
T9
NORTH FACE



T10
EAST FACE



T11
EAST FACE



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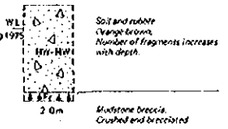

T13
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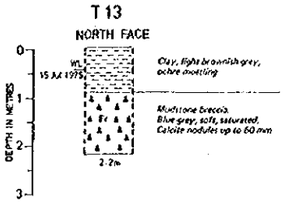
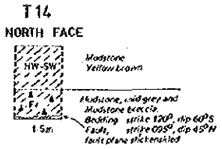
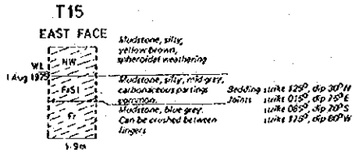


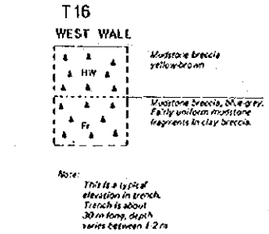
T14
NORTH FACE



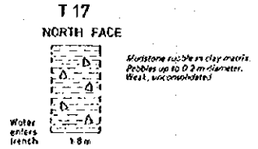
T15
EAST FACE



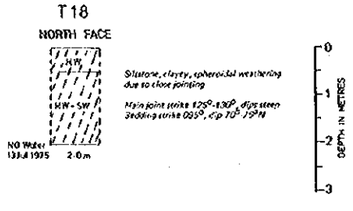
T16
WEST WALL



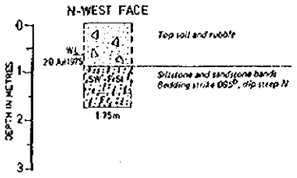
T17
NORTH FACE



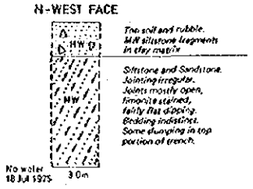
T18
NORTH FACE



T19
N-WEST FACE



T20
N-WEST FACE



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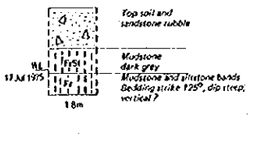

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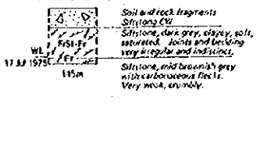
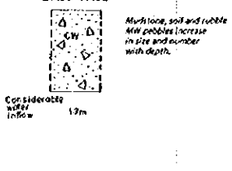
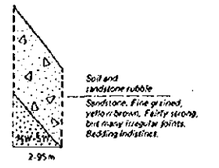


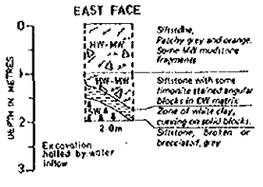
T23
EAST FACE



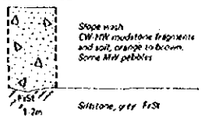
T24
EAST FACE



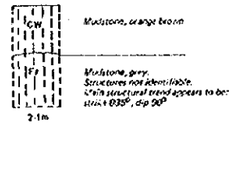
T25
EAST FACE

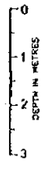


T26
NORTH FACE



T27
EAST FACE





NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... Figures 30-34(1429-S3162/1-5)

WABO POWER PROJECT
SADDLE DAMS

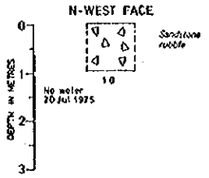
GEOLOGICAL LOGS OF TRENCHES

TRENCH T1 — TRENCH T27

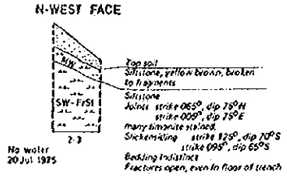
SHEET 1 OF 10

51

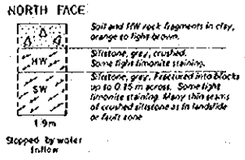
T 28
N-WEST FACE



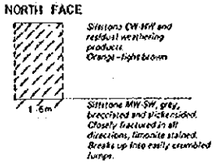
T 29
N-WEST FACE



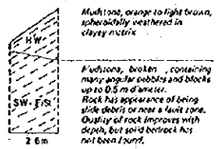
T 31
NORTH FACE



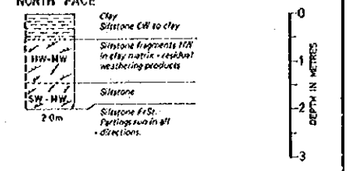
T 32
NORTH FACE



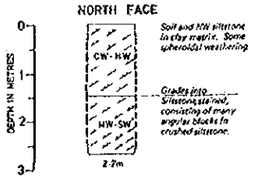
T 33
NORTH FACE



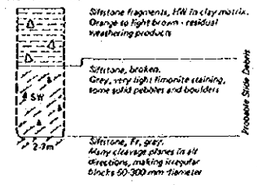
T 34
NORTH FACE



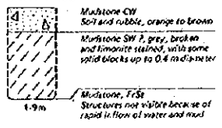
T 35
NORTH FACE



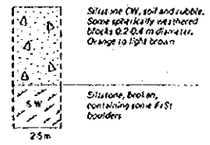
T 36
NORTH FACE



T 37
NORTH FACE



T 38
NORTH FACE



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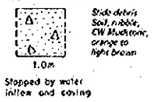

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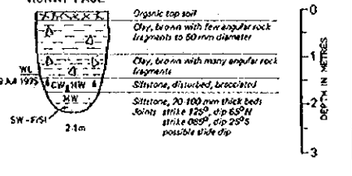

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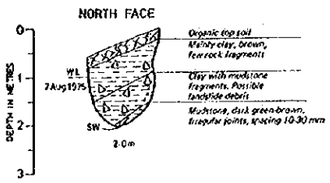

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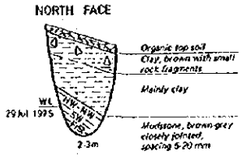

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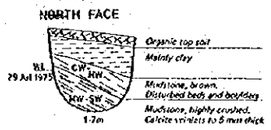

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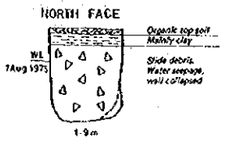

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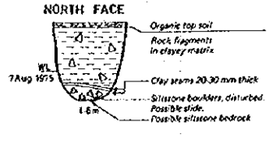

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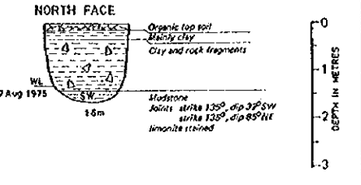

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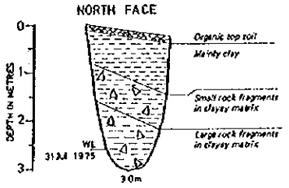

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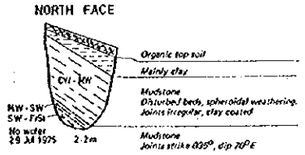

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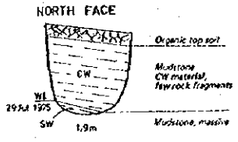

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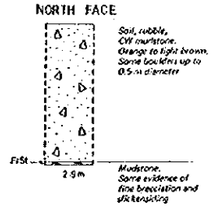

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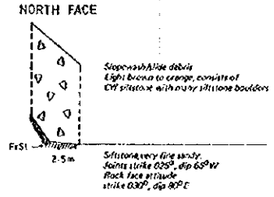
NORTH FACE



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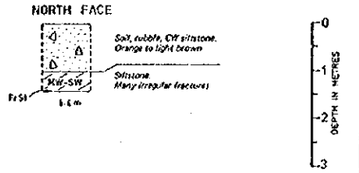
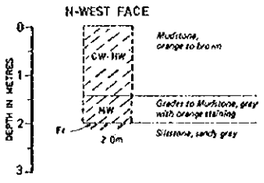


T 53
N-WEST FACE



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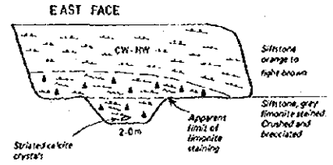
EAST FACE



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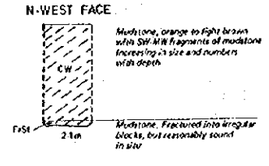
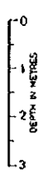
N-WEST FACE





NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan.....Figures 30-34(1429-S3(62/1-5)
Log of trench T30.....Figure 59(1429-S3045/9)

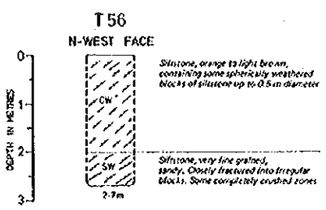
WABO POWER PROJECT
SADDLE DAMS

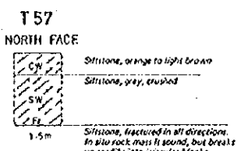
GEOLOGICAL LOGS OF TRENCHES

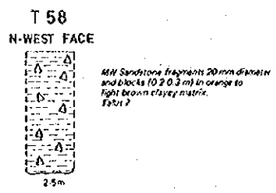
TRENCH T28 — TRENCH T55

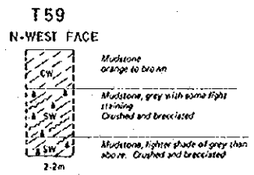
SHEET 2 OF 10

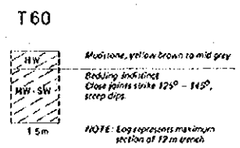
52

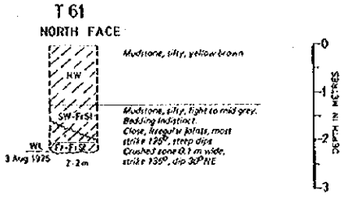


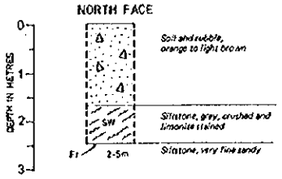


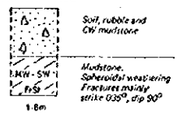


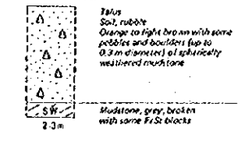


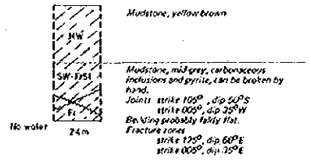


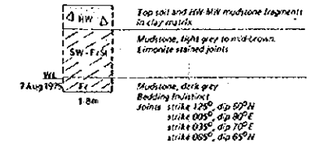


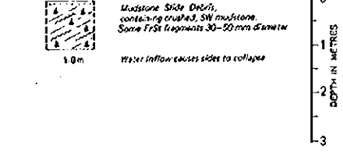


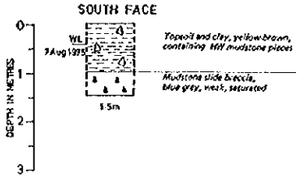


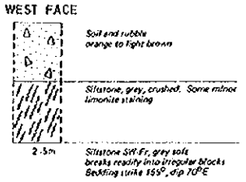


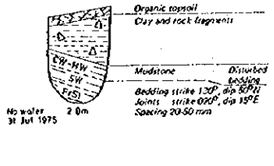


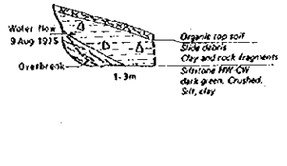


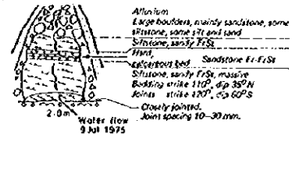


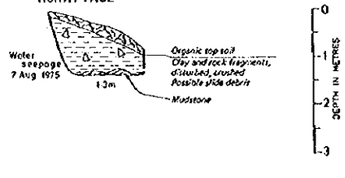


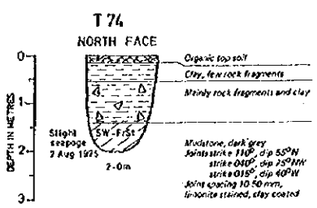


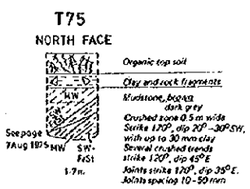


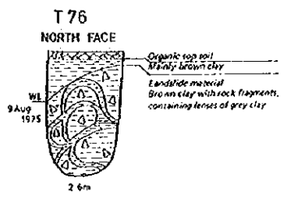


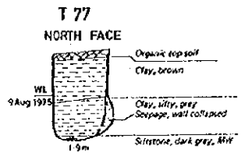


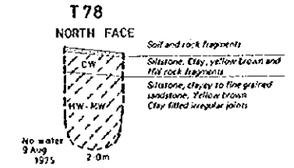


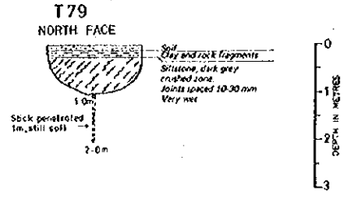


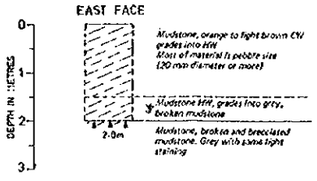


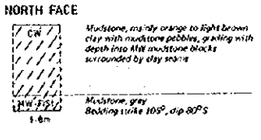


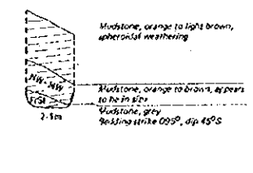


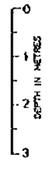












NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project - Geological Plan ..... Figures 30-34(1429-S3162/1-5)

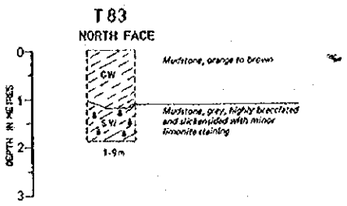
WABO POWER PROJECT
SADDLE DAMS

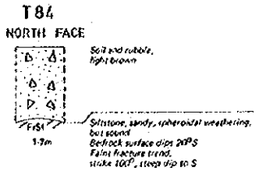
GEOLOGICAL LOGS OF TRENCHES

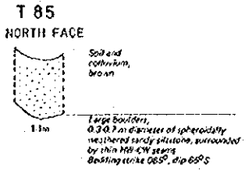
TRENCH T56 — TRENCH T82

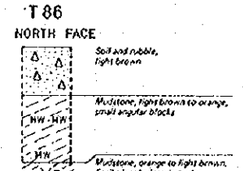
SHEET 3 OF 10

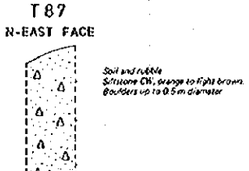
53

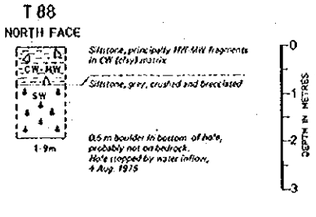


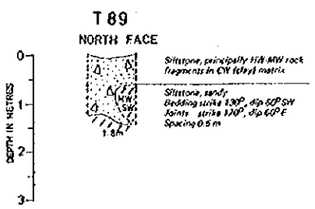


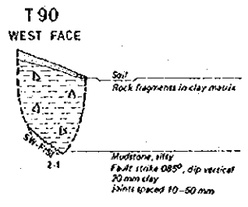


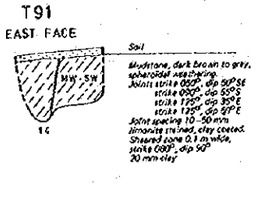


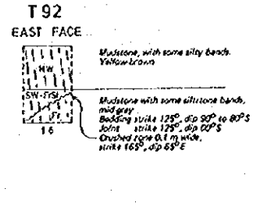


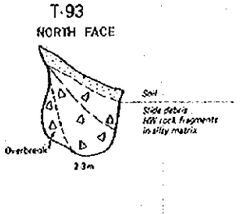


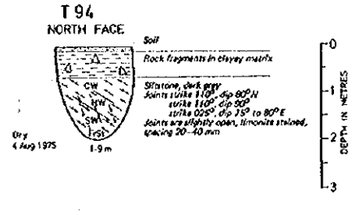


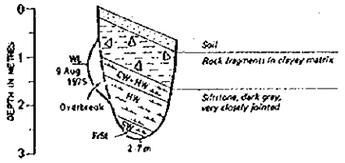


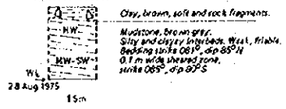


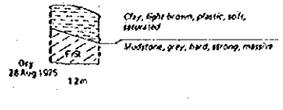


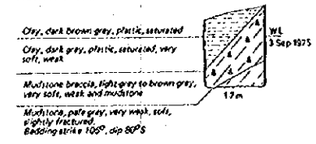


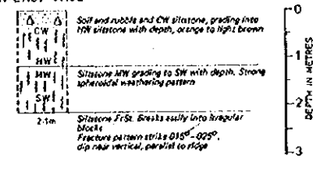


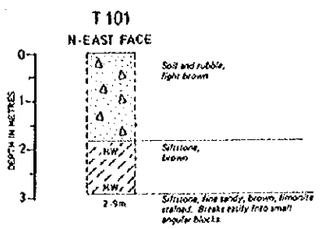


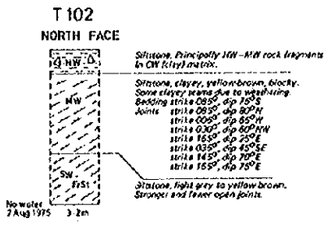


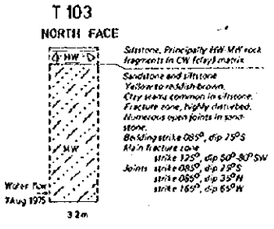


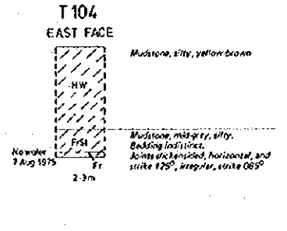


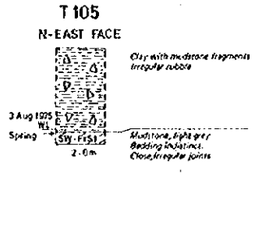


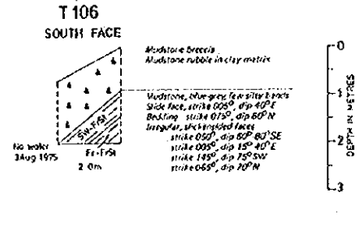


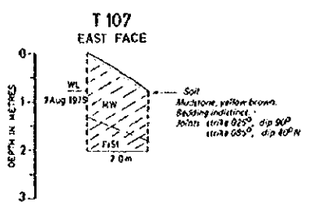


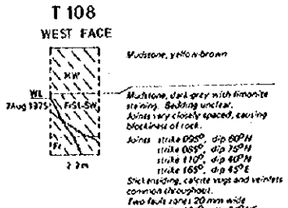


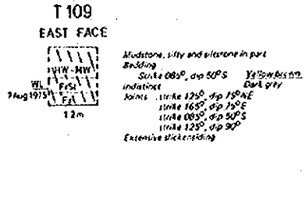


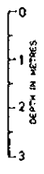












NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project - Geological Plan ..... Figures 30-34(1429-S3162/1-3)

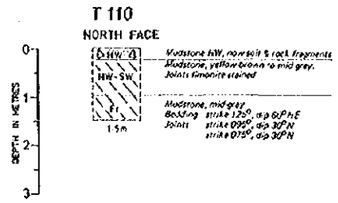
WABO POWER PROJECT
SADDLE DAMS

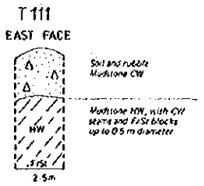
GEOLOGICAL LOGS OF TRENCHES

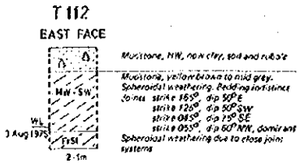
TRENCH T83 — TRENCH T109

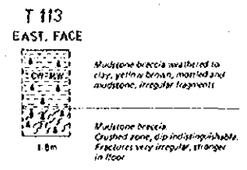
SHEET 4 OF 10

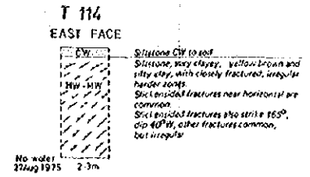
54

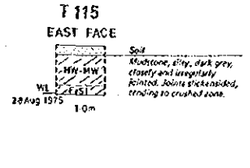


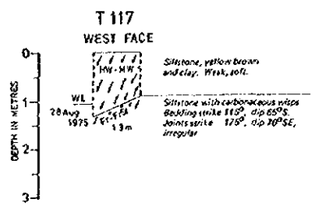


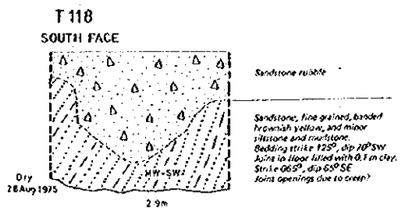


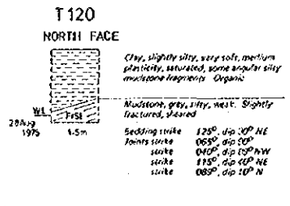


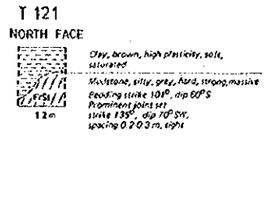


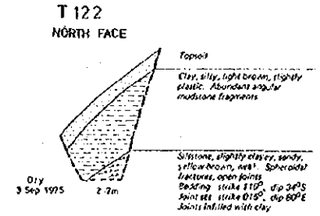


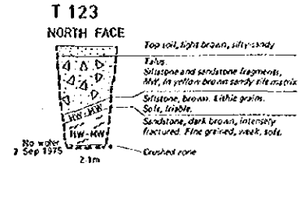


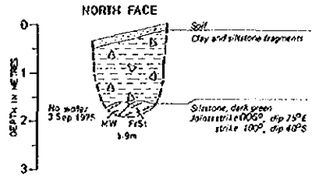


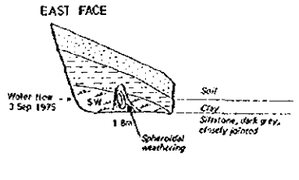


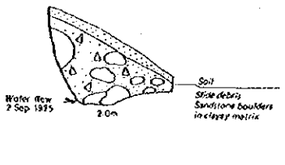


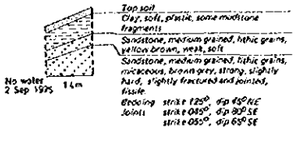


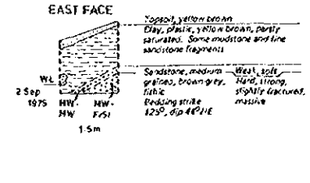


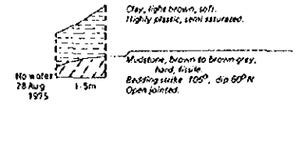


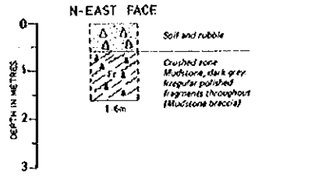


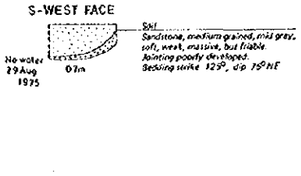


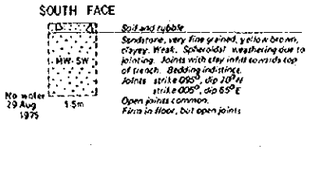


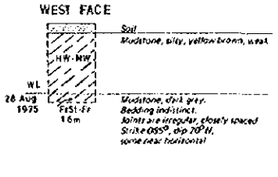


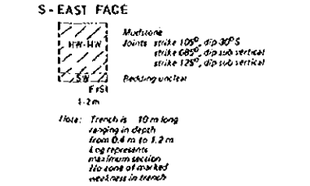


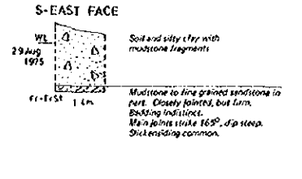












NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project –

Geological Plan.....Figures 30-34(1429-S3162/1-5)

Logs of trenches T116, T119, T130 and T131.....Figure 59 (1429-S3045/9)

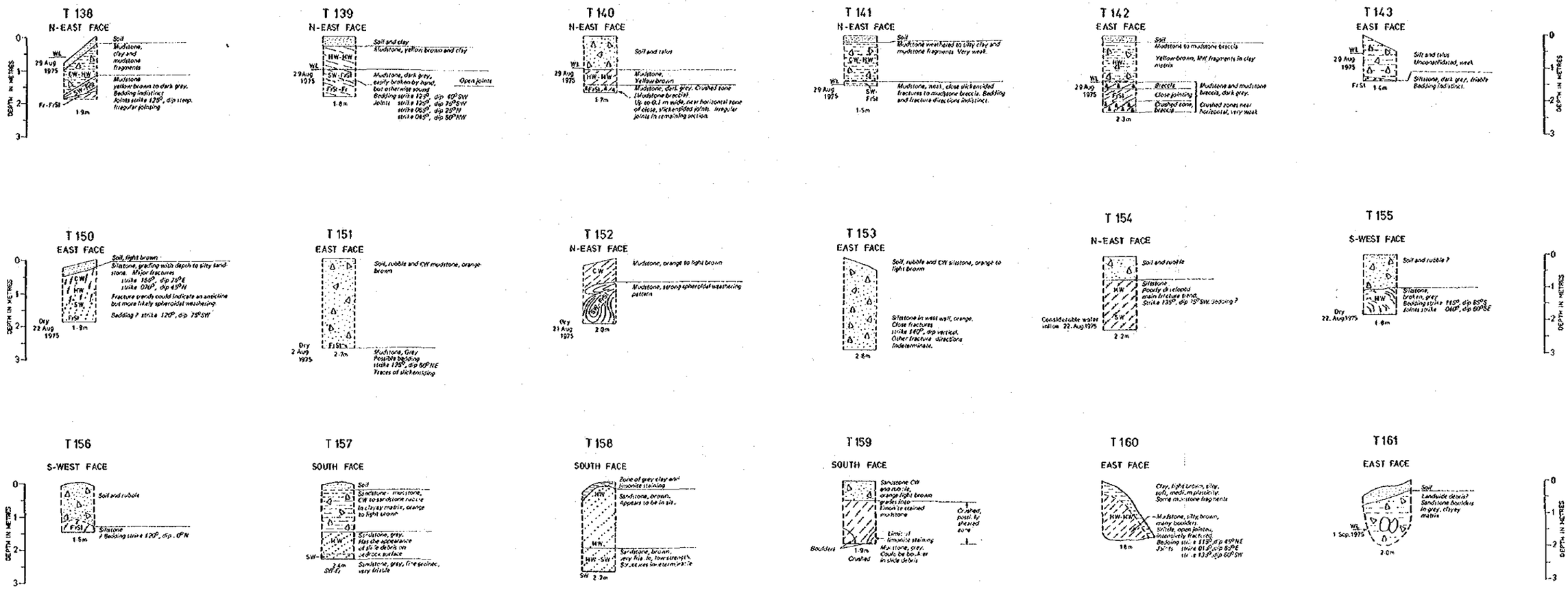
WABO POWER PROJECT
SADDLE DAMS

GEOLOGICAL LOGS OF TRENCHES

TRENCH T110 — TRENCH T137

SHEET 5 OF 10

55



NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan ..... Figures 30-34 (1429-S3162/1-5)
Logs of trenches T144 to T148 ..... Figure 60 (1429-S3045/10)
Log of trench T149 ..... Figure 58 (1429-S3045/8)

WABO POWER PROJECT
SADDLE DAMS

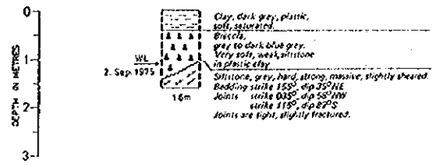
GEOLOGICAL LOGS OF TRENCHES

TRENCH T138 — TRENCH T161

SHEET 6 OF 10 56

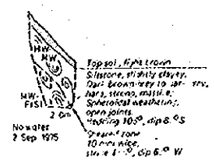
T162

EAST FACE



T163

NORTH FACE

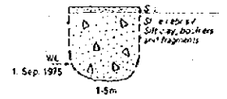


T164

N-EAST FACE

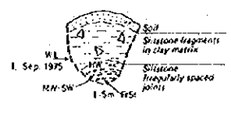
T165

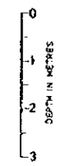
N-EAST FACE



T166

N-EAST FACE





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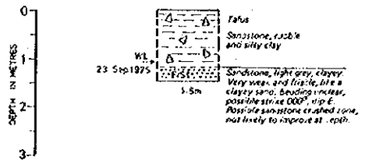

T169

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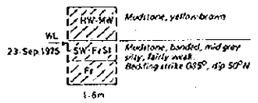
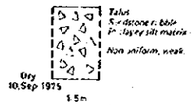


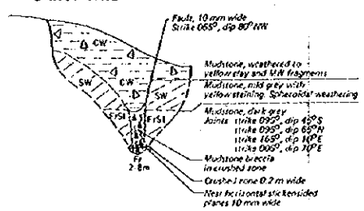
T170

NORTH FACE



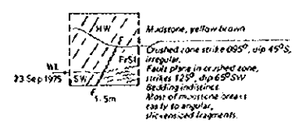
T172

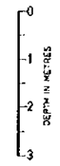
S-WEST FACE



T173

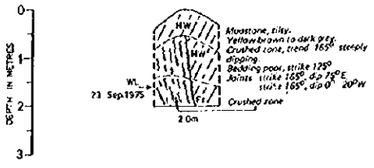
EAST FACE





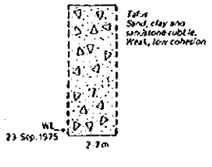
T175

N-WEST FACE



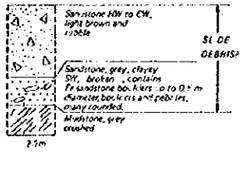
T177

N-EAST FACE



T178

NORTH FACE



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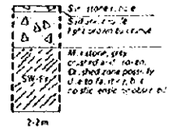
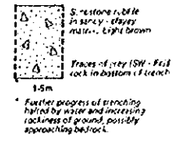
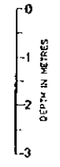
N-WEST FACE



T180

N-WEST FACE





NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project -

Geological Plan ..... Figures 30-34(1429-S3162/1-5)

Logs of trenches T168, T171, T174, T176 and T181 ..... Figure 58(1429-S3045/8)

WABO POWER PROJECT
SADDLE DAMS

GEOLOGICAL LOGS OF TRENCHES

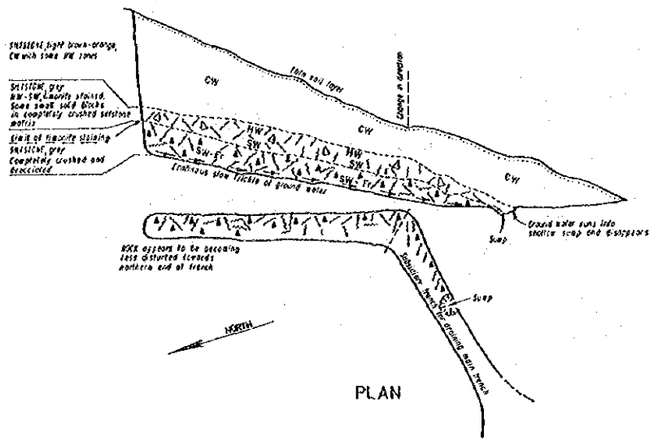
TRENCH T162 — TRENCH T180

SHEET 7 OF 10

☒ 57

T149

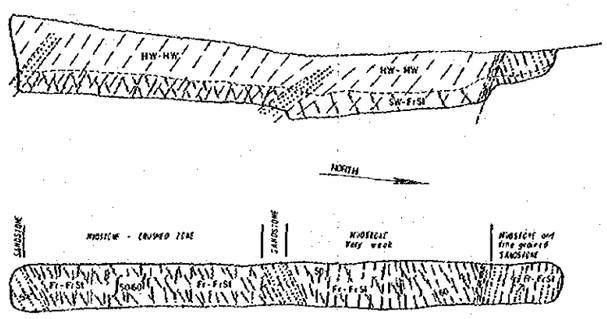
ELEVATION OF EAST WALL



PLAN

T168

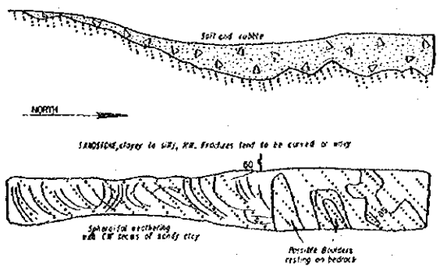
ELEVATION OF WEST WALL



PLAN

T171

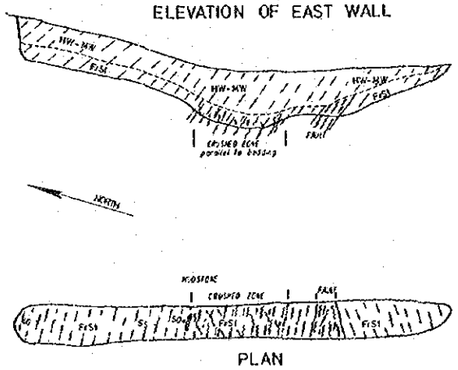
ELEVATION OF WEST WALL



PLAN

T176

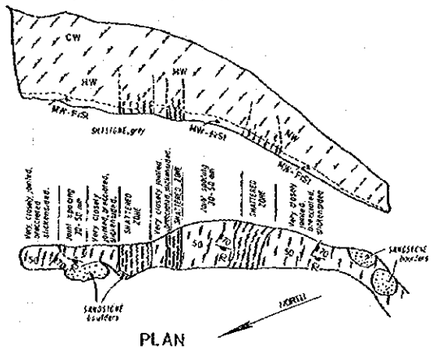
ELEVATION OF EAST WALL



PLAN

T181

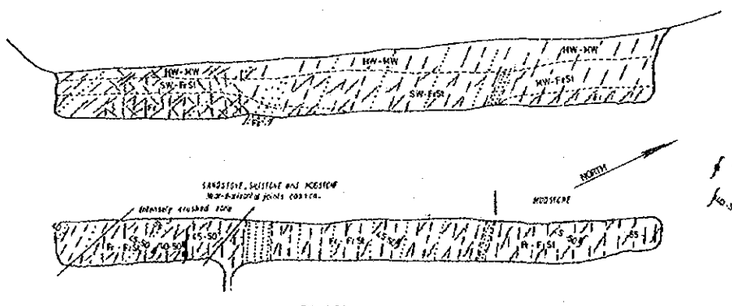
ELEVATION OF EAST WALL



PLAN

T174

ELEVATION OF WEST WALL



PLAN

Vertical fracture

Strike and dip of fracture

0 0·5 1 2 3 4 5m

NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project - Geological Plan — Figures 30-34(1429-S3162/1-5)

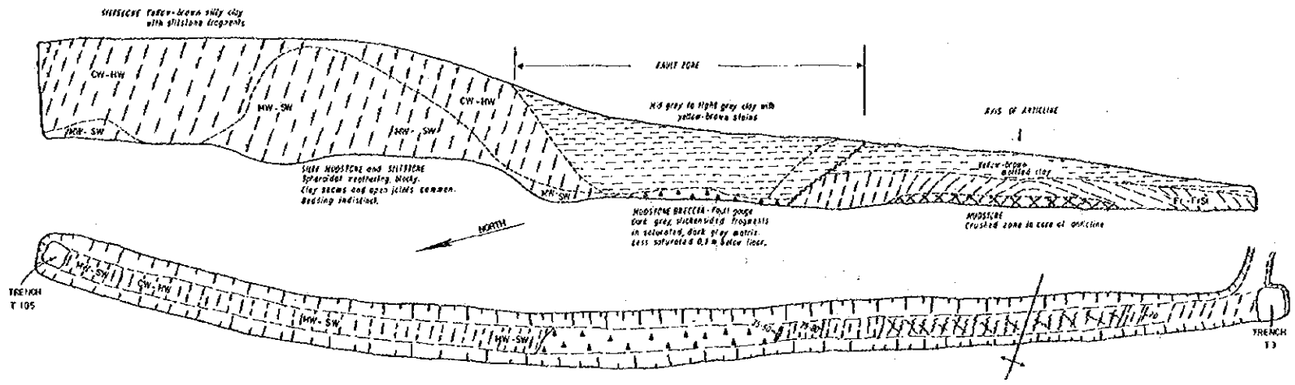
WABO POWER PROJECT
SADDLE DAM

GEOLOGICAL LOGS OF TRENCHES

TRENCH T149, T168, T171, T174, T176 & TRENCH T181

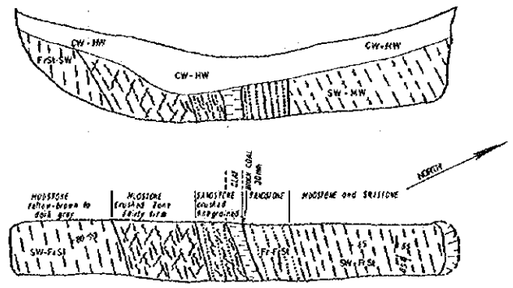
SHEET 8 OF 10 — 58

T30
ELEVATION OF EAST WALL



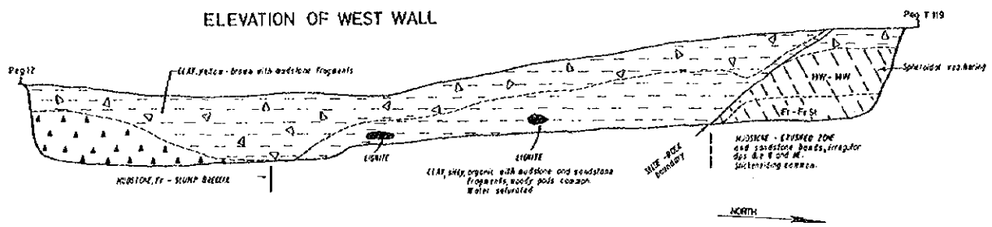
PLAN

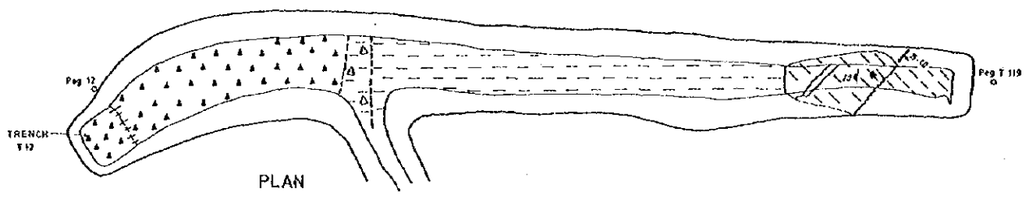
T116
ELEVATION OF WEST WALL



PLAN

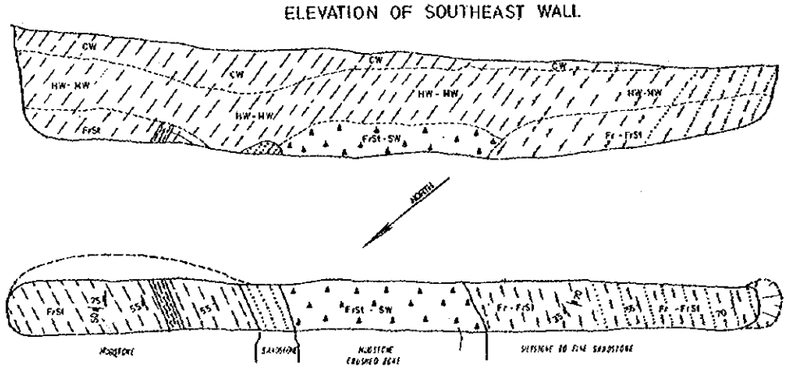
T119
ELEVATION OF WEST WALL





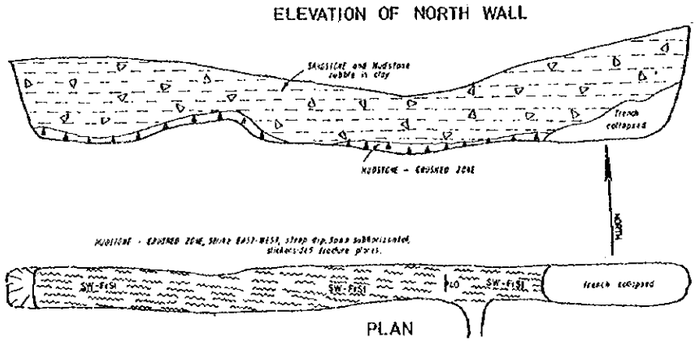
PLAN

T130
ELEVATION OF SOUTHEAST WALL



PLAN

T131
ELEVATION OF NORTH WALL



PLAN

NOTE

- For legend see sheet 10 (Figure 60)

REFERENCE DRAWINGS

Wabo Power Project - Geological Plan — Figures 30-34 (1429-S3162/1-5)

0 0.5 1 2 3 4 5m

WABO POWER PROJECT
SADDLE DAM

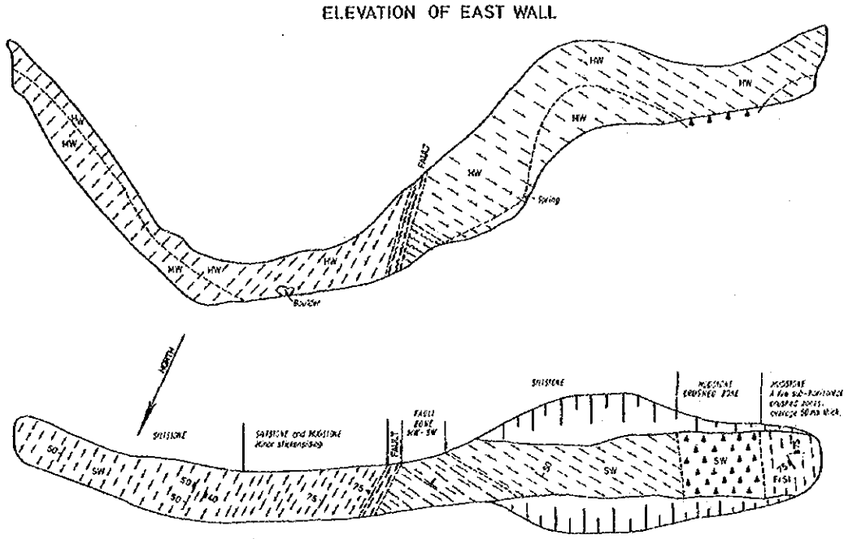
GEOLOGICAL LOGS OF TRENCHES

TRENCH T30, T116, T119, T130, & TRENCH T131

SHEET 9 OF 10 — Fig 59

T144

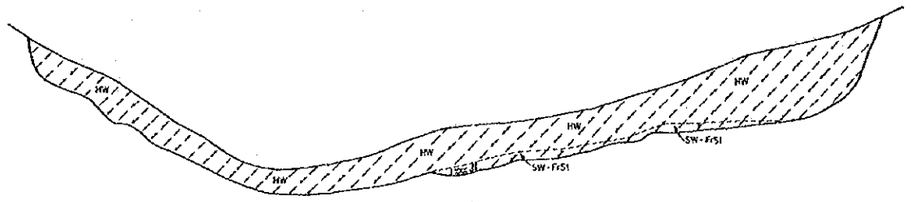
ELEVATION OF EAST WALL

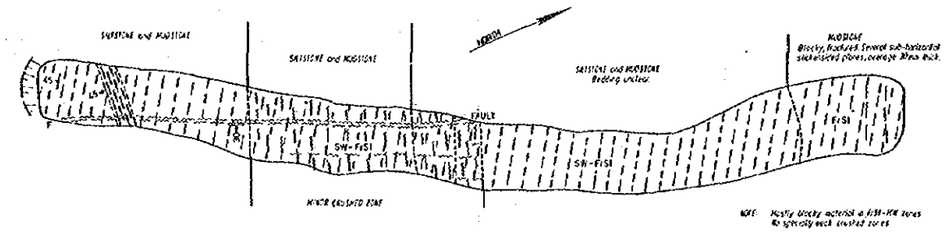


PLAN

T145

ELEVATION OF WEST WALL

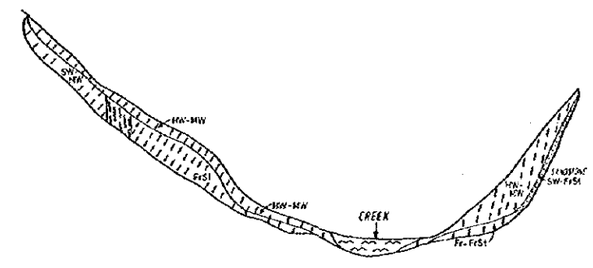




PLAN

T146

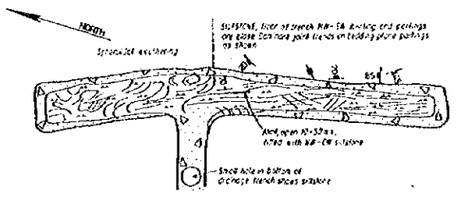
ELEVATION OF WEST WALL



PLAN

T147

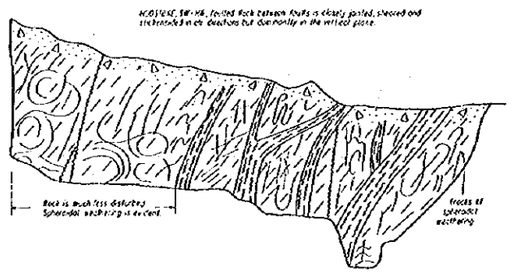
ELEVATION OF EAST WALL

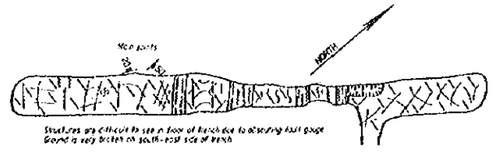


PLAN

T148

ELEVATION OF NORTH-WEST WALL





PLAN

NOTE: For location of trenches see drawing 1429-5

REFERENCE DRAWINGS

Wabo Power Project -
Geological Plan ..... Figures 30-34(1429-S3162/1-5)

0 0.5 1 2 3 4 5m

LEGEND

GEOLOGICAL BOUNDARIES

——— Accurate

- - - - - - - Approximate

DEGREE OF WEATHERING

CW Completely weathered
HW Highly weathered
MW Moderately weathered
SW Slightly weathered
FrSt Fresh with limonite stained joints
Fr Fresh

50/ Bedding strike and dip, inclined, vertical
60/ Joint strike and dip, inclined, vertical
45-/ Fault, seam or sheared zone, inclined, vertical
45-50/ Fracture strike and dip, inclined, vertical
-/- Anticlinal axis

WABO POWER PROJECT
SADDLE DAM

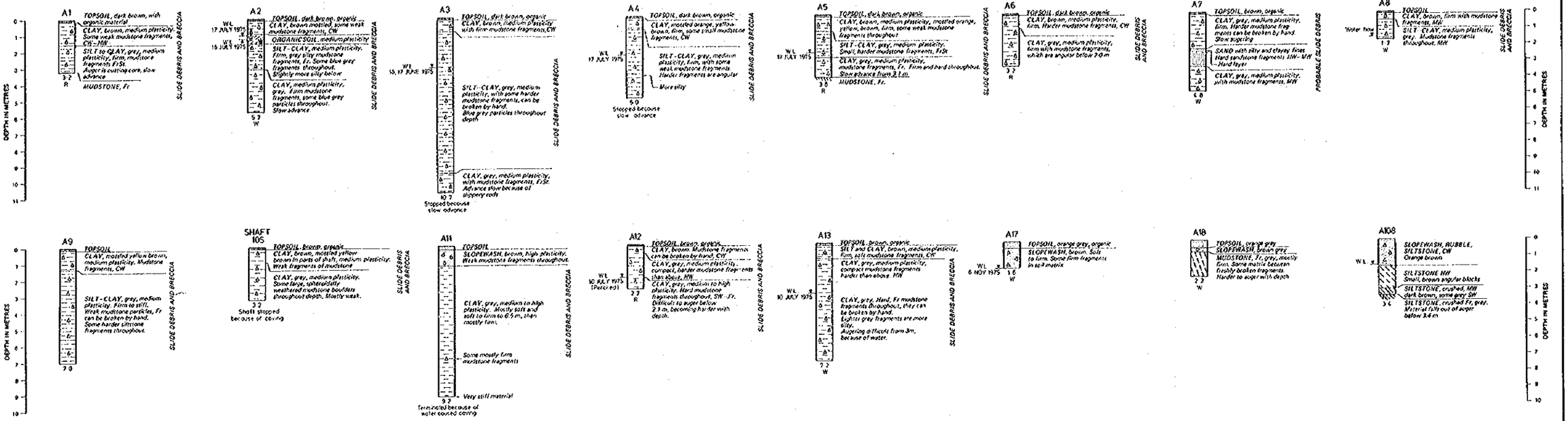
GEOLOGICAL LOGS OF TRENCHES

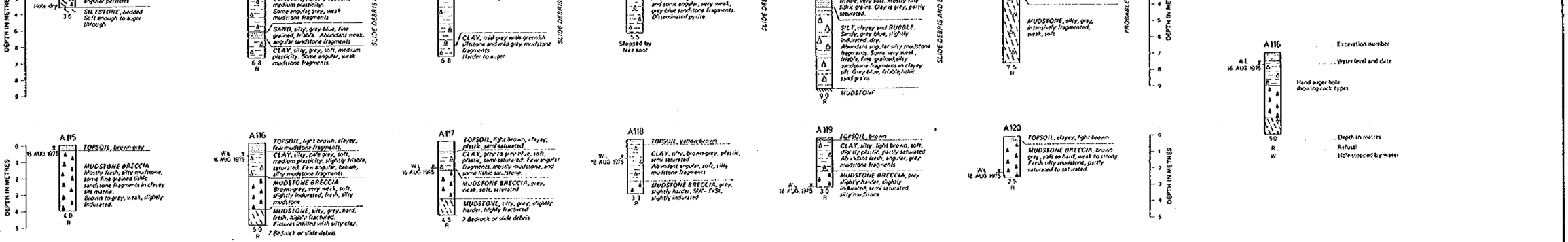
TRENCH T144 — TRENCH T148

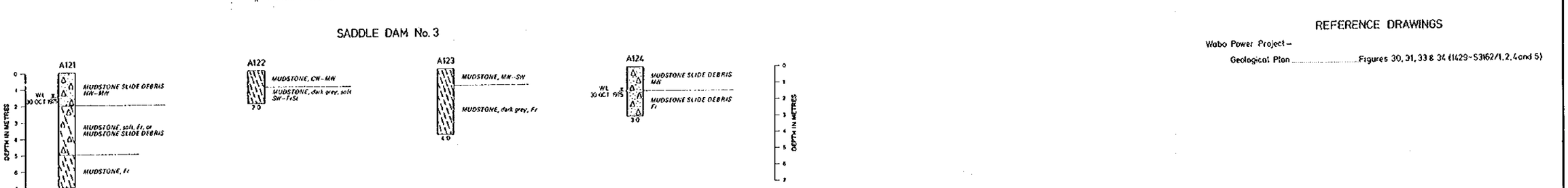
SHEET 10 OF 10

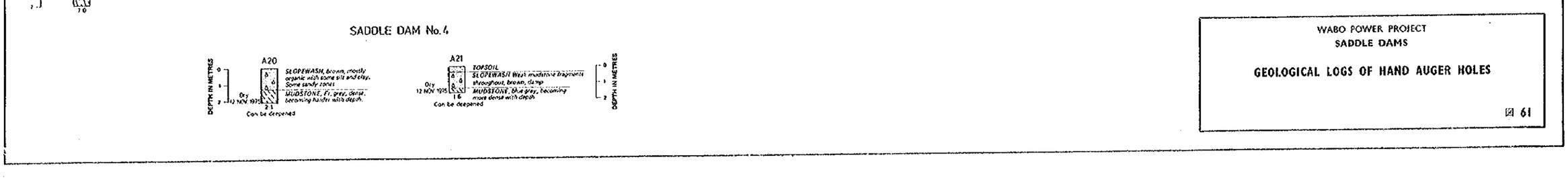
60

SADDLE DAM No. 1









SADDLE DAM No. 3

SADDLE DAM No. 4

LEGEND

REFERENCE DRAWINGS

Wabo Power Project –

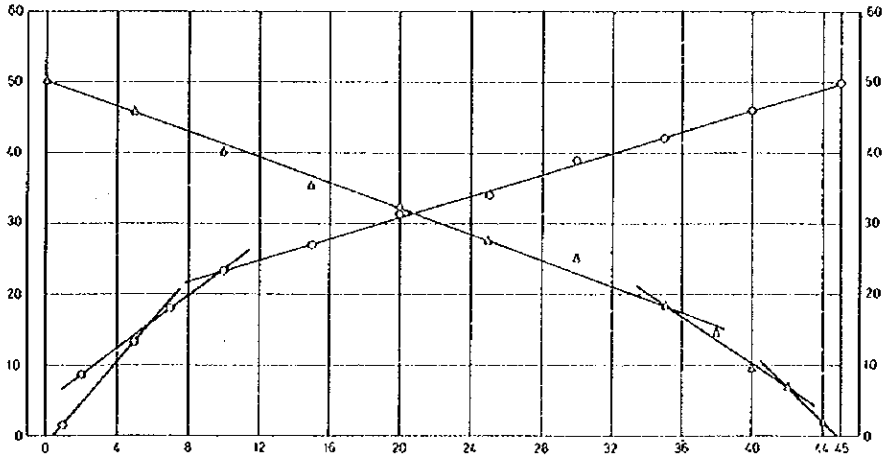
Geological Plan ..... Figures 30, 31, 33 & 34 (1429–S3162/1, 2, 4 and 5)

WABO POWER PROJECT
SADDLE DAMS

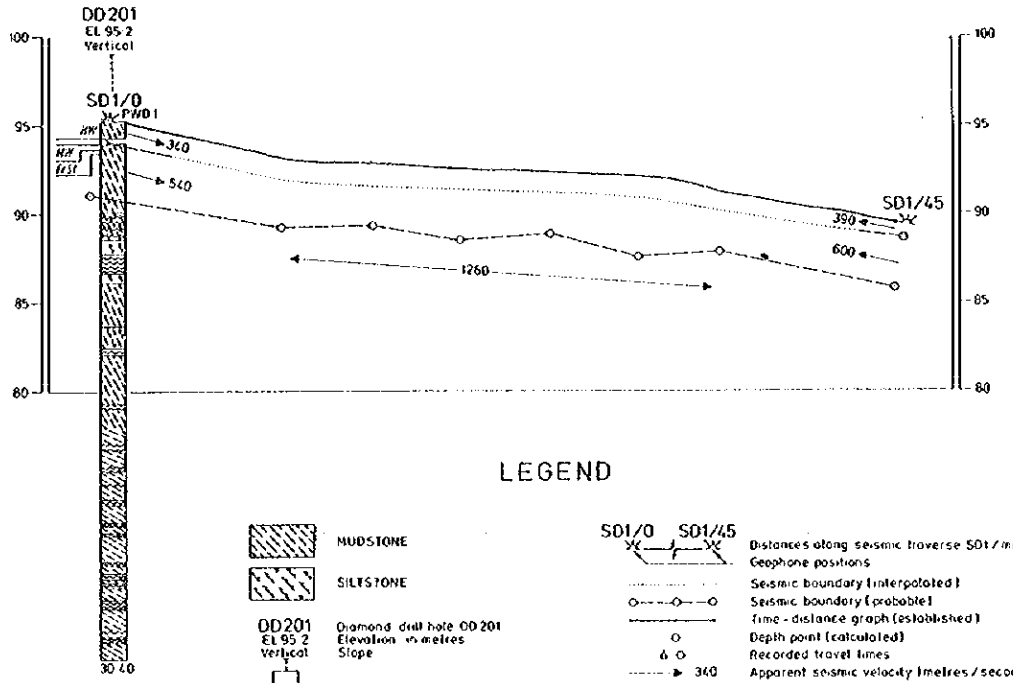
GEOLOGICAL LOGS OF HAND AUGER HOLES

図 61

TIME - DISTANCE GRAPH , TRAVERSE SD1



SEISMIC SECTION SD1



LEGEND

MUDSTONE

SILTSTONE

OD201 EL 95·2 Vertical — Diamond drill hole OD 201 Elevation in metres Slope

NO CORE — Summary log of diamond drill hole showing rock types, degree of weathering and more core losses

Fault or sheared zone

SD1/0 SD1/45 — Distances along seismic traverse SD1 / metres; Geophone positions

Seismic boundary (interpolated)

Seismic boundary (probable)

Time - distance graph (established)

Depth point (calculated)

Recorded travel times

340 — Apparent seismic velocity (metres / seconds)

1260 — Mean seismic velocity (metres / seconds)

DEGREE OF WEATHERING

HW - Highly weathered
MW - Moderately weathered
F/SF - Fresh, with limonite stained joints

NOTES

- Only the upper surface of the highest velocity layer is shown. The thickness of this layer is not known and there may be material with different velocities below it
- Seismic survey was carried out with a "BISON 1570B, SIGNAL ENHANCEMENT" hammer seismograph

REFERENCE DRAWINGS

Wabo Power Project - Geological Plan, sheet 2

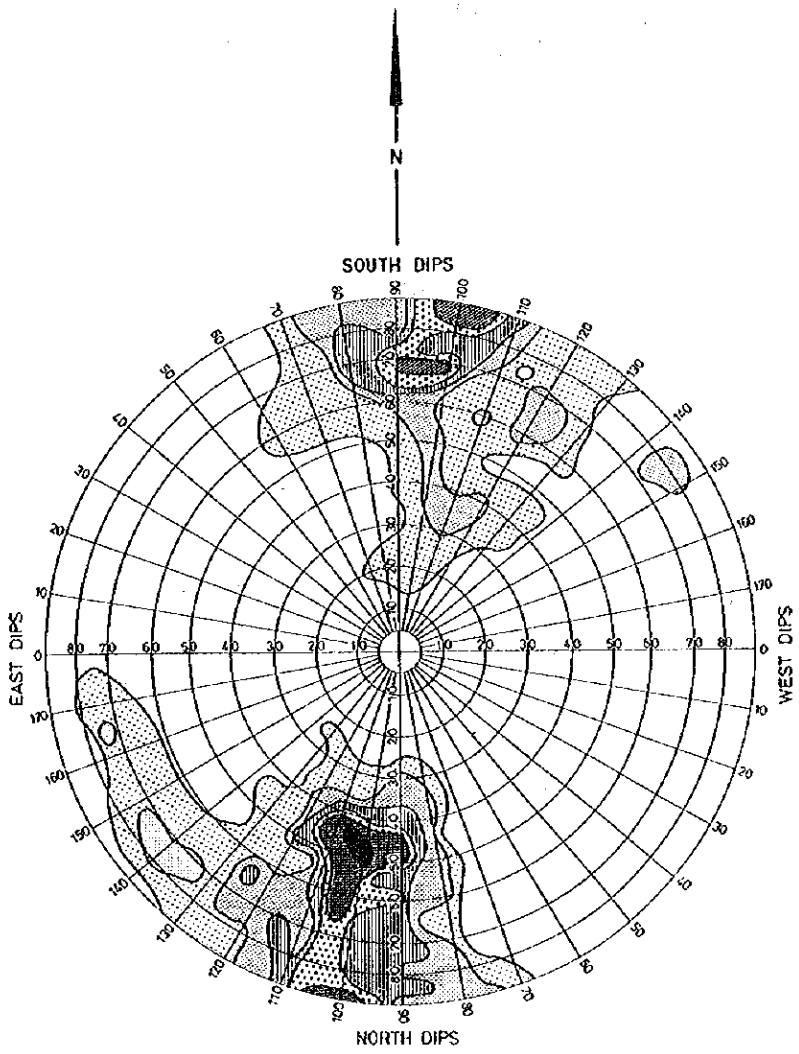
FIGURE 33 (1629 - S3162/2)

0 2 10 20
2

WABO POWER PROJECT
SADDLE DAM No. 1

TIME-DISTANCE GRAPH & SEISMIC SECTION OF TRAVERSE SD1

62



LEGEND

BEDDING — 167 POINTS

1%
2%
3%
4%
5%
6%
7% and over

— PER 1% OF AREA

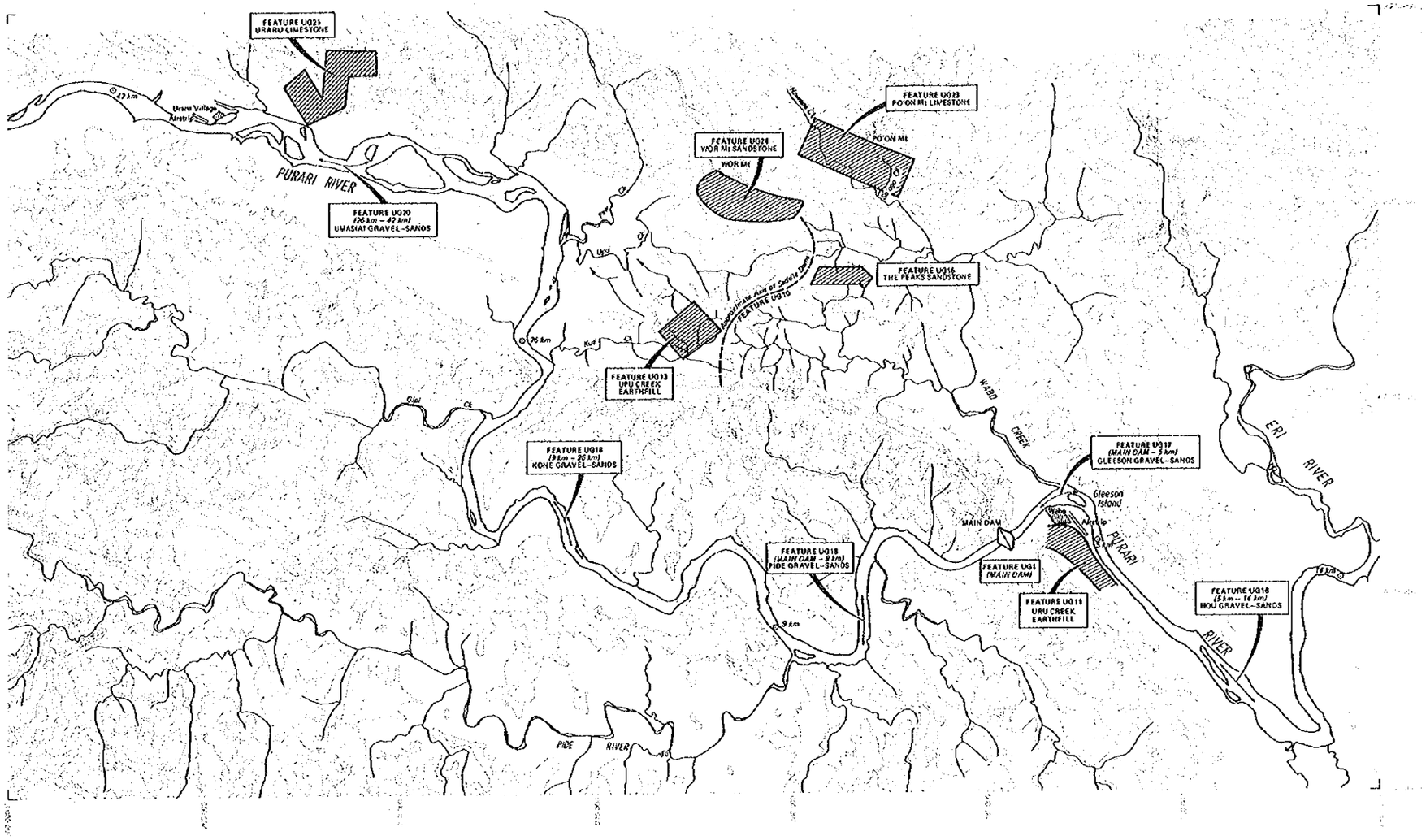
SCHMIDT NET LOWER HEMISPHERE
GRADUATED FOR POLES OF PLANAR ELEMENTS

- Read strike of plane along circumference in degrees east of north.
- Read dip of plane along diameter.

WABO POWER PROJECT
SADDLE DAMS

POLAR DIAGRAM – BEDDING PLANES

図 63



⊙ 16 km ... Distances in kilometres upstream and downstream of Main Dam Axis

REFERENCE DRAWINGS

- *FEATURE UG11*
  For Plan of Exploration and Excavation Logs see ..... FIGURE 65
- *FEATURE UG13*
  For Plan of Exploration see ..... FIGURE 66
- *FEATURES UG1, UG17, UG16*
  For Plan of Exploration and Excavation Logs see ..... FIGURE 78
- *FEATURES UG18, UG19*
  For Plan of Exploration and Excavation Logs see ..... FIGURE 79
- *FEATURE UG20*
  For Plan of Exploration and Excavation Logs see ..... FIGURE 80

NOTE:

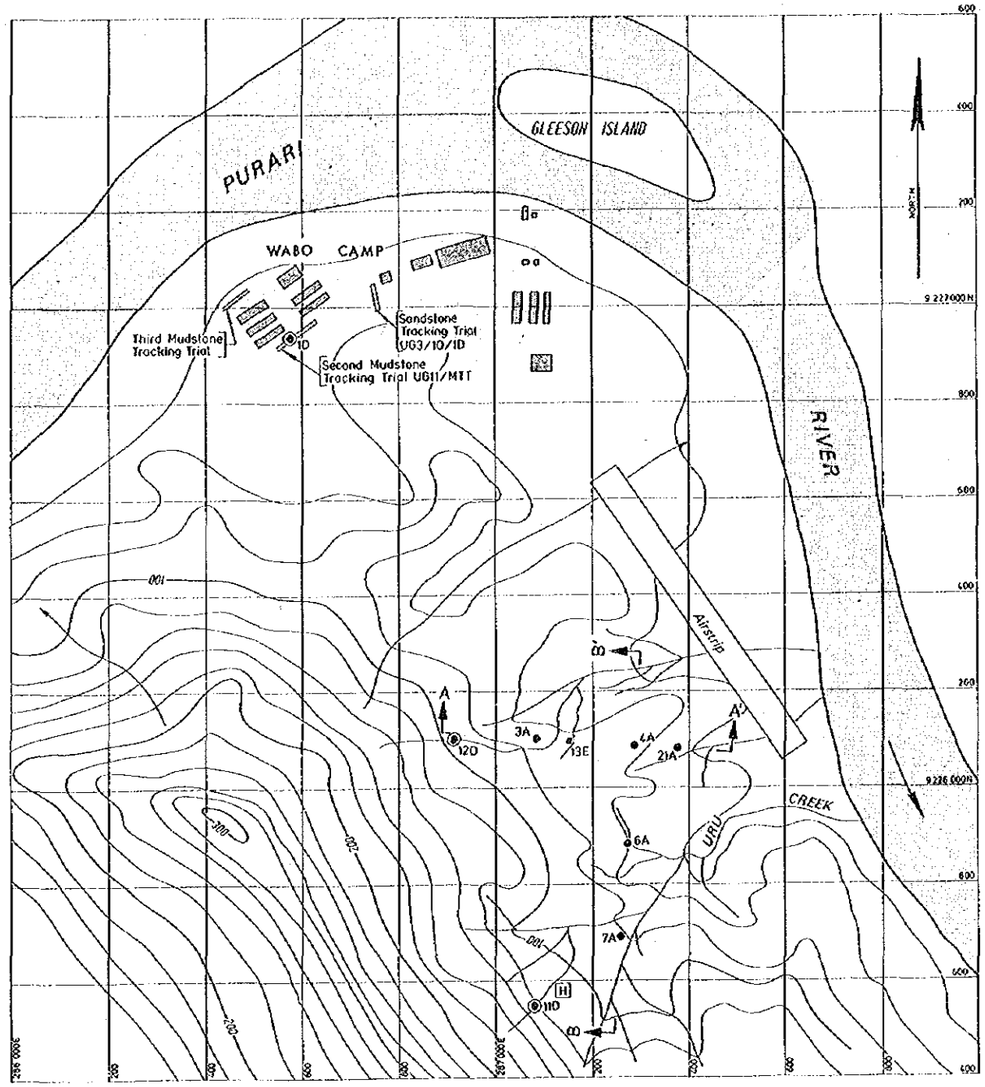
Topographical relief has been compiled with 25 m auxiliary form lines, interpolated between 100 m contours and is an approximate representation only.

0 05 1 2 3 4 5
05

WABO POWER PROJECT
PROJECT AREA

LOCATION OF EXPLORATION FEATURES

図 64



PLAN
SCALE A

LEGEND

- 12D — Diamond drill hole, AMLC
- 3A — Hand auger hole, 100 mm diameter.
- 13E — Hand dug excavation.
- H — Helipad location.

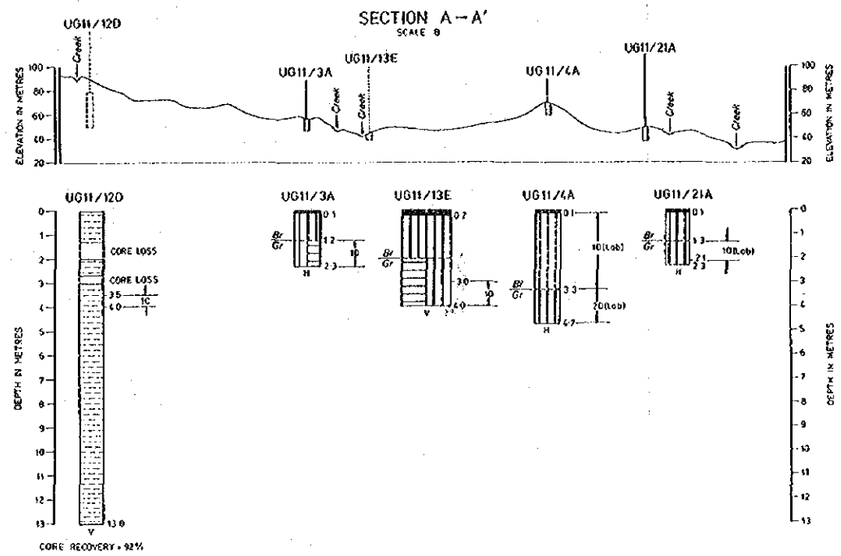
NOTE

- The contour lines on this drawing have been scaled up from topographic sheets 'Papua New Guinea 1:25 000 Topographic Survey' Sheets 7984-III-SW and 7983-IV-NW. Ground topography has been modified slightly as necessary to tie in with compass, tape and abney level traverses and topographic notes on exploration traverse lines.

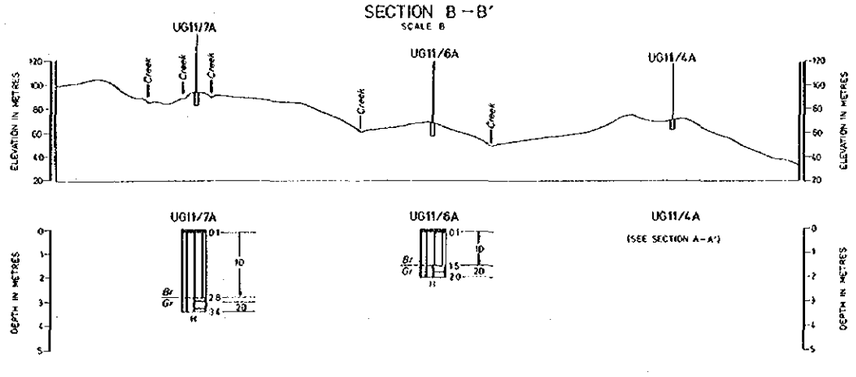
NOTES

- Soil classifications representative of all soil between the depths shown are field classifications, except where laboratory test results are available. Laboratory classifications are shown thus: (Lab.)
- Hand augering was unable to progress past the level of fresh mudstone (indicated MT).
- Soils are classified in terms of the Unified Soil Classification System. Borderline classifications are shown on the logs by dual symbols.

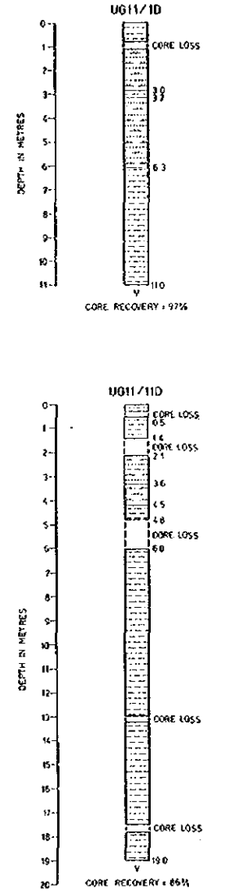
SECTION A–A'
SCALE B



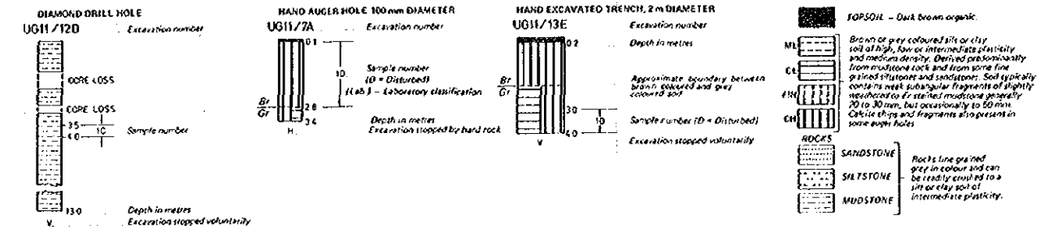
SECTION B–B'
SCALE B



LOGS OF DIAMOND DRILL HOLES NOT SHOWN IN SECTIONS



LEGEND



SCALE A 0 50 100 200 300 400 500m
50

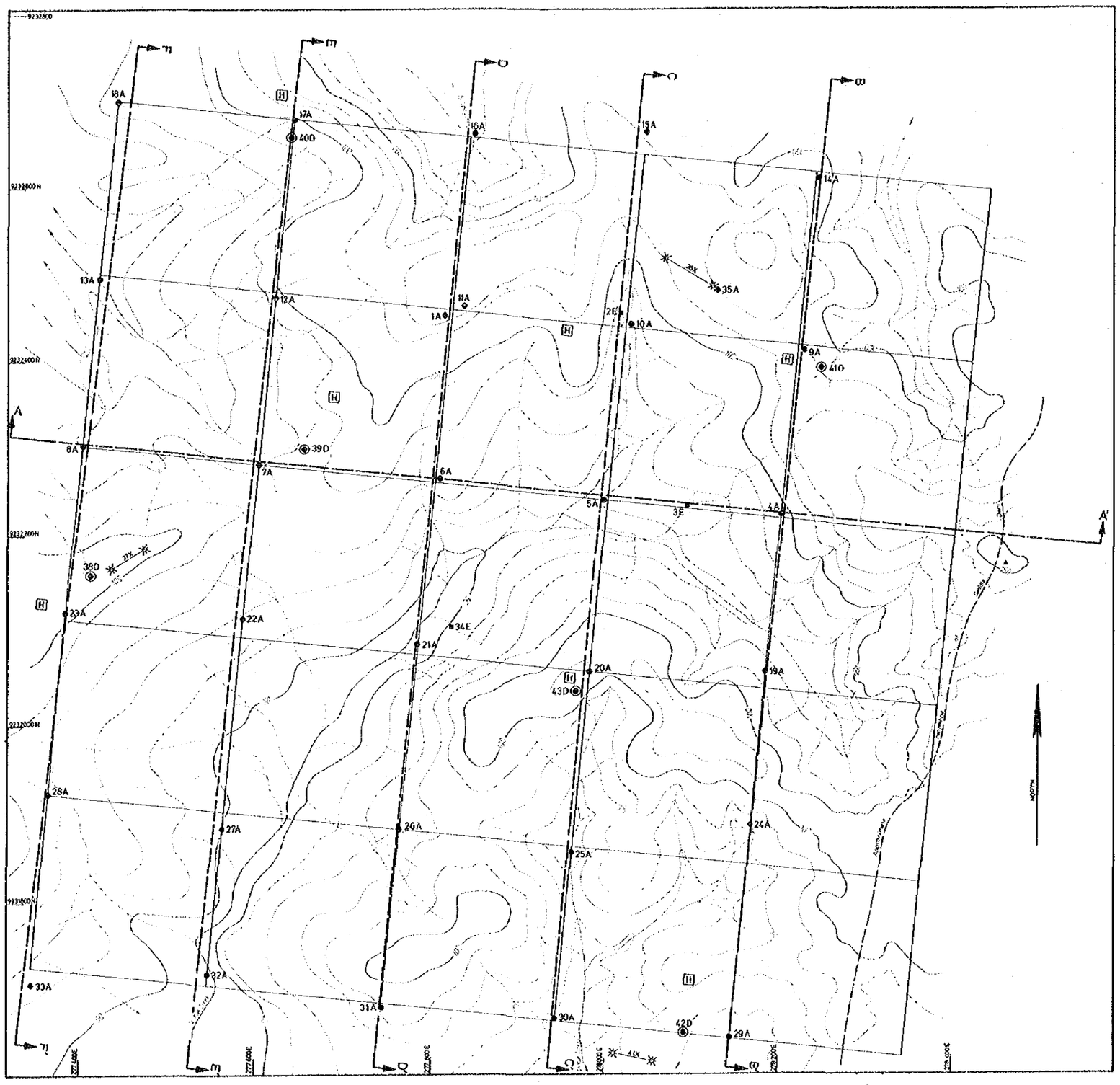
SCALE B 0 20 100 200m
20

WABO POWER PROJECT
MAIN DAM

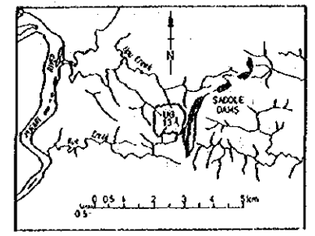
PLAN OF EXPLORATION AND EXCAVATION LOGS

FEATURE UG11 — URU CREEK EARTHFILL BORROW AREA

65



LOCATION MAP



LEGEND

- 41D ..... Diamond drill hole, AMEC
- 10A ..... Hand auger hole, 100 mm diameter.
- 2E ..... Hand dug excavation.
- 35X ..... Seismic traverse.
- H ..... Helipad location.
- ——— ..... Layout of Exploration Grid (Tape and Compass)

NOTES:

- The contour lines on this drawing have been scaled up from topographic sheet 'Pabua New Guinea 1: 25 000 Topographic Survey' Sheet 7684—II—SE. Ground topography has been modified slightly as necessary to tie in with compass, tape and abney level surveys and topographic notes on exploration traverse lines.
- Figures shown on marginal ticks are grid co-ordinates from the 1:25 000 topographic map. The 200 metre grid shown is a local exploration grid.

REFERENCE DRAWINGS

- For sections and logs of excavations see ..... FIGURES 67 and 68
- For time distance graphs and seismic sections see ..... FIGURE 70

0 20 100 200m

CONTOUR INTERVAL 10m

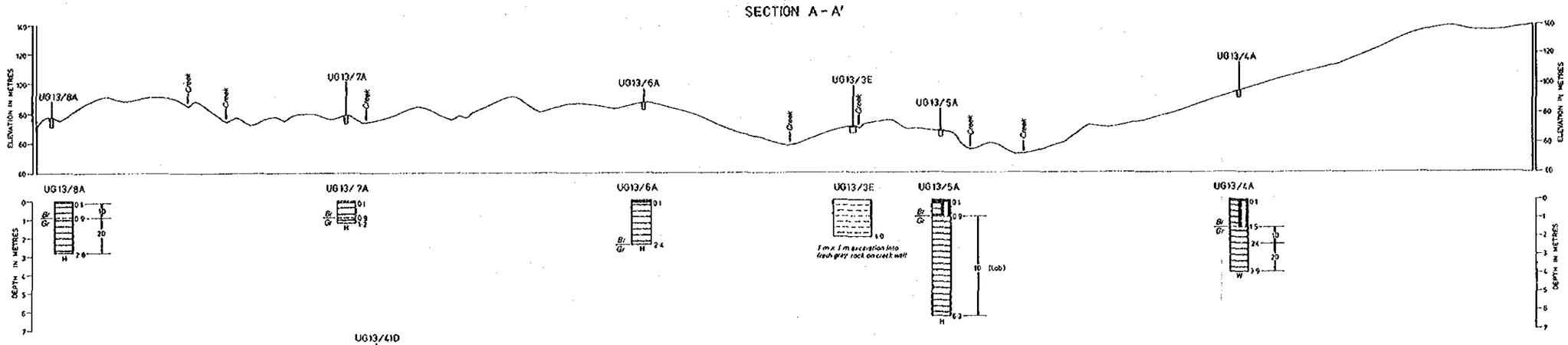
WABO POWER PROJECT
SADDLE DAM

PLAN OF EXPLORATION

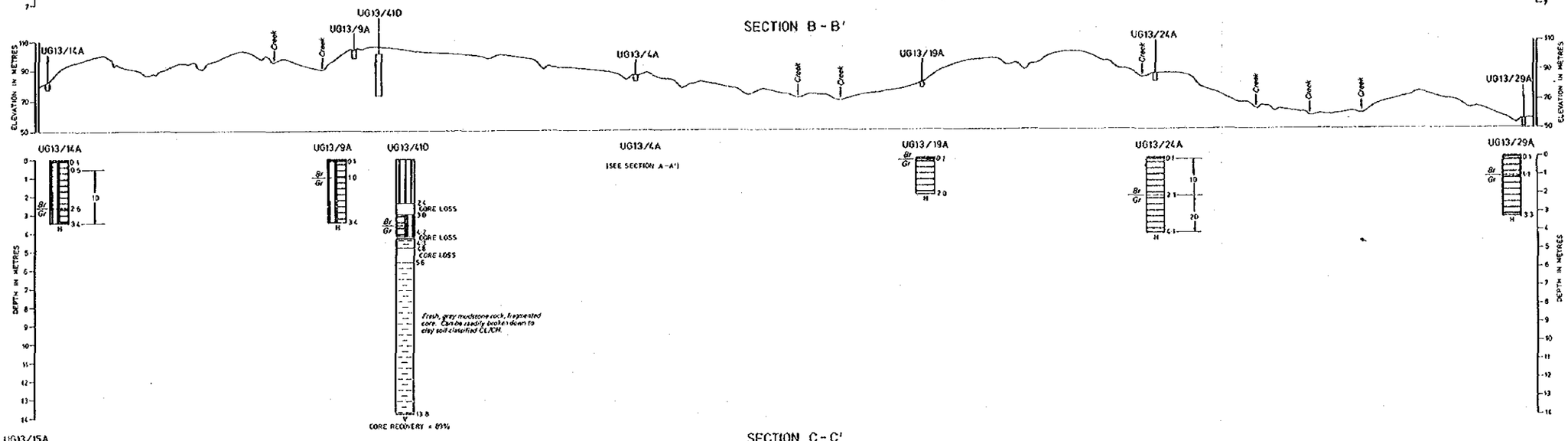
FEATURE UG13 — UPU CREEK EARTHFILL BORROW AREA

図 66

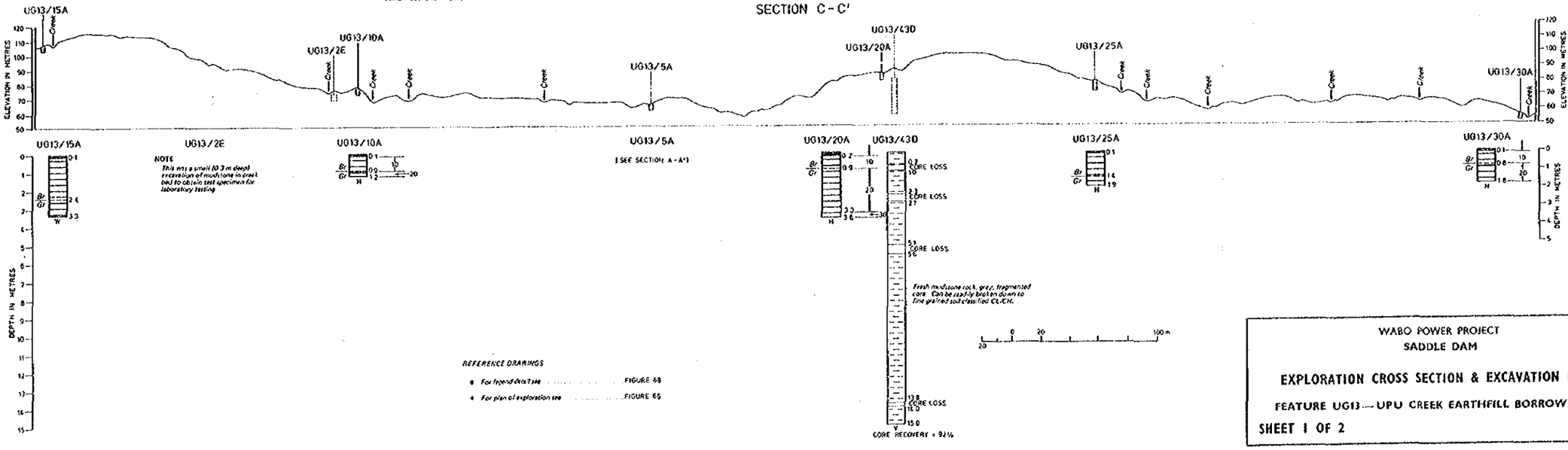
SECTION A - A'



SECTION B - B'



SECTION C - C'



REFERENCE DRAWINGS

- For legend and Test pit ..... FIGURE 68
- For plan of exploration see ..... FIGURE 66

WABO POWER PROJECT
SADDLE DAM

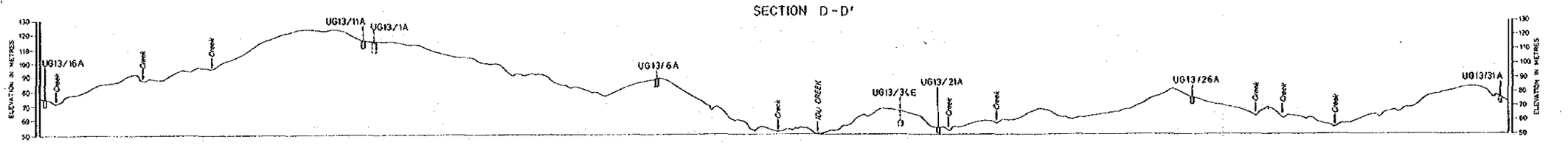
EXPLORATION CROSS SECTION & EXCAVATION LOGS

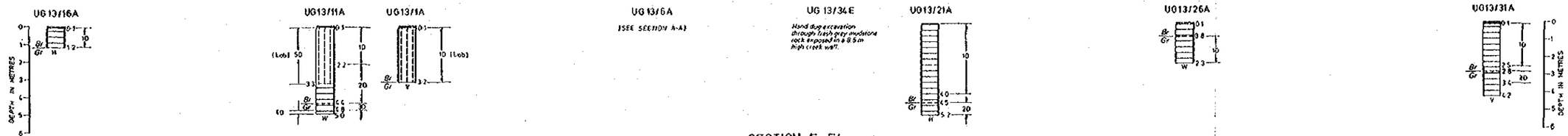
FEATURE UG13 — UPU CREEK EARTHFILL BORROW AREA

SHEET 1 OF 2

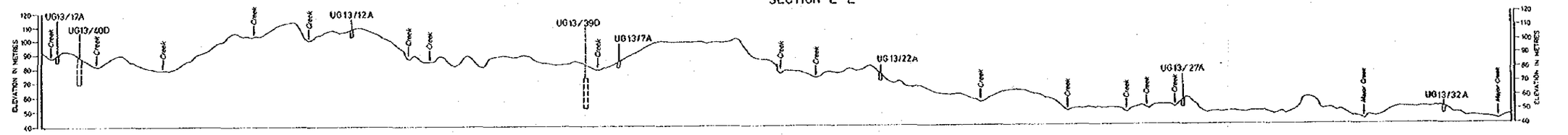
図 67

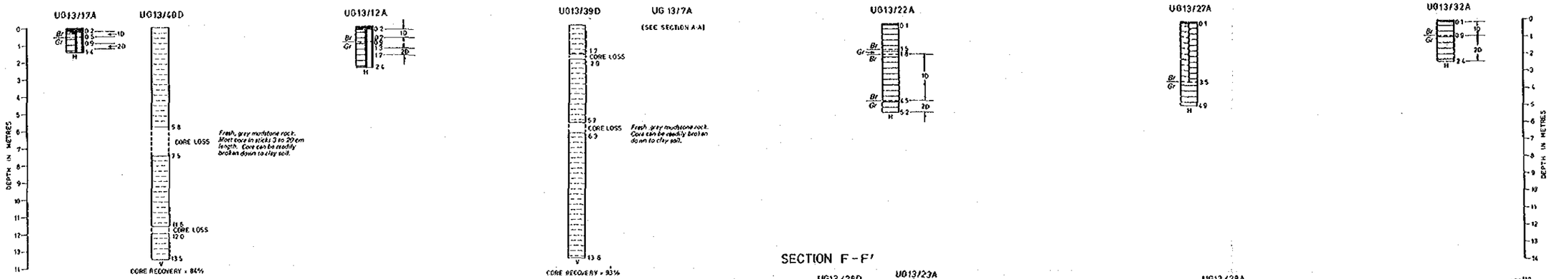
SECTION D-D'



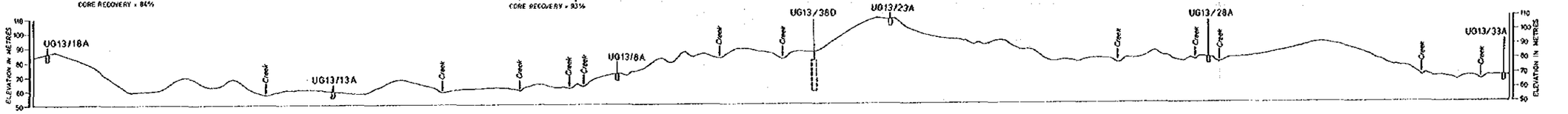


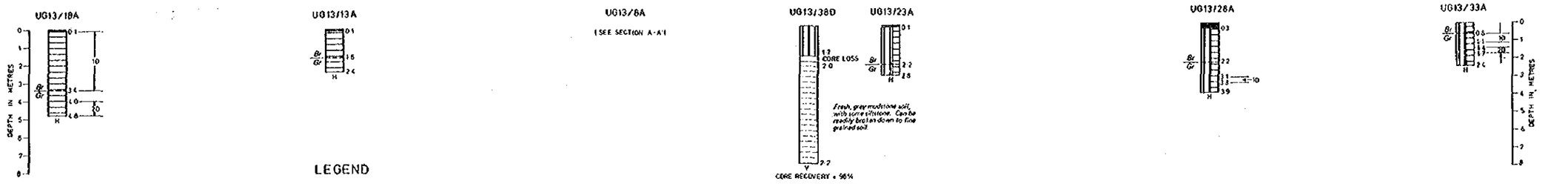
SECTION E-E'





SECTION F-F'





LEGEND

HAND AUGER HOLE, 100 mm DIAMETER
UG13/18A — Excavation number
10 — Sample number (D = disturbed)
Depth in metres
H — Excavation stopped by Hard rock
W — Excavation stopped by Water
V — Excavation stopped Voluntarily
Approximate boundary between brown and grey mudstone soil.

DIAMOND DRILL HOLE
UG13/L00 — Excavation number
AWLC size (core diameter 27 mm) drilled with 'Winkie' portable diamond drill. Model GW 15
CORE LOSS
Depth in metres

HAND EXCAVATION for large samples of fresh mudstone and siltstone.
UG13/3XE — Excavation number

SOILS - Classified according to Unified (Modified) System.
TOPSOIL - Dark brown organic.
ML, CL, MH, CH — Brown or grey coloured silt or clay soil of high, low or intermediate plasticity and medium density. Derived predominantly from mudstone rock and from some fine grained siltstones and sandstones. Soil typically contains weak subangular fragments of slightly weathered to fr stained mudstone generally 20 to 30 mm, but occasionally to 50 mm. Calcite chips and fragments also present in some auger holes

ROCKS
SANDSTONE, SILTSTONE, MUDSTONE — Rocks fine grained grey in colour and can be readily crushed to a silt or clay soil of intermediate plasticity.

NOTES
- Soil classifications representative of all soil between the depths shown are Field classifications, except where laboratory test results are available. Laboratory classifications are shown thus: (Lab.)
- Hand augering was unable to progress past the level of Fresh mudstone (indicated H)
- Soils are classified in terms of the Unified Soil Classification System. Borderline classifications are shown on the logs by dual symbols.

REFERENCE DRAWINGS
- For plan of exploration see ..... FIGURE 65

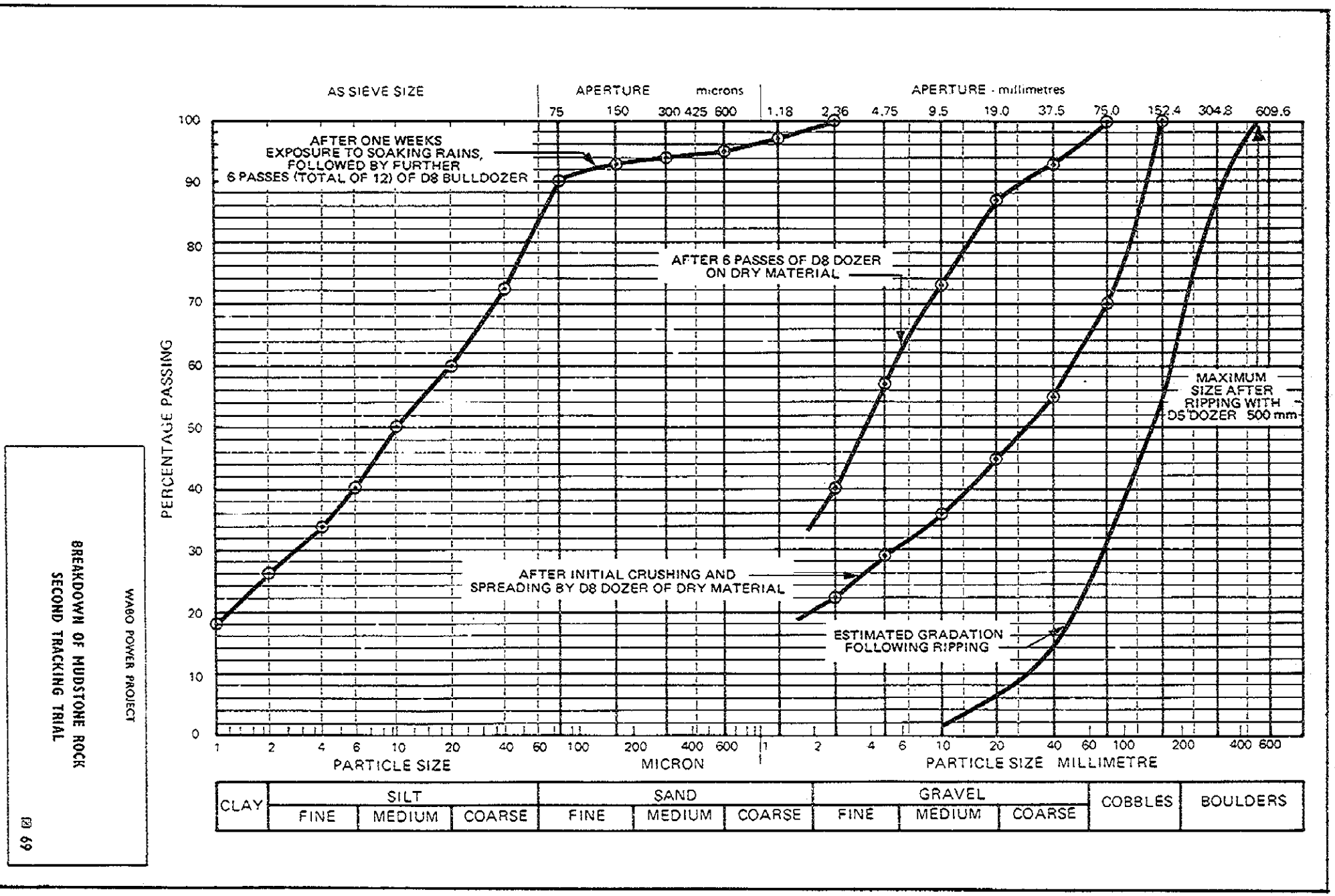
0 20 100m

WABO POWER PROJECT
SADDLE DAM

EXPLORATION CROSS SECTION & EXCAVATION LOGS

FEATURE UG13 — UPU CREEK EARTHFILL BORROW AREA

SHEET 2 OF 2 ☒ 68



WAGO POWER PROJECT

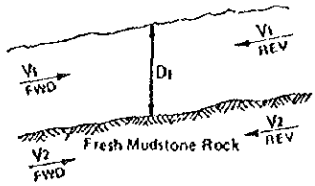
BREAKDOWN OF MUDSTONE ROCK
SECOND TRACKING TRIAL

69

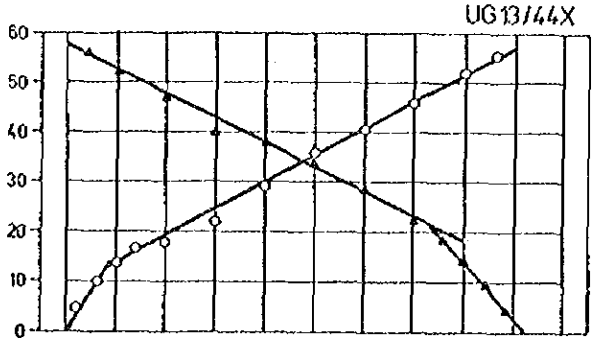
LEGEND

Forward run

Reverse run

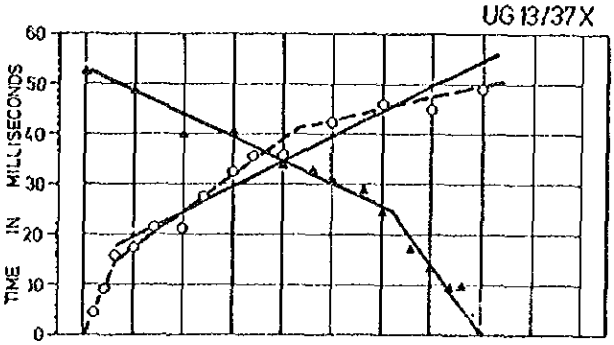


UG 13/44X



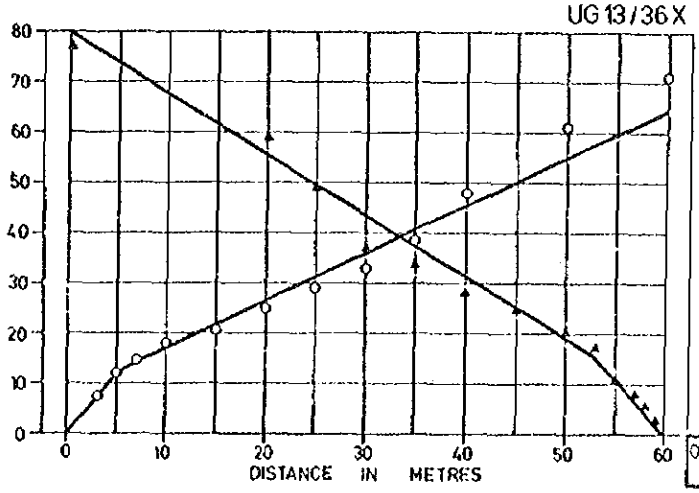
	VELOCITIES metres/sec V1	V2	INTERCEPT DEPTH metres D1
FWD	— *	927	—
REV	444	1013	3.0
MEAN	—	968	—

UG 13/37X



FWD	— *	1000	—
REV	363	1111	3.1
MEAN	—	1053	—

UG 13/36X



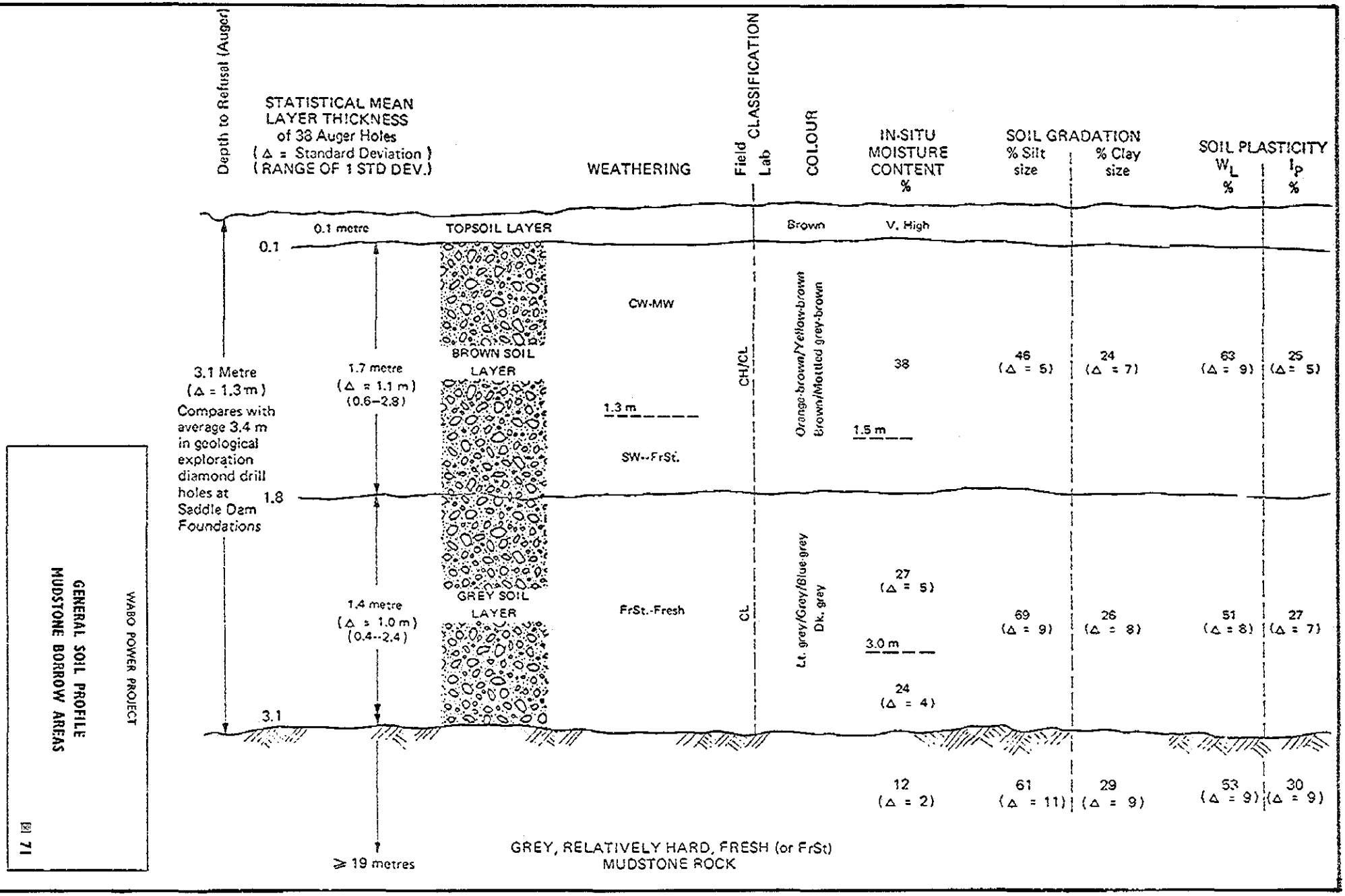
FWD	417	1058	1.7
REV	455	828	1.9
MEAN	435	929	1.8
OVERALL MEAN	420	990	

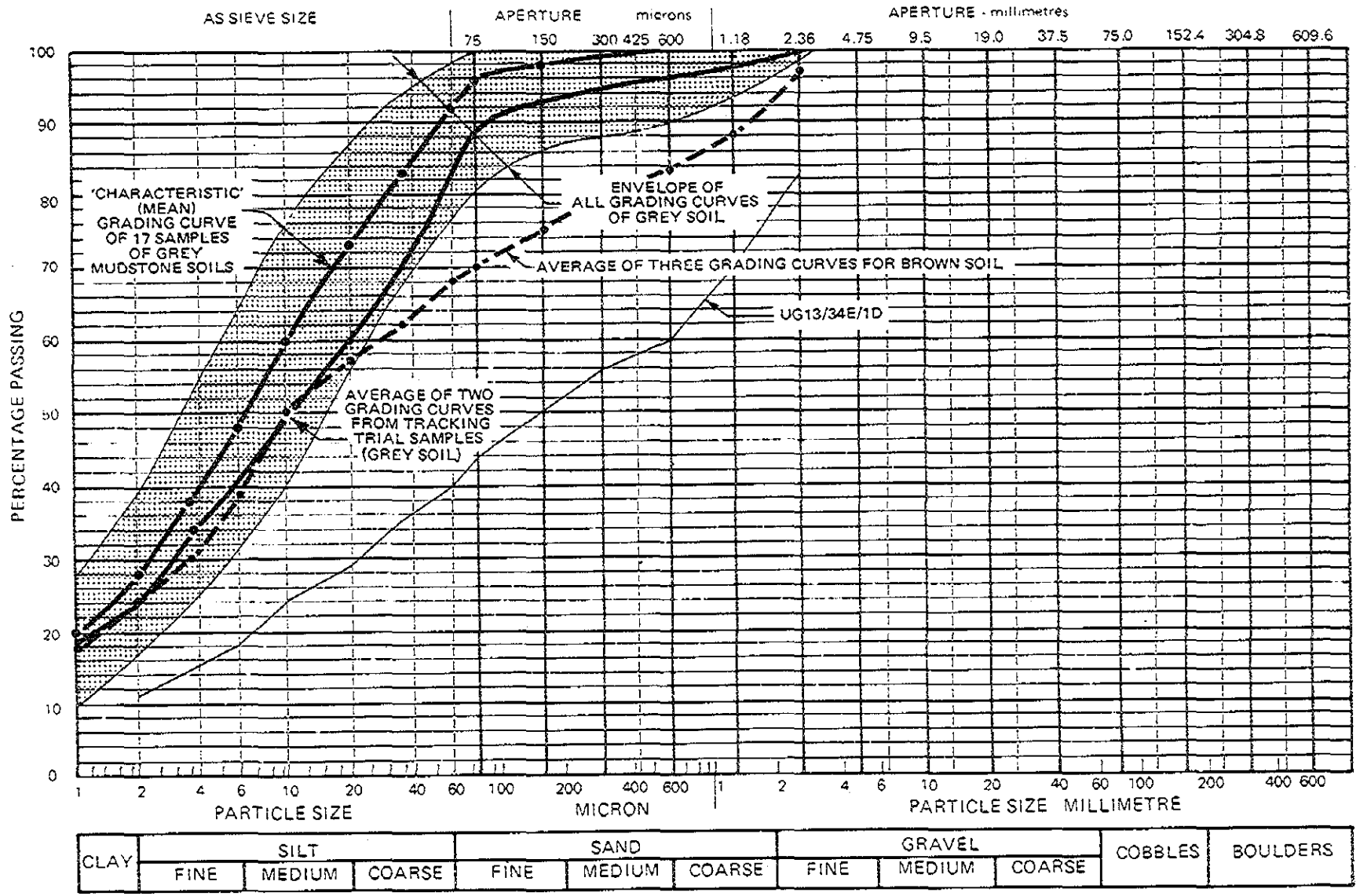
* *Interpretation unreliable*

WABO POWER PROJECT

SEISMIC TRAVERSES IN FEATURE UG13
TIME-DISTANCE DATA

Fig 70

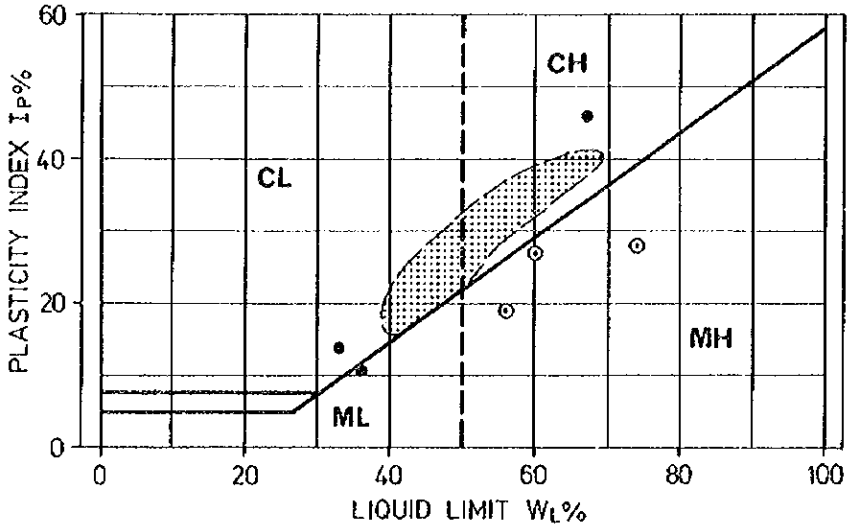

WABO POWER PROJECT
GENERAL SOIL PROFILE
MUDSTONE BORROW AREAS
図 71
Depth to Refusal (Auger)
STATISTICAL MEAN LAYER THICKNESS of 38 Auger Holes
(Δ = Standard Deviation)
(RANGE OF 1 STD DEV.)
WEATHERING
Field CLASSIFICATION
Lab
COLOUR
IN-SITU MOISTURE CONTENT %
SOIL GRADATION
% Silt size
% Clay size
SOIL PLASTICITY
W_L %
I_P %
0.1 metre
TOPSOIL LAYER
Brown
V. High
0.1
CW-MW
BROWN SOIL LAYER
Orange-brown/Yellow-brown
Brown/Mottled grey-brown
38
46 (Δ = 5)
24 (Δ = 7)
63 (Δ = 9)
25 (Δ = 5)
3.1 Metre (Δ = 1.3 m)
Compares with average 3.4 m in geological exploration diamond drill holes at Saddle Dam Foundations
1.7 metre (Δ = 1.1 m) (0.6–2.8)
1.3 m
CH/CL
1.5 m
SW--FrSt.
1.8
GREY SOIL LAYER
Lt. grey/Grey/Blue-grey
Dk. grey
27 (Δ = 5)
1.4 metre (Δ = 1.0 m) (0.4--2.4)
FrSt.-Fresh
CL
69 (Δ = 9)
26 (Δ = 8)
51 (Δ = 8)
27 (Δ = 7)
3.0 m
24 (Δ = 4)
3.1
12 (Δ = 2)
61 (Δ = 11)
29 (Δ = 9)
53 (Δ = 9)
30 (Δ = 9)
≥ 19 metres
GREY, RELATIVELY HARD, FRESH (or FrSt) MUDSTONE ROCK



WABO POWER PROJECT

GRADATION ANALYSES OF MUDSTONE SOILS

FIG 72



NOTES: Shaded area shows range for 14 grey soil samples

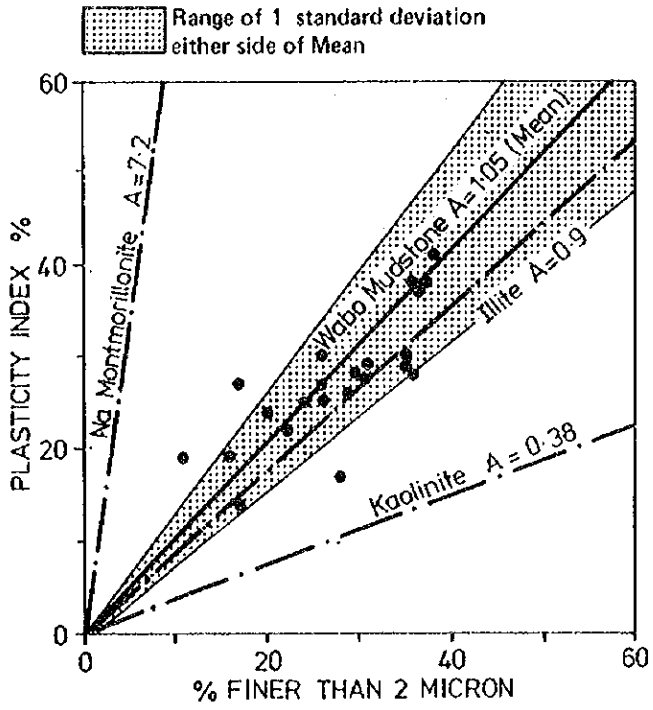
⊙ Individual plots of 3 brown soil samples

• Individual plots of 3 grey soil samples falling outside the general range.

WABO POWER PROJECT

PLASTICITY RANGE OF MUDSTONE SOILS

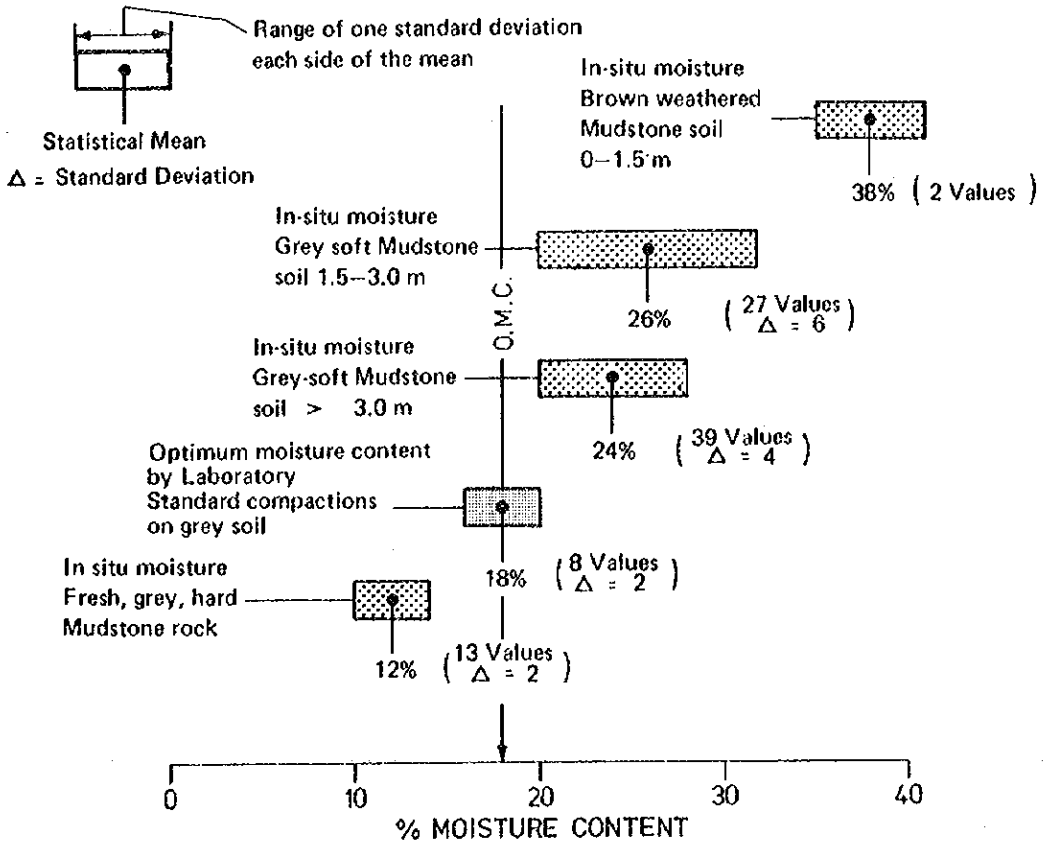
⊠ 73



WABO POWER PROJECT

ACTIVITY OF MUDSTONE SOILS

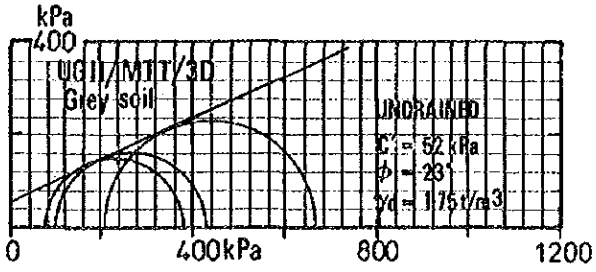
☒ 74

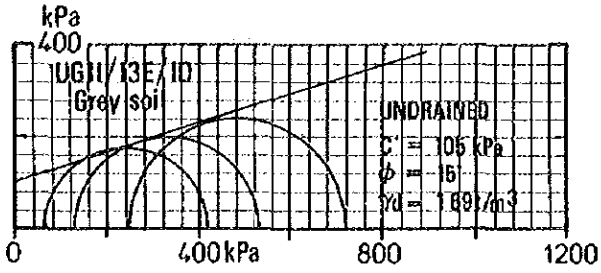


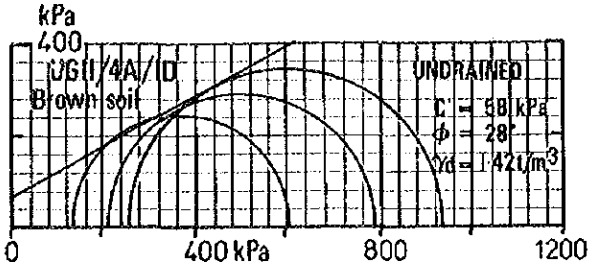
WABO POWER PROJECT

MOISTURE RANGE
MUDSTONE SOIL AND ROCK

図 75



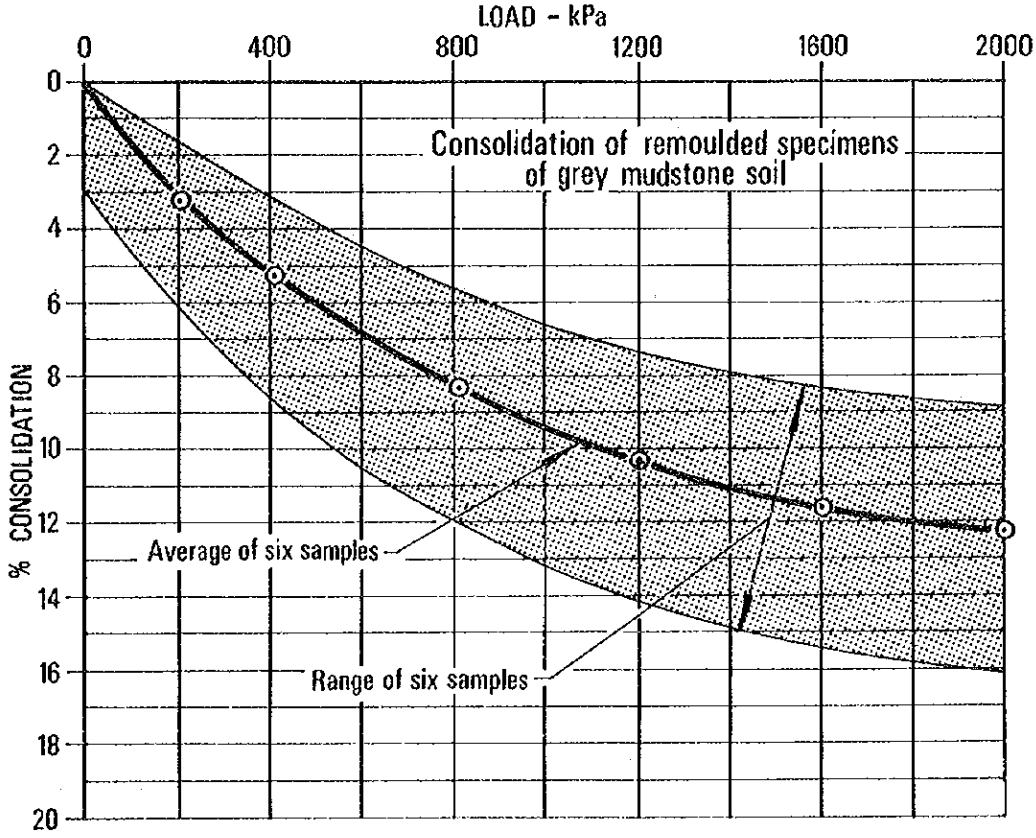




WABO POWER PROJECT

MUDSTONE TRIAXIAL TESTS
MOHR CIRCLE PLOTS – REMOULDED SPECIMENS

☒ 76

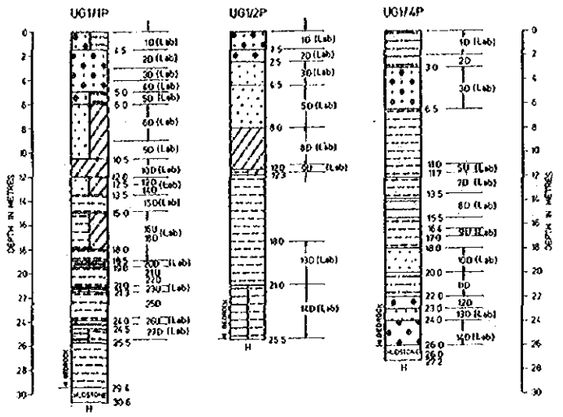


WABO POWER PROJECT

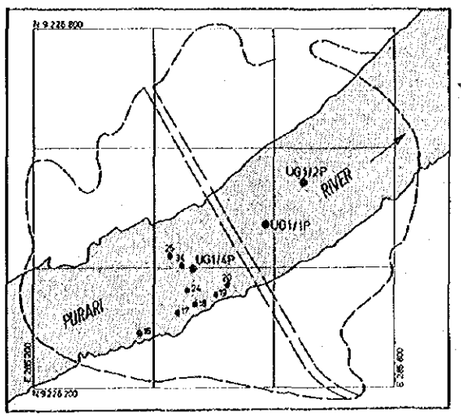
MUDSTONE SOILS – CONSOLIDATION DATA

77

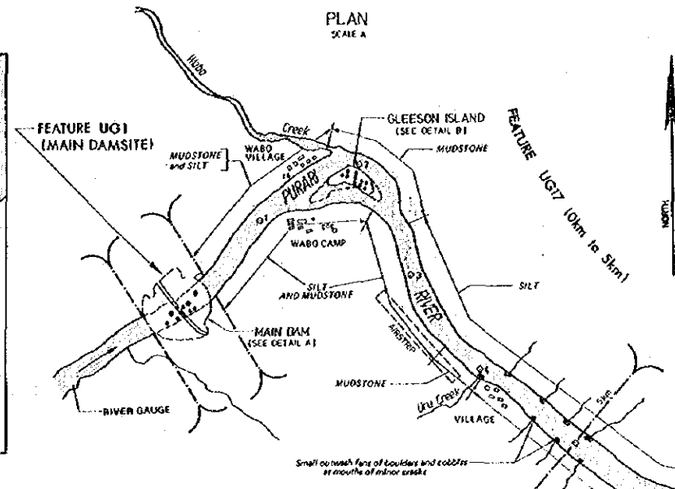
DAMSITE - (UG1)
LOGS OF PERCUSSION DRILL HOLES



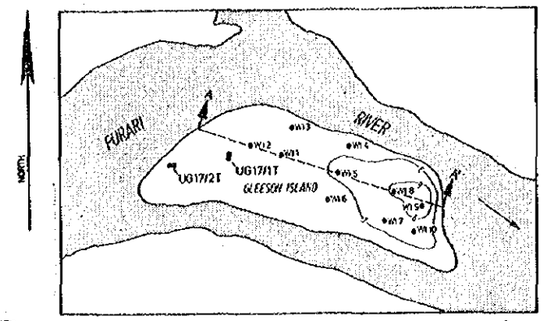
DETAIL A
SCALE C



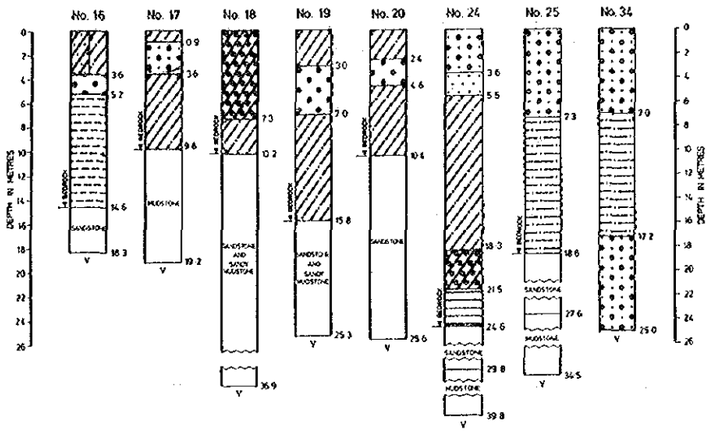
PLAN
SCALE A



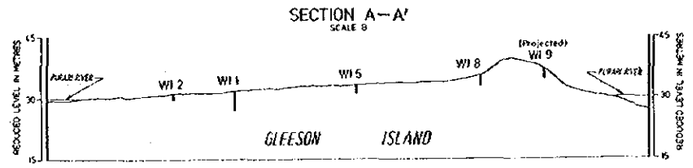
DETAIL B
NOT TO SCALE



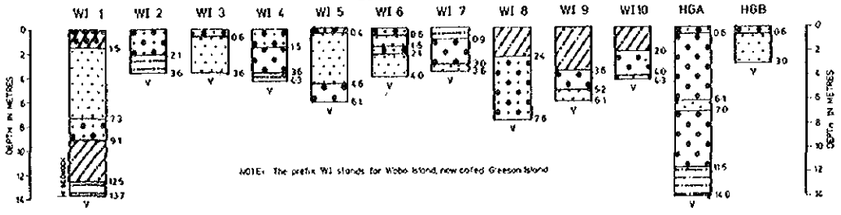
LOGS OF BOREHOLES BY GEORGE WIMPEY & CO. (1959)
(SHELL AND AUGER, JETTING AND ROTARY CORE)



SECTION A–A'
SCALE B

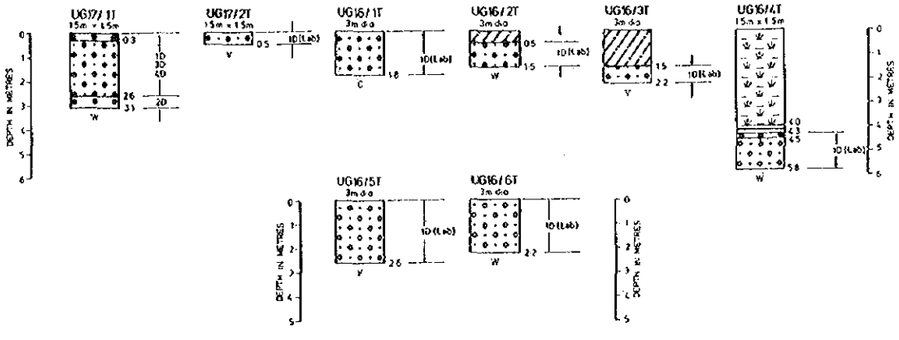


GLEESON ISLAND

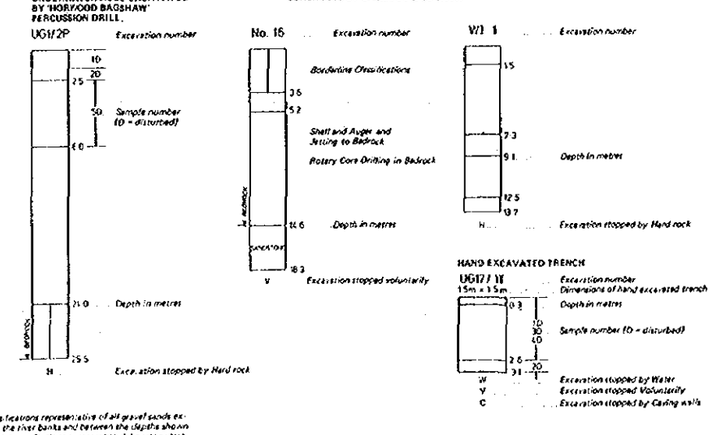


NOTE: The prefix WI stands for Wabo Island, now called Gleeson Island

LOGS OF HAND EXCAVATED TRENCHES



LEGEND



NOTES

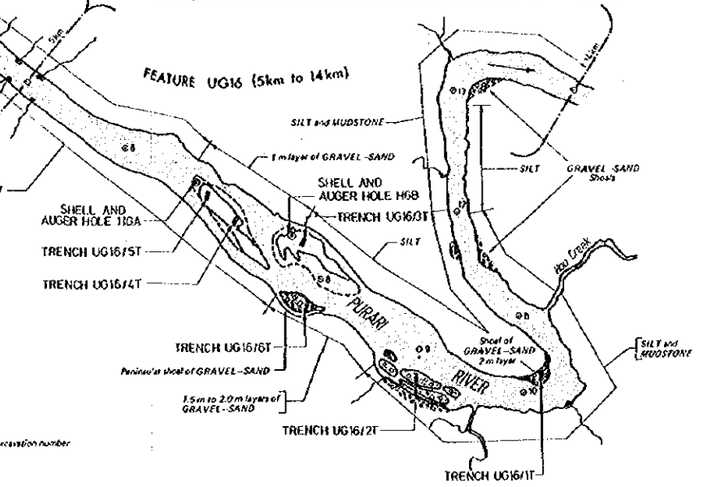
- Soil classifications representative of all gravel sands exposed in the river banks and between the depths shown are visual determinations except where laboratory test results are available.
  Laboratory classifications are shown thus: (Lab)
- Gravel sands are classified in terms of the United Soils Classification System (With select) Borderline classification shown by dual symbols.
- Description of material in logs of underwater drill holes refer only to material recovered by Chop pump, bailer or driven tube sampler
- The exposed features of the river banks, the islands and the Mudflow gravel sand bars are subject to variation depending on river height, accordingly all river thicknesses are approximate only.
- Plan of exploration was compiled from reference plan: Wabo Hydro Electric Project, Reservoir Area (Dec 1971) at scale of 1:20000.

Scale A — 0 0.2 1km

Scale B — 0 25 100 200m

Scale C — 0 60 200 400m

FEATURE UG16 (5km to 14km)



ALLUVIAL SOILS

ML, CL, OL — Clayey, Sandy Silt and fine to medium Sands, light grey to dark grey and brown, low plasticity, some organic material.

GRAVEL–SANDS

GW, GP, GC, SW, SP, SM, SC — Purari River gravel sand. White, buff, grey and brown gravel, mostly rounded with some flat and elongated particles.

Hard, dense and composed predominantly of limestone with lesser amounts of basalt, sandstone and siliceous rocks. Generally of 150 mm maximum size with occasional cobbles to 300 mm. Grey coloured, fine to coarse sands with rounded to sub-angular grains. Occasionally gravels are bedded in clay matrix or silty and clayey layers are present in the gravel sands, iron staining often present.

- Feature boundary
- Hand dug trench
- Percussion Drill Hole
- Drill Hole – Shell Auger, jetting or rotary.
- River distance in kilometres downstream of Main Dam Axis.
- Location of gravel sand deposits (shown for bank deposits only)

WABO POWER PROJECT
MAIN DAM

PLAN OF EXPLORATION AND EXCAVATION LOGS
FEATURE UG1 — MAIN DAMSITE
FEATURE UG17 — GLEESON GRAVEL SANDS
FEATURE UG16 — HOU GRAVEL SANDS

☒ 78

LOGS OF HAND EXCAVATED TRENCHES

LOG OF PERCUSSION DRILL HOLE

LEGEND

HAND EXCAVATED TRENCH, 2 m DIAMETER

UG18/1T — Excavation number

10 — Sample number (D = Disturbed)

2.2 — Depth in metres

C — Excavation stopped by caving walls

V — Excavation stopped voluntarily

W — Excavation stopped by water

UNDERWATER PERCUSSION DRILL HOLE BORED BY 'HYDROMASTER' PERCUSSION DRILL

UG18/1P — Excavation number

10L — Sample number (D = Disturbed)

3.3 — Depth in metres

MB — Hole stopped by mechanical breakdown

GRAVEL – SANDS

GM — Fluvial River gravel sand. White, buff, grey and brown gravel, mostly rounded with some flat and elongated particles

GW — Hard, dense and composed predominantly of limestone with lesser amounts of basalt, sandstone and siliceous rocks. Generally of 150 mm maximum size with occasional cobbles to 300 mm. Grey coloured, fine to coarse sand with rounded to subangular grains. Occasionally gravels are bedded in clay matrix or silty and clayey layers are present in the gravel sands from straining often present.

SM

SP

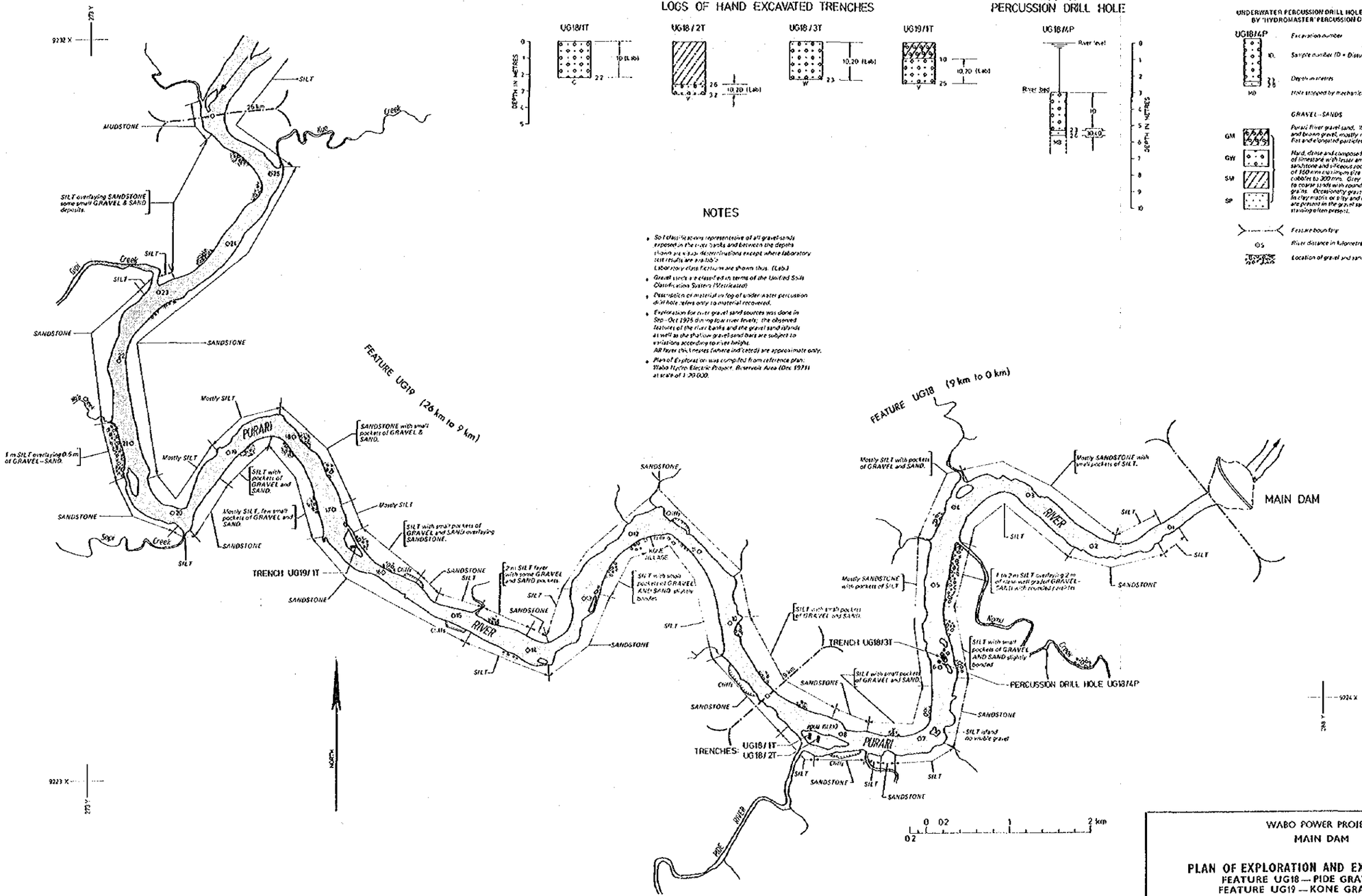
Feature boundary

05 — River distance in kilometres upstream or downstream of Main Dam axis

Location of gravel and sand deposits

NOTES

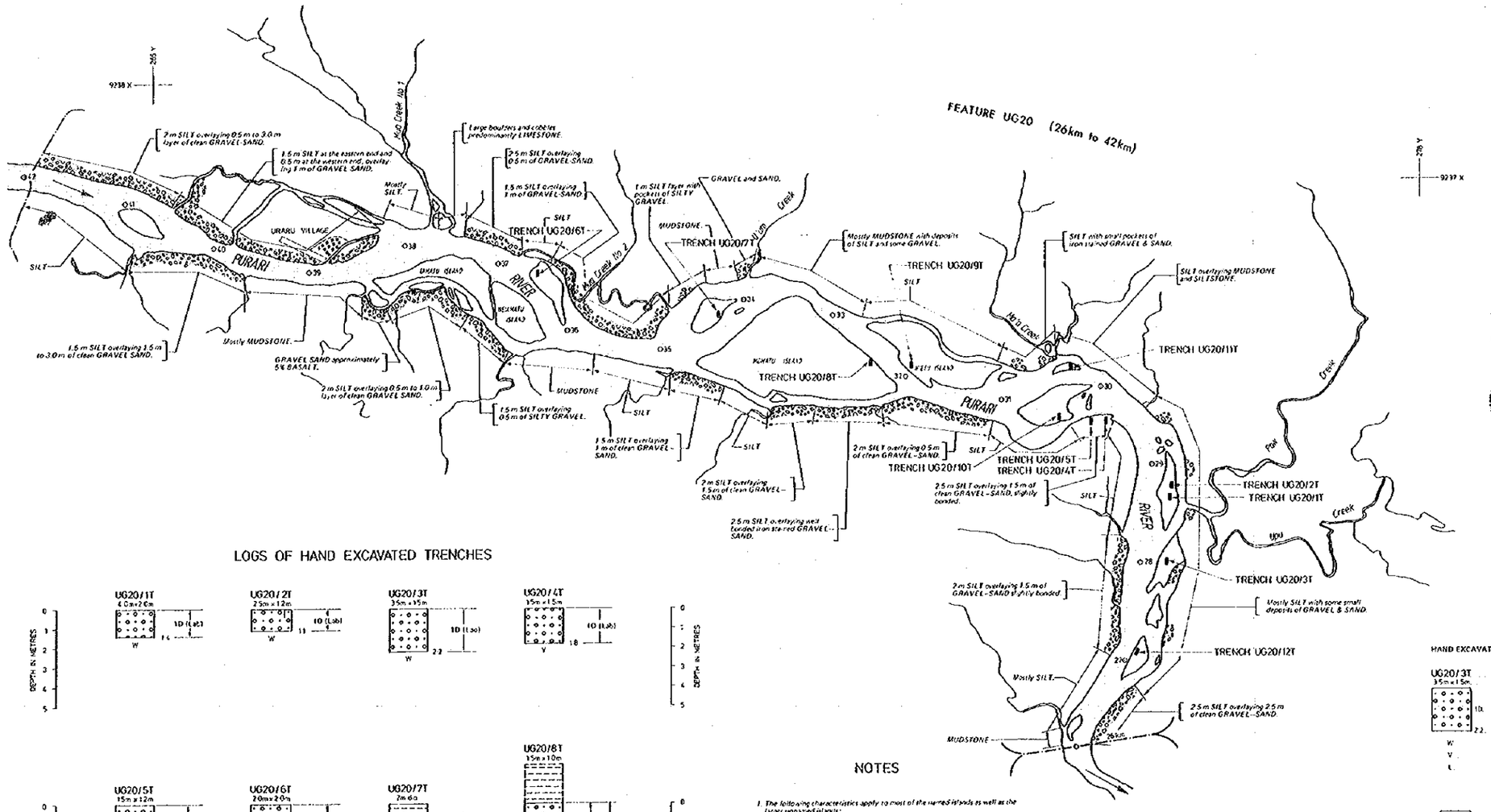
- Soil classifications representative of all gravel-sands exposed in the river banks and between the depths shown and hand excavations except where laboratory test results are available.
  Laboratory classifications are shown thus: (Lab.)
- Gravel sands are classified in terms of the United Soils Classification System (Modified).
- Description of material in log of under water percussion drill hole refers only to material recovered.
- Exploration for river gravel sand sources was done in Sep - Oct 1975 during low river levels; the observed features of the river banks and the gravel sand islands as well as the shallow gravel-sand beds are subject to variations according to river heights.
  All layer thicknesses (where indicated) are approximate only.
- Plan of Exploration was compiled from reference plan, Wabo Hydro Electric Project, Riverbed Area (Dec 1971) at scale of 1:20 000.



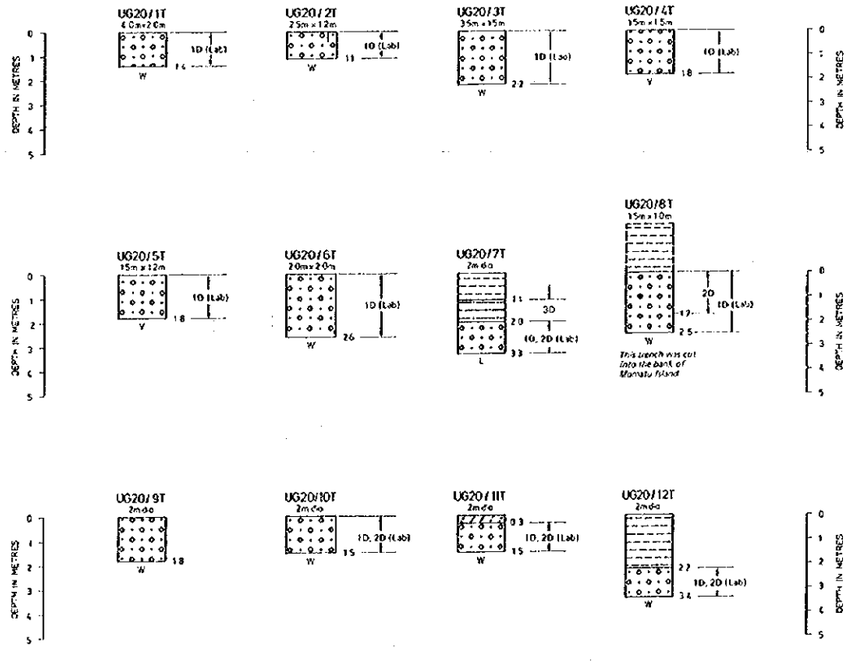
WABO POWER PROJECT
MAIN DAM

PLAN OF EXPLORATION AND EXCAVATION LOGS
FEATURE UG18 — PIDE GRAVEL SANDS
FEATURE UG19 — KONE GRAVEL SANDS

79



LOGS OF HAND EXCAVATED TRENCHES



NOTES

1. The following characteristics apply to most of the named islands as well as the larger unnamed islands:
   - Most of the higher ground is covered by jungle growth and tall grasses
   - Under the vegetation there is a silt layer varying in depth from 0.5 m to 2.5 m as observed in the banks, but this layer could be deeper around the higher points of the islands
   - The silt layer overlies gravel sands of generally undetermined depth. Exploratory trenches sometimes encountered and penetrated the silt layer, but on the higher parts of the islands, depths of silt and gravel sands above river level were not fully determined. Usually the gravel sands are exposed around the perimeter of the islands
   - Silt or sandy silt banks are mostly formed on the downstream extremities of the islands, with gravel sand shoals on the upstream ends
2. Soil classifications representative of all gravel sands exposed in the river banks and between the depths shown are visual determinations except where laboratory test results are available.

   Laboratory classifications are shown thus: (GW)
3. Gravel sands are classified in terms of the Unified Soils Classification System (Metricated).
4. Exploration for river gravel sand sources was done in Sep Oct 1975 during low river levels; the observed features of the river banks and the gravel sand islands as well as the shallow gravel sand bars are subject to variations according to river height.

   All layer thicknesses (where indicated) are approximate only.
5. Plan of Exploration was compiled from reference plan: Wabo Hydro Electric Project Reservoir Area (Dec 1971) at scale of 1:20 000.

0 0·2 1 2 km

0·2

LEGEND

HAND EXCAVATED TRENCH

UG20/3T 3.5m x 1.5m — Excavation number; Dimensions of trench

10, 22 — Sample number (D = Disturbed); Depth in metres

W — Excavation stopped by Water

V — Excavation stopped Voluntarily

L — Excavation stopped by practical Limit of equipment

SILT

ML — Dark grey silt of low plasticity and very fine sand with some organic material.

GRAVEL–SANDS

GW, SW — Recent River gravel, mostly rounded, some flat particles, hard, composed predominantly of limestone with lesser amounts of basalt and sandstone. 200 mm maximum size. Rounded and subangular sand grains coarse to fine, occasional silty fines with low dry strength, medium compacted and dense in place. Colour generally white, grey and brown (stained); alluvial gravel sand.

Feature boundary

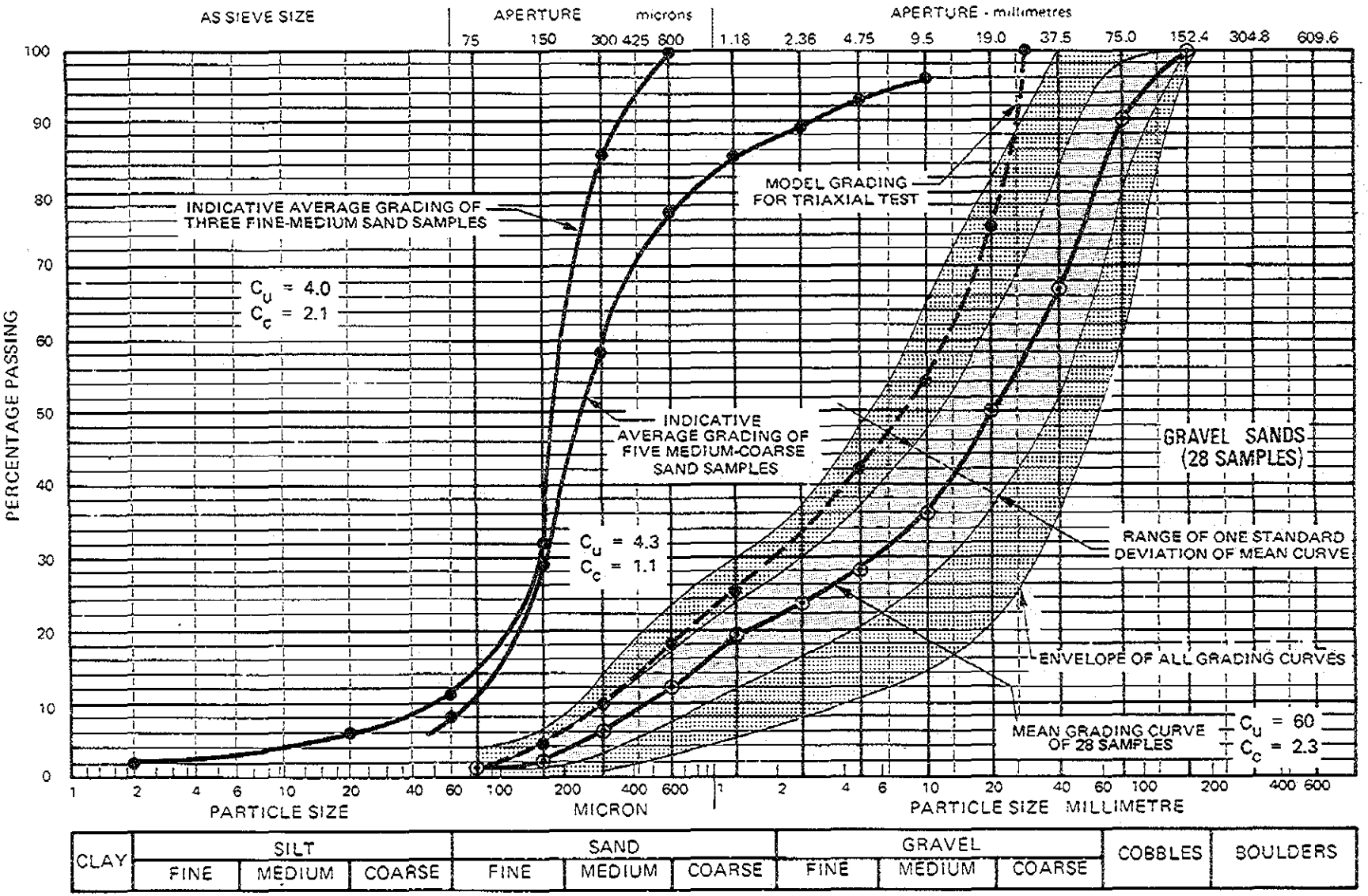
0·32 — River distance in kilometres upstream of Main Dam axis

Deposits of GRAVEL SAND (Shown for river bank deposits only)

WABO POWER PROJECT
MAIN DAM

PLAN OF EXPLORATION AND EXCAVATION LOGS
FEATURE UG20 — UMASIAI GRAVEL SANDS

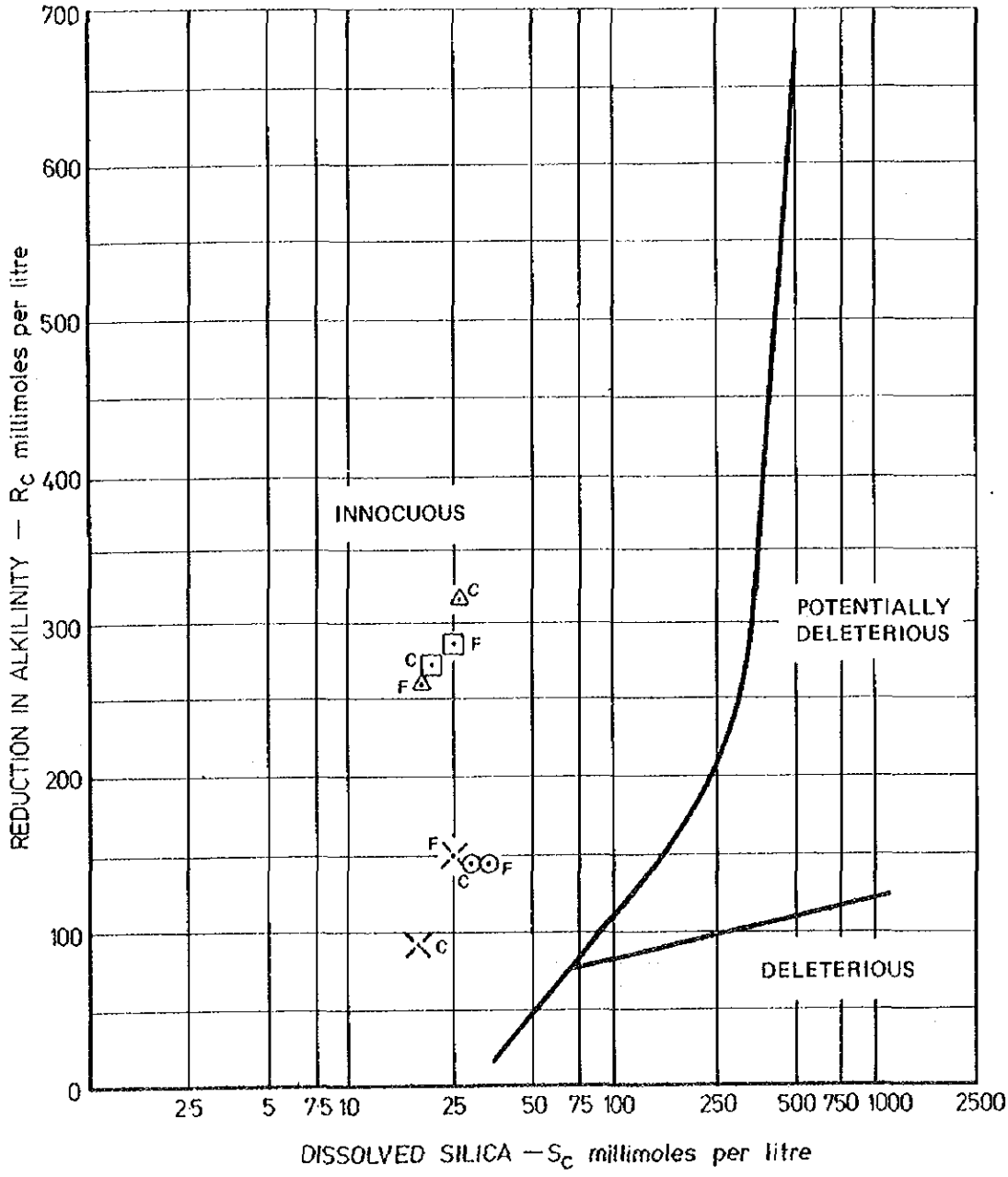
80



GRADATION CURVES OF GRAVEL - SANDS

WABO POWER PROJECT

18 図



⊙ UG17/1T/1D
△ UG17/1T/4D
✕ UG18/1T/1D
⊡ UG20/1E/1D

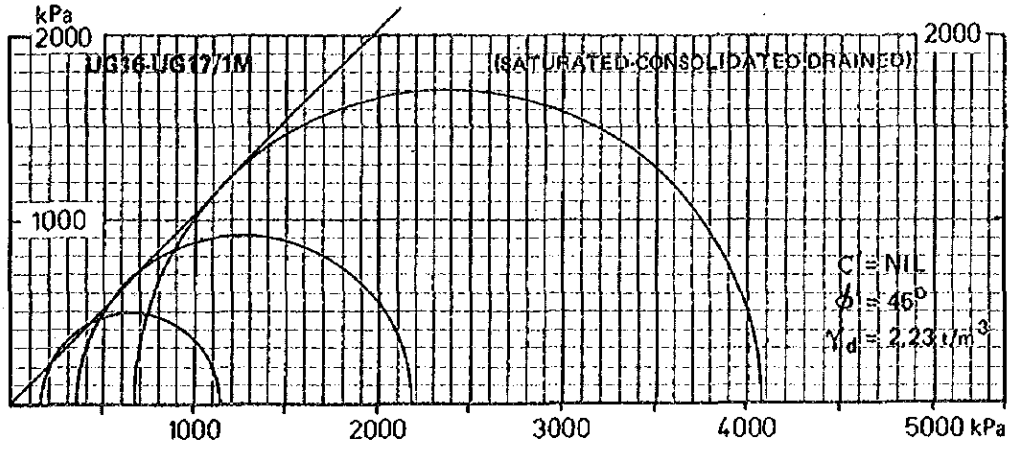
NOTE: Each point plotted represents the Mean of three separate determinations for that sample.

F = Fine Aggregate Fraction of Sample
C = Coarse Aggregate Fraction of Sample

WABO POWER PROJECT

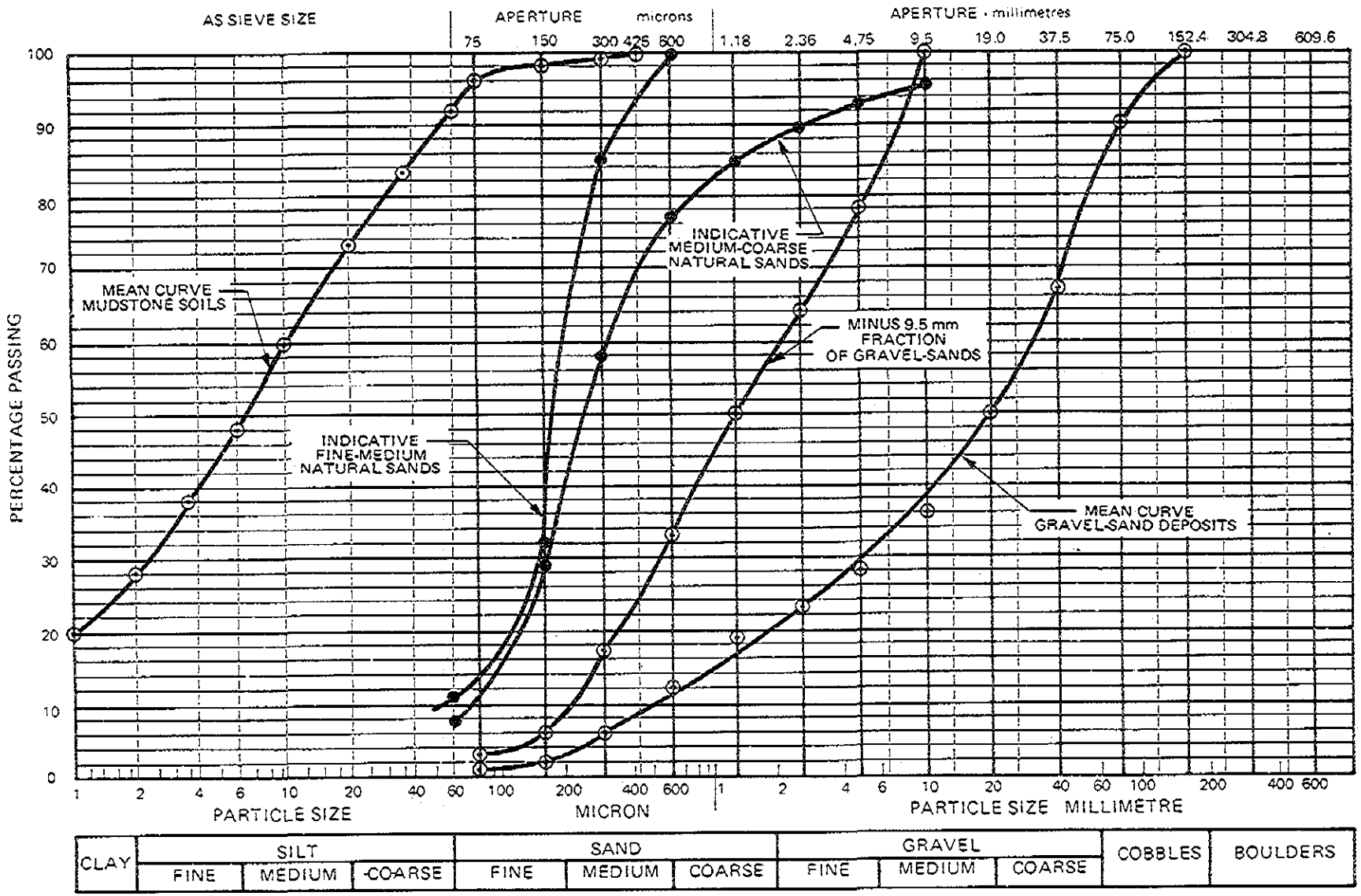
POTENTIAL REACTIVITY OF GRAVEL – SANDS (CHEMICAL METHOD)

82



WABO POWER PROJECT

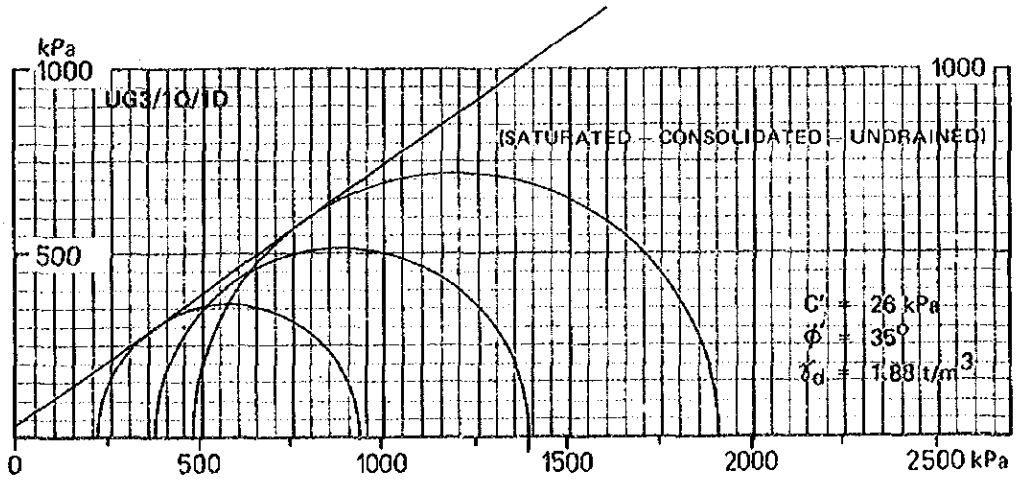
GRAVEL – SANDS TRIAXIAL TEST
MOHR CIRCLE PLOTS



GRAVEL – SANDS AS FILTER ZONE MATERIAL

WABO POWER PROJECT

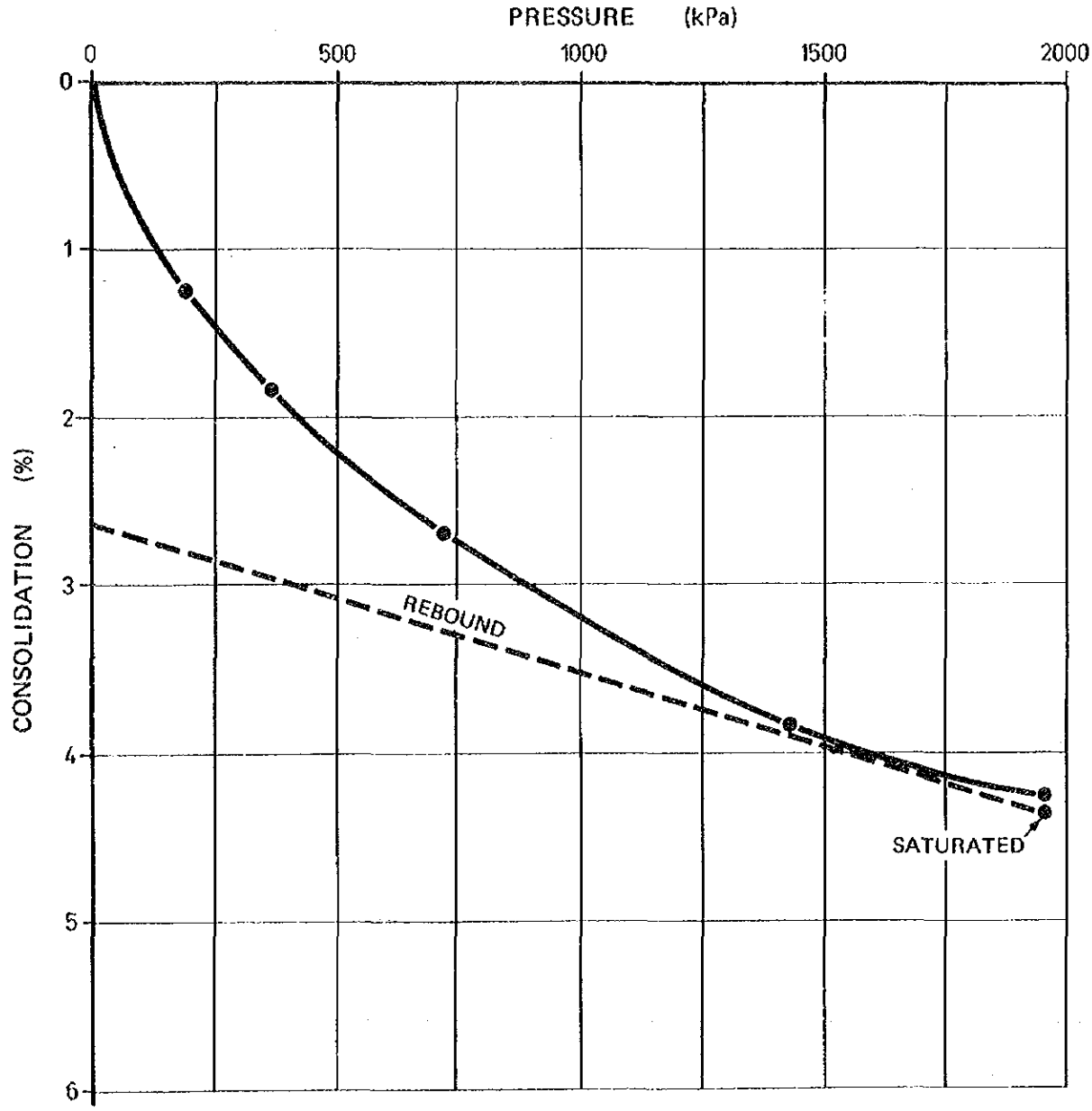
84



WA80 POWER PROJECT

RANDOM FILL TRIAXIAL TESTS
MOHR CIRCLE PLOTS

☒ 85



DESIRED TEST CONDITIONS

γ_d = 1.87 t/m^3

w = 14.8%

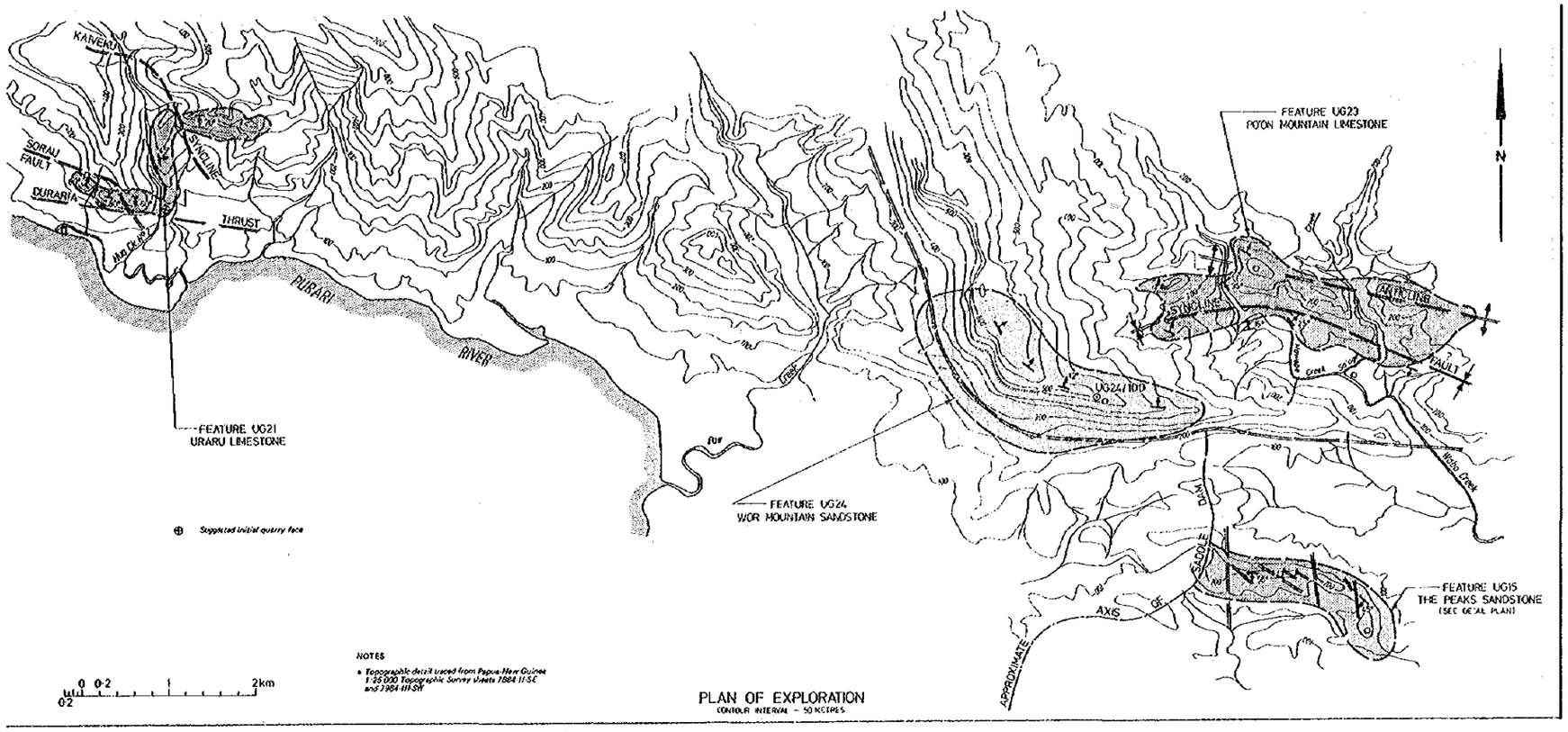
TEST CONDITIONS

	PLACEMENT	LOADED	UNLOADED
Actual γ_d (t/m^3)	1.87	1.96	1.92
Actual w (%)	14.7	–	14.9
Actual e	0.44	0.37	0.40
Actual Sr (%)	90.7	–	100.4
Actual Gs (%)	2.69	2.69	2.69
Consolidation (%)	–	4.4	2.6

WABO POWER PROJECT

CONSOLIDATION CURVE FOR RANDOM FILL

図 86

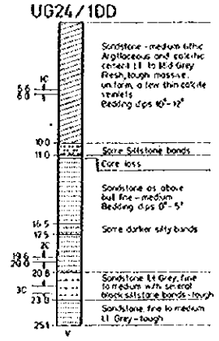


NOTES

- Topographic detail traced from Papua-New Guinea 1:25 000 Topographic Survey Sheets 7864 II-SE and 7864 III-SW

PLAN OF EXPLORATION
CONTOUR INTERVAL = 50 METRES

LOG OF DIAMOND DRILL HOLE
AMLC SIZE CORE
UG24/1DD



LEGEND

DIAMOND DRILL HOLE
UG24 / 1DD — Excavation number
3C — Sample number
25·1 — Depth in metres
V — Hole stopped voluntarily

HAND AUGER HOLE
11A — Excavation number
9·3 — Depth in metres
H — Hole stopped by hard material

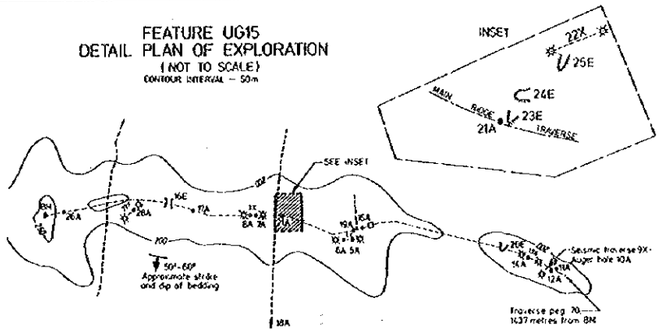
HAND EXCAVATED TRENCH
23E — Excavation number
SOUTH FACE
0·2, 0·8, 1·7 — Depth in metres

Line of a thrust, fault or fold
Shear, crush or fault zone
Strike and dip of bedding
Traverse cut and surveyed
Hand auger hole
Diamond drill hole
French excavated and logged
Helipad
Bench Mark
Seismic traverse

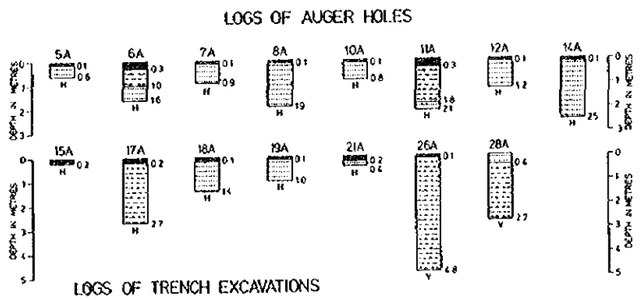
Topsoil
Sandstone - angular to subangular fragments to 70 mm of SW - MW Sandstone - generally Lt - Dk Brown in matrix, usually sandy but occasionally clayey.
CW - MW Mudstone and Siltstone Grey Brown - Grey in clayey matrix Fragments to 35 mm

Refers to logs of Feature UG15 only. Log of diamond drill hole to Feature UG24 is as described on the log itself.

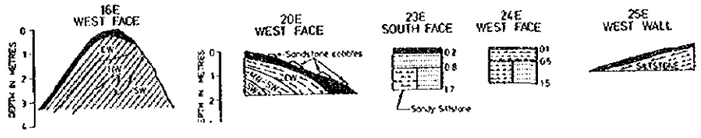
FEATURE UG15
DETAIL PLAN OF EXPLORATION
(NOT TO SCALE)
CONTOUR INTERVAL = 5m



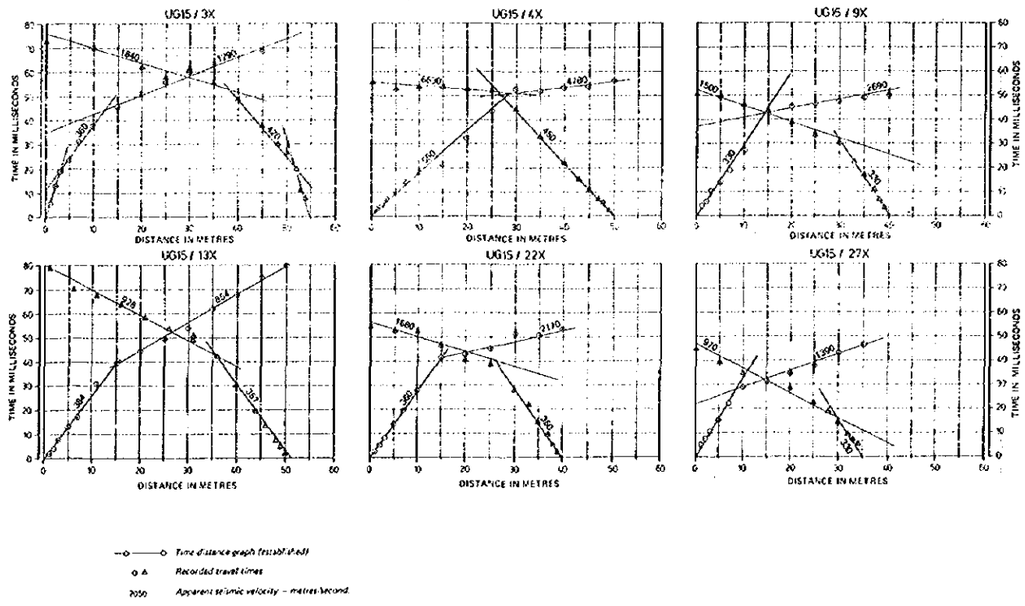
LOGS OF AUGER HOLES



LOGS OF TRENCH EXCAVATIONS



FEATURE UG15 - SEISMIC TRAVERSE TIME - DISTANCE GRAPHS

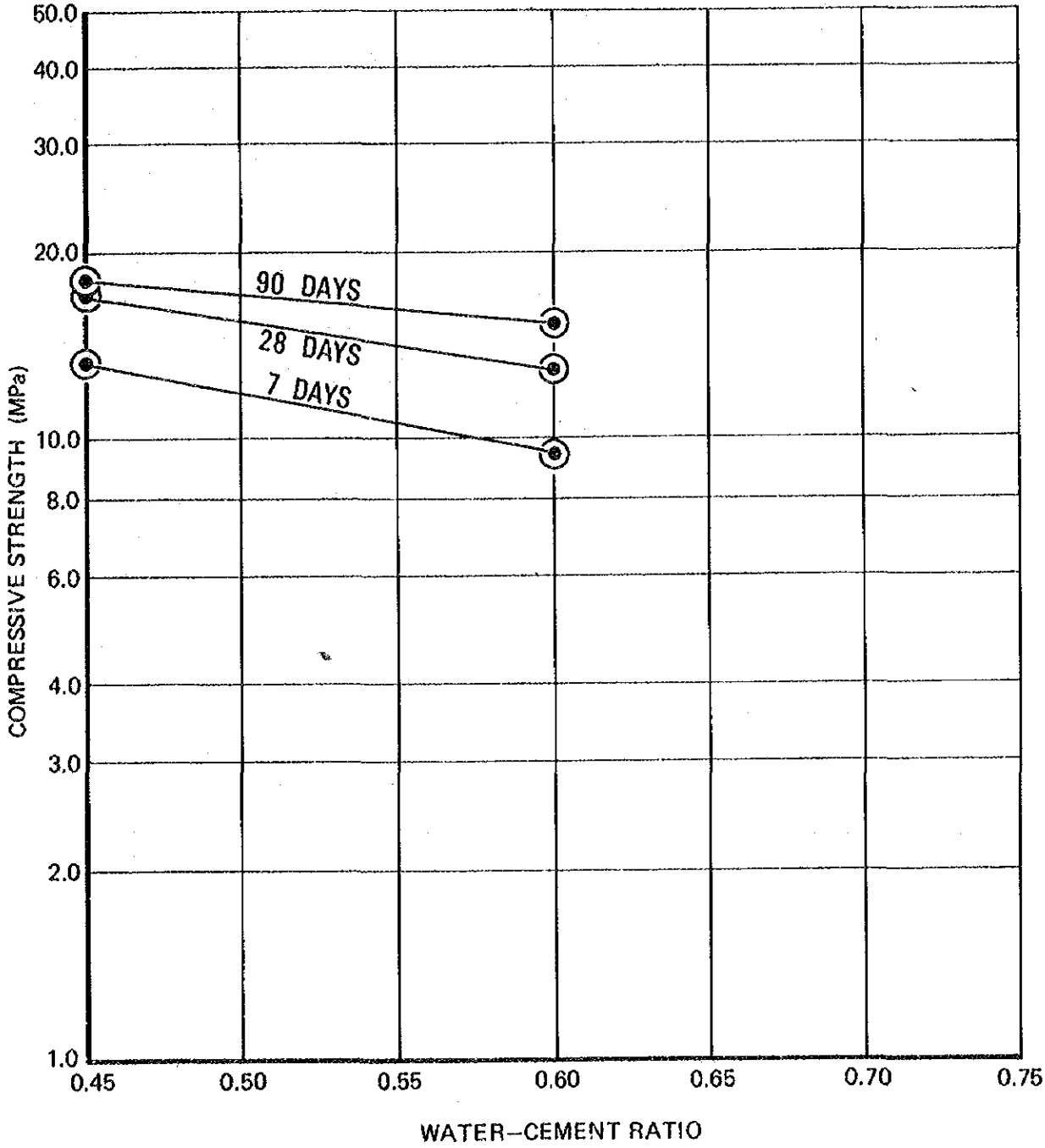


Time distance graph (straight sheet)
Recorded travel times
Apparent seismic velocity - metres/second

WABO POWER PROJECT
SADDLE DAM

LOCATION & EXPLORATION OF QUARRIED ROCK SOURCES
FEATURE AREAS UG15, UG21, UG23 and UG24

87



WABO POWER PROJECT

TRIAL CONCRETE MIXES
COMPRESSIVE STRENGTH RESULTS

88

付　録　A

放射性炭素年代測定報告

THE UNIVERSITY OF NEW SOUTH WALES

DEPARTMENT OF NUCLEAR AND RADIATION CHEMISTRY

RADIOCARBON DATING LABORATORY

REPORT ON RADIOCARBON AGE DETERMINATION

1. FOR: MR. K.R. SHARP
2. ORGANIZATION: SNOWY MOUNTAINS ENGINEERING CORPORATION
3. ADDRESS: PO BOX 356, COOMA NORTH NSW 2629
4. SUBMITTED BY: MR. K.R. SHARP
5. SAMPLE TYPE & SITE REFERENCE: WOOD. WABO POWER PROJECT PNG
6. CODE NO: SAMPLE A
7. REFERENCE FOR PUBLICATION: NSW 152
8. RADIOCARBON AGE: 1430 ± 100 YEARS B.P.

$\Delta\ C^{14}$ ‰	% MODERN	Est. $\delta\ C^{13}$ ‰
-162 ± 10.7	83.14 ± 0.90	-24.0 ± 2.0
COUNTING TIME	PREPARATION NO.	COUNT NO
2,400 min	26/75	1741,1780

AUTHORIZED SIGNATURE

V. Fochtze

DATE RECEIVED: 4.11.75

DATE RELEASED: 1.4.76

REMARKS: VISIBLE CONTAMINATING MATTER WAS REMOVED FROM SAMPLE BY HAND PICKING UNDER THE MICROSCOPE

SAMPLE WAS PRETREATED WITH 1N HCl and 1N NaOH ONLY

SAMPLE SIZE WAS ADEQUATE

THE AGE OF THE HUMIC ACID FRACTION IS: 1330 ± 100 YEARS B.P.

THE UNIVERSITY OF NEW SOUTH WALES

DEPARTMENT OF NUCLEAR AND RADIATION CHEMISTRY

RADIOCARBON DATING LABORATORY

REPORT ON RADIOCARBON AGE DETERMINATION

1. FOR: MR. K.R. SHARP
2. ORGANIZATION: SNOWY MOUNTAINS ENGINEERING CORPORATION
3. ADDRESS: PO BOX 356, COOMA NORTH NSW 2629
4. SUBMITTED BY: MR. K.R. SHARP
5. SAMPLE TYPE & SITE REFERENCE: WOOD. WABO POWER PROJECT P.N.G.
6. CODE NO: SAMPLE B
7. REFERENCE FOR PUBLICATION: NSW 153
8. RADIOCARBON AGE: 1150 $\pm$ 80 B.P.

ΔC^{14} ‰	% MODERN	(Est. ∂C^{13} ‰
-133.8 $\pm$ 7.6	86.61 $\pm$ 0.70	-24.0 $\pm$ 2.0
COUNTING TIME	PREPARATION NO.	COUNT NO
3400 min	28/75	1781,1786,1805

AUTHORISED SIGNATURE

V. Djokadze

DATE RECEIVED: 4.1175

DATE RELEASED: 1.4.76

REMARKS: VISIBLE CONTAMINATING MATTER WAS REMOVED FROM SAMPLE BY HAND PICKING UNDER THE MICROSCOPE.

SAMPLE WAS PRETREATED WITH 1N HCl and 1N NaOH ONLY

SIZE WAS ADEQUATE

THE AGE OF THE HUMIC ACID FRACTION IS: 485 $\pm$ 300 YEARS B.P.

付　　録　　B

地質編纂図の索引及び補助断面

PURARI

RIVER

LEGEND

10 — Cover of Detailed Compilation Plans at scale 1:500

A — A' — Location of supplementary Geological Sections at 1:500 (Natural)

NOTE

- The plans and geological sections referred to are in draft form only

0 20 100 200m

WABO POWER PROJECT
MAIN DAM AREA

INDEX TO GEOLOGICAL COMPILATION PLANS AND SUPPLEMENTARY SECTIONS

APPENDIX "B"

付　録　C

ボーリング柱状図一覧表

LIST OF DIAMOND DRILL HOLES

HOLE NO.	CO-ORDINATES (m) East	North	SURFACE ELEVATION m	ANGLE FROM HORIZONTAL	BEARING (GRID)	DEPTH m
MAIN DAM AND ASSOCIATED WORKS						
1959 DRILLING (Cores no longer available)						
BH1	285 462	9 226 514	28.5	51°	053°30'	45.72
BH2	415	499	29.5	50°	057°	61.42
BH3	345	485	28.1	50°	058°	60.96
BH4	397	568	55.5	50°	060°	45.71
BH5	476	605	84.4	90°	-	24.99
BH6	354	540	52.8	50°	060°	30.48
BH7	565	351	25.8	50°	045°	46.13
BH8	524	323	29.4	50°	045°	61.26
BH9	423	270	29.4	50°	055°	76.81
BH10	573	309	47.8	50°	053°	15.85
BH11	604	300	61.3	50°	045°	30.63
BH12	727	411	33.4	90°	-	15.24
BH13	768	407	43.8	90°	-	30.48
BH14	521	266	52.1	50°	053°	30.79
BH15	457	225	64.7	50°	055°	46.03
BH16*	374	290	15.6	90°	-	18.29
BH17*	439	324	10.8	90°	-	19.20
BH18*	467	339	12.1	90°	-	36.88
BH19*	505	357	14.3	90°	-	25.30
BH20*	524	371	12.9	90°	-	25.60
BH24*	456	362	8.2	90°	-	39.78
BH25*	424	418	8.2	90°	-	34.44
BH34*	444	403	7.9	90°	-	24.99
BH40	413	495	26.3	27°30'	115°	137.16
BH41	411	491	25.7	20°	199°	42.37
BH42	413	493	25.5	27°	153°	32.11
BH43	511	320	26.6	25°	313°	28.65
BH44	512	321	26.7	36°	000°	30.94
BH45	358	485	28.5	50°	058°	38.71
BH46	512	321	26.7	43°	007°	126.49

* Holes BH16 to BH34 drilled in the river were commenced with shell and auger sampling, then wash drilled to bedrock, and finally rotary core drilled into bedrock.

Appendix C

LIST OF DIAMOND DRILL HOLES – Continued

HOLE NO.	CO-ORDINATES (m) East	North	SURFACE ELEVATION m	ANGLE FROM HORIZONTAL	BEARING (GRID)	DEPTH m
MAIN DAM AND ASSOCIATED WORKS (Continued)						
1971 DRILLING (Cores available and core photographs included)						
L1	285 488	9 226 534	30.1	45°	146°	106.8
L2	465	558	52.0	90°	–	45.4
L3	403	664	97.1	90°	–	31.8
R1	571	355	27.4	45°	324°	106.7
R2	603	300	62.0	90°	–	42.7
R3	617	273	72.8	90°	–	32.4
1975-76 DRILLING (Cores available and core photographs included)						
DD101	285 694.4	9 226 861.8	46.1	45°	064°	100.00
DD102	638.6	835.3	48.0	45°	064°	100.00
DD103	441.4	974.3	151.6	90°	–	150.00
DD104	364.5	780.3	155.5	48°	066°	120.68
DD105	365.7	805.0	156.6	90°	–	70.00
DD106	308.1	519.1	62.2	50°	063°	60.00
DD107	904.6	478.2	37.8	45°	068°	99.50
DD108	781.5	186.8	159.7	90°	–	91.89
DD109	758.1	966.6	54.3	90°	–	60.00
DD110	700.9	941.3	54.4	45°	067°	70.00
DD111	822.9	341.5	76.0	45°	068°	100.00
DD112	398.6	510.1	34.2	90°	–	48.87
DD113	754.8	783.6	30.5	90°	–	60.00
DD114	527.3	215.3	87.7	90°	–	49.41
DD115	834.7	926.4	33.5	90°	–	59.75
DD116	505.8	661.8	66.1	90°	–	20.00
DD117	647.0	714.6	28.3	90°	–	21.70
DD118	613.7	758.6	43.1	90°	–	15.70
DD119	729.8	9 227 093.5	68.8	90°		16.27
DD120	862.4	9 226 913.6	29.6	90°	–	12.80
DD121	947.0	389.7	70.6	90°	–	23.20

LIST OF PERCUSSION DRILL HOLES

HOLE NO.	CO-ORDINATES (m) East	North	SURFACE ELEVATION m	ANGLE FROM HORIZONTAL	BEARING (GRID)	DEPTH m
MAIN DAM AND ASSOCIATED WORKS (Continued)						
1975 DRILLING (no core photographs)						
UG1/1P	285 582.9	9 226 472.7	11.0	90°	-	30.6
UG1/2P	646.0	543.1	11.4	90°	-	25.5
UG1/4P	460.5	400.0	9.2	90°	-	27.2

LIST OF DIAMOND DRILL HOLES

HOLE NO.	CO-ORDINATES (m) East	North	SURFACE ELEVATION m	ANGLE FROM HORIZONTAL	BEARING (GRID)	DEPTH m
SADDLE DAMS						
1959 DRILLING (Cores no longer available)						
BH1	278 256	9 231 379	92	90°	-	15.24
BH2	257	436	82	90°	-	12.19
BH3	248	514	94	90°	-	15.24
BH4	285	612	84	90°	-	12.19
BH5	303	672	96	90°	-	15.24
BH6	319	811	112	90°	-	15.24
BH7	309	876	112	90°	-	15.24
BH8	388	942	103	90°	-	15.24
1975 DRILLING (Cores available and core photographs included)						
DD201	278 245.0	9 231 524.6	95.2	90°	-	30.40
DD202	250.5	460.7	83.9	45°	185°	50.00
DD203	255.4	418.3	84.7	90°	-	25.00
DD204	246.8	276.7	123.5	90°	-	25.00
DD205	336.9	121.7	134.5	45°	000°	25.00
DD206	492.0	230 929.8	122.1	45°	167°	29.74
DD207	607.0	661.2	142.4	90°	-	20.00
DD208	300.1	231 760.8	98.4	45°	203°	50.00
DD209	412.0	232 054.6	122.3	45°	180°	30.00
DD210	576.3	465.4	147.9	45°	225°	50.00
DD211	696.8	580.8	123.4	45°	208°	49.68
DD212	279 109.0	637.4	151.8	45°	212°	30.00
DD213	399.7	733.3	149.7	90°	-	14.96
DD214	280 044.1	844.6	145.8	45°	045°	30.20
DD215	293.0	233 039.9	141.7	90°	-	15.00
DD216	521.3	750.1	144.6	45°	019°	23.89
DD217	543.5	798.2	145.4	45°	017°	25.00
DD218	420.3	234 285.8	138.2	45°	356°	25.40

付　　録　　D

岩石と土の定義及び化学的風化度

SNOWY MOUNTAINS ENGINEERING CORPORATION

DEFINITIONS OF ROCK, SOIL, AND DEGREES OF CHEMICAL WEATHERING

(A) GENERAL DEFINITIONS — ROCK AND SOIL

ROCK

In engineering usage, rock is a natural aggregate of minerals connected by strong and permanent cohesive forces.

Note: Since 'strong' and 'permanent' are subject to different interpretations, the boundary between rock and soil is necessarily an arbitrary one.

SOIL

In engineering usage, soil is a natural aggregate of mineral grains which can be separated by such gentle mechanical means as agitation in water.

The two principal classes of soil are:

(a) Residual soils - soils which have been formed in situ by the chemical weathering of parent rock. Residual soil may retain evidence of the original rock texture or fabric or, when mature, the original rock texture may be destroyed.

(b) Transported soils - soils which have been moved from their places of origin and deposited elsewhere. The principal agents of erosion, transport and deposition are water, wind, ice and gravity. Two important types of transported soil in engineering geology and materials investigations are:

(i) Slopewash - a soil, often including angular rock fragments and boulders, which has been transported downslope predominantly under the action of gravity assisted by water. The principal forming process is that of soil creep in which the soil moves after it has been weakened by saturation. It may be water borne for short distances.

(ii) Alluvium - a soil which has been transported and deposited by running water. The larger particles (sand and gravel size) are water worn.

(B) ROCK WEATHERING DEFINITIONS

COMPLETELY WEATHERED ROCK	(CW)	Rock which retains most of the original rock texture (fabric) but the bond between its mineral constituents is weakened by chemical weathering to the extent that the rock will disintegrate when immersed and gently shaken in water. In engineering usage this is a soil.
HIGHLY WEATHERED ROCK	(HW)	Rock which is weakened by chemical weathering to the extent that dry pieces about the size of 50 mm diameter drill core can be broken by hand across the rock fabric. Highly weathered rock does not readily disintegrate when immersed in water.
MODERATELY WEATHERED ROCK	(MW)	Rock which exhibits considerable evidence of chemical weathering, such as discolouration and loss of strength but which has sufficient remaining strength to prevent dry pieces about the size of 50 mm diameter drill core (of inherently hard rock) being broken by hand across the rock fabric. Moderately weathered rock does not ring when struck with a hammer.
SLIGHTLY WEATHERED ROCK	(SW)	Rock which exhibits some evidence of chemical weathering, such as discolouration, but which has suffered little reduction in strength. Except for some inherently soft rocks, slightly weathered rock rings when struck with a hammer.
FRESH WITH LIMONITE STAINED JOINTS	(Fr St)	Joint faces coated or stained with limonite but the blocks between joints are unweathered.
FRESH ROCK	(Fr)	Rock which exhibits no evidence of chemical weathering. Joint faces may be clean or coated with clay, calcite, chlorite or other minerals.

The degrees of rock weathering may be gradational. Intermediate stages are described by dual symbols with the predominant degree of weathering first (e.g., CW-HW).

The various degrees of weathering are not absolute strength parameters as some rocks are weak, even when fresh, to the extent that they can be broken by hand across the fabric.

Fresh drill cores of some rock types, mainly shale, siltstone, and silty or tuffaceous sandstone may disintegrate after exposure to the atmosphere due to slaking, desiccation, expansion or contraction, stress relief or a combination of any of these factors.

Form 241
6/146a (4/74)

付　　録　　E

UG1　主ダムの基礎：現場並びに室内土質試験結果の概要

PRETREATMENT

NONE

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT WADO POWER PROJECT

FEATURE UG1 - MAIN DAM FOUNDATION

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

SAMPLE No.	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller: MAX SIZE mm	GRAVEL 9.5 mm	GRAVEL 4.75 mm	SAND 2.36 mm	SAND 1.18 mm	SAND 600 µm	SAND 300 µm	SAND 150 µm	SILT 75 µm	CLAY 2 µm	Linear Shrinkage %	ATTERBERG w_L %	ATTERBERG I_p %	G_s	COMPACTION (2) MDD t/m³	COMPACTION (2) OMC %	FIELD (10) Density ρd t/m³	FIELD (10) Moisture Content FMC %	SHEAR (3) Values @ Undisturbed (7) Effective Stress c' kPa	Undisturbed (7) Effective Stress φ' o	Undisturbed (7) Total Stress c kPa	Undisturbed (7) Total Stress φ o	Remoulded (8) Effective Stress c' kPa	Remoulded (8) Effective Stress φ' o	Remoulded (8) Total Stress c kPa	Remoulded (8) Total Stress φ o	PERMEABILITY (4) @ 124.5 kPa Settlement %	@ 124.5 kPa k m/s 10⁻⁸	@ 622.5 kPa Settlement %	@ 622.5 kPa k m/s 10⁻⁸	Consolidation (5) %	REMARKS
UG1																																		
1P/1D	0.0- 1.5	GW-SW	325	87	78	71	63	43	14	6	3																							Clean gravel-sand (6)
2D	1.5- 3.0	GW	53	67	57	48	41	33	20	11	6					2.73																		Clean gravel-sand (6)
3D	3.0- 4.0	GW	53	44	29	24	19	14	8	5	3																							Clean gravel-sand (6)
4D	4.0- 5.0	GW	53	47	38	33	29	23	9	4	2																							Clean gravel-sand (6)
5D	5.0- 6.0	GW-SW	53	83	76	68	62	54	25	12	8																							Clean gravel-sand (6)
6D	6.0- 9.0	SP-SM	6	100	99	97	94	85	36	16	11					2.73																		Relatively clean sand
7SPT	9.0- 9.3	-																					S.P.T.	N = 6									
8SPT	9.3- 9.6	-																					S.P.T.	N = 6									Relatively clean sand
9D	9.0-10.5	SP-SM	2			100	98	90	32	12	7																							Sand with silty fines - grey
10D	10.5-12.0	SM	2			100	99	94	50	32	19																							
11SPT	12.5-12.8	-																					S.P.T.	N =18									
12D	12.5-12.8	SP-SM	1				100	95	42	21	12																							From SPT tube - fine grey sand
14D	12.0-13.5	SM	2			100	99	94	61	46	31																							fine sand and silt - grey coloured
15D	13.5-15.0	ML	1				100	98	84	76	56		1	19	2																			Grey, sandy silt
16U	15.0-15.6	ML (9)	0.3						100	99	70	12				2.74			1.51	26.1	37	32.9							1.5	2.2	3.0	1.3	2.5	Grey, sandy silt - 62 mm dia tube
17SPT	15.6-15.9	-																					S.P.T.	N =11									
18D	15.0-18.0	ML	1				100	99	87	79	62		1	18	2	2.74																		Grey silt and fine sand
19SPT	18.5-18.8																						S.P.T.	N =12									
20D	18.5-19.0	CL	0.6						100	99	91	20	5.1	33	11																			Grey, silty clay
21U	19.0-19.3	ML (9)	1.2					100	98	96	88								1.61	26.0														Grey silt and fine sand
22D	18.0-21.0	ML (9)	1				100	99	91	85	73																							Grey silt and fine sand
23U	21.0-21.3	CL	0.1							100	97	9	3	30	8				1.44	28.7	52	25							falling head No surcharge Method		6.5			Grey, silty clay - 75 mm dia piston tube sample
																							S.P.T.	N = 10									
24SPT	21.5-21.8	-																																
25D	21.0-24.0	ML (9)	0.6					100	93	89	77																							Grey silt and fine sand
26U	24.0-24.4	CL						100	99	98	94		2	26	6	2.74			1.55	24.4														Grey silt and fine sand
27D	24.0-25.5	CL-ML	1				100	99	93	89	73	13	2.3	26	5	2.69									23	37.8								Grey silt and fine sand

NOTES: (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is ..... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under 1 970 kPa, unless otherwise stated.
(6) Grading analysis of gravel-sands refer to the broken returns from chop-pump. Grading in situ would thus be coarser than indicated. Therefore SW classification may in fact be GW.
(7) Undrained, 3 stage, multistage triaxial tests
(8) Saturated, consolidated, undrained single stage triaxial tests
(9) Field Classification
(10) Field density and moisture content obtained from triaxial test specimen drive tubes

PRETREATMENT

NONE

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT . . WADO POWER PROJECT . . . . . .

FEATURE . . UG1 – MAIN DAM FOUNDATION . . . . . .

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

SAMPLE No.	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller: MAX SIZE mm	GRAVEL 9.5 mm	GRAVEL 4.75 mm	SAND 2.36 mm	SAND 1.18 mm	SAND 600 µm	SAND 300 µm	SAND 150 µm	SILT 75 µm	CLAY 2 µm	Linear Shrinkage %	ATTERBERG w_L %	ATTERBERG I_p %	G_s	COMPACTION (2) MDD t/m³	COMPACTION (2) OMC %	FIELD (10) Density ρ_d t/m³	FIELD (10) Moisture Content FMC %	SHEAR Values @ Undisturbed (7) Effective Stress c' kPa	Undisturbed (7) Effective Stress φ' o	Undisturbed (7) Total Stress c kPa	Undisturbed (7) Total Stress φ o	Remoulded (8) Effective Stress c' kPa	Remoulded (8) Effective Stress φ' o	Remoulded (8) Total Stress c kPa	Remoulded (8) Total Stress φ o	PERMEABILITY (4) @ 124.5 kPa Settlement %	@ 124.5 kPa k m/s 10⁻⁸	@ 622.5 kPa Settlement %	@ 622.5 kPa k m/s 10⁻⁸	Consolidation (5) %	REMARKS
UG1 (Continued)																																				
2P/1D	0.0– 1.5	GW	75	61	40	30	25	17	5	2	1																									Sound clean gravel-sand, White & grey
2D	1.5– 2.5	GP	38	64	50	42	36	26	10	4	2																									Sound clean gravel-sand, White & grey
3D	2.5– 4.5	SP	19	94	84	71	62	48	24	11	6																									Clean, compact gravel-sand
4SPT	5.0– 5.3	–																					S.P.T. N = 37													
5D	4.5– 8.0	SP	38	98	98	96	91	63	16	9	6																									Finer sandy gravel, grey and white
7SPT	8.0– 8.3	–																					S.P.T. N = 10													
8D	8.0–12.0	SM	9.5		100	98	96	85	68	63	41	10	0.7	NP	NP	2.69																					Grey fine sand and silt
9U	12.0–12.3	SM–ML (9)																	1.55	26.5	10	35.3													7.2	Grey silt and fine sand
10SPT	12.3–12.6	–																		22.7			S.P.T. N = 37													
12SPT	18.5–18.8	–																					S.P.T. N = 20													
13D	18.0–21.0	ML (9)	2.4				100	97	91	89	70	13																									Grey silt and fine sand
14D	21.0–25.5	CL–ML	1.2				100	99	97	95	74	17	1.8	26	6	2.74										13	36.3									Grey silt and fine sand
4P/1D	0.0– 2.0	SW	38	87	72	57	43	29	17	10	6					2.71																					Coarse sand and gravel – grey white
3D	3.0– 6.6	GW	38	52	23	10	6	5	4	2	1					2.71																					Coarse gravel and sand – grey white
5U	11.0–11.7	ML	0.6						100	99	79	13	0.4	24	0				1.49	28.7	2	36.7									1.8	0.25	3.8	0.16		Grey silt and fine sand
6SPT	11.8–12.1	–																					S.P.T. N = 32													
7D	11.9–13.2	ML (9)	4.75		100	99	99	98	98	95	71	12																									Grey silty sand from SPT tube
8D	13.5–15.5	CL	0.6				100	99	98	95	66		2	22	5	2.74			1.36	20.9																	Grey silt and fine sand
9U	16.4–17.0	ML	0.6							100	81	12	1.1	25	2	2.74					63	25.6									1.3	0.95	2.8	0.49	3.8	Compact, grey silty sand. Piston sample
10D	18.0–20.0	SP	38	89	82	63	36	19	10	8	6																										Coarse sand & gravel, clean, grey white
13D	23.0–23.4	SP	19	98	93	80	57	30	11	5	3																										Coarse sand & gravel, clean, grey white
14D	24.0–26.8	GP	53	42	29	21	14	9	5	3	2																										Coarse, clean gravel and sand

NOTES: (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is.....unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under ..... kPa, unless otherwise stated.

For other notes refer to Sheet 1.

付　　録　　F

UG10　副ダムの基礎：現場並びに室内試験結果の概要

PRETREATMENT

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT ... WABO POWER PROJECT

FEATURE ... UG10 - SADDLE DAM FOUNDATIONS

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

SAMPLE No	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller: MAX SIZE mm	GRAVEL 9.5 mm	GRAVEL 4.75 mm	SAND 2.36 mm	SAND 1.18 mm	SAND 600 μm	SAND 300 μm	SAND 150 μm	SILT .5 μm	CLAY 2 μm	Linear Shrinkage %	ATTERBERG w_L %	ATTERBERG I_p %	G_s	COMPACTION (2) MDD t/m³	COMPACTION (2) OMC %	FIELD (7) Density ρd t/m³	FIELD (7) Moisture Content FMC %	SHEAR (3) Values @ OMC: Effective Stress c' kPa	Effective Stress φ' °	Total Stress c kPa	Total Stress φ °	Unconfined Compressive Strength: Effective Stress c' kPa	Effective Stress φ' °	Total Stress c kPa	Total Stress φ °	PERMEABILITY (4) @ 124.5 kPa: Settlement %	k cm/s 10⁻⁸	@ 622.5 kPa: Settlement %	k cm/s 10⁻⁸	Consolidation % (5)	Vane Shear kPa	Pocket Penetrometer kPa	REMARKS
UG10																																			
7A/1U	1.9 - 2.1																		30.2																37 mm Tube. Firm, grey mudstone
																																			soil. Some harder particles.
3U	4.6 - 4.7																		27.0																37 mm Tube. Grey mudstone soil.
8A/1U	1.5 - 1.7																		28.8																37 mm Tube. Grey mudstone soil,
																																			some harder particles.
9A/1U	1.7 - 1.8																		26.3																37 mm Tube. Grey mudstone soil -
																																			firm to stiff. Some harder fragment
2U	3.0 - 3.2																		30.2																Ditto
3U	4.4 - 4.8															2.70			21.5														10.3		Ditto
4U	5.0 - 5.4									100	99	38	10.1	52	28	2.65			19.7	125	Zero														Ditto
5U	5.6 - 5.7																		24.2																Ditto
6U	5.9 - 6.0																		26.2																Ditto
7U	6.3 - 6.5																		31.2																Ditto
8U	6.6 - 7.0			100	99	99	99	99	99	98	91	26	7.9	48	25	2.73			24.0	64	13.0													13.0		75 mm Tube Ditto
12U	3.6 - 4.1	CL	2.4				100	99	99	99	97	29	8.4	49	25	2.73																		3.0	(9)		Ditto
10S/1VS	1.6																																	17		Grey mudstone soil. Spheroidally
																																			weathered mudstone boulders presen
2U	1.5 - 1.6	CL*																1.43	32.1													33				37 mm Tube Ditto
3U	2.0 - 2.1	CL*																1.53	15.9													401				Ditto
4VS	2.1																																	18		Ditto
5U	2.3 - 2.5			93	92	92	92	92	91	91	88	26	9.8	54	30	2.67			19.6	160	Zero													9.5		2 boxes Ditto
7VS	1.5 North																																	17		Vane shears
8VS	1.5 South																																	25		Vane shears
9U	2.7 - 2.8	CL*																1.62	17.9													241				37 mm Tube Ditto
10VS	2.7																																	30		Vane shear Ditto
11U	3.0 - 3.1	CL*																1.47	30.6													33				37 mm Tube Ditto
12VS	3.0																																	29		Vane shear Ditto
11A/1U	5.6 - 5.7																		23.8																37 mm Tube } Mudstone soil - grey
2U	5.8 - 5.9																		26.4																37 mm Tube } soft and soft - firm

NOTES. (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is ..... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under 1,000 kPa, unless otherwise stated.
(6) Sample 15E/DS is composite result of in-situ direct shear test on 4 samples 15E/10S to 40S
(7) Field density and moisture contents obtained from undisturbed triaxial or unconfined compression test specimens.
* Field Classification
(8) Falling Head Permeability (no surcharge)
(9) Consolidation test in Cooma Laboratories. Consolidation results not so annotated are from other laboratories
(10) This test consolidated, undrained. All other triaxial shear tests were undrained condition.

PRETREATMENT

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT... WADO POWER PROJECT

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

FEATURE... UG10 - SADDLE DAM FOUNDATIONS

SAMPLE No.	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller: MAX SIZE mm	GRAVEL 9.5 mm	GRAVEL 4.75 mm	SAND 2.36 mm	SAND 1.18 mm	SAND 600 µm	SAND 300 µm	SAND 150 µm	SILT 75 µm	CLAY 2 µm	Linear Shrinkage %	ATTERBERG w_L %	ATTERBERG I_p %	G_s	COMPACTION (2) MDD t/m^3	COMPACTION (2) OMC %	FIELD Density ρd t/m^3	FIELD Moisture Content FMC %	SHEAR (3) Values @ OMC Effective Stress c' kPa	SHEAR (3) Values @ OMC Effective Stress ϕ' o	SHEAR (3) Values @ OMC Total Stress c kPa	SHEAR (3) Values @ OMC Total Stress ϕ o	SHEAR (3) Unconfined Compressive Strength Effective Stress c' kPa	SHEAR (3) Unconfined Compressive Strength Effective Stress ϕ' o	SHEAR (3) Unconfined Compressive Strength Total Stress c kPa	SHEAR (3) Unconfined Compressive Strength Total Stress ϕ o	PERMEABILITY (4) @ 124.5 kPa Settlement %	PERMEABILITY (4) @ 124.5 kPa k $m/s\ 10^{-8}$	PERMEABILITY (4) @ 622.5 kPa Settlement %	PERMEABILITY (4) @ 622.5 kPa k $m/s\ 10^{-8}$	Consolidation (5) %	Vane Shear kPa	Pocket Penetrometer kPa	REMARKS
3U	6.1 - 6.5															2.76				29.2										-(8)	0.03			17.4			75 mm Tube } to 6.5 m then mostly
4U	6.5 - 6.9						100	99	99	99	98	17	5.8	33	14	2.62				26.6	100	Zero															75 mm Tube } firm. Very stiff
5U	7.5 - 7.6																			26.4																37 mm Tube } material in end of
7PP	6.5																																			118	POC PEN } 9U. Some fragments in
8PP	6.9																																			225	POC PEN } end of 9U.
9U	8.8 - 9.2															2.74				18.6	130	Zero															75 mm Tube)
11A/10PP	9.2																																			>450	POC PEN Mudstone - probably fresh
																																					rock
13A/1U	3.0 - 3.1																		1.55	27.2								25.9									37 mm tube Grey mudstone soil
																																					hard fragments present
2U	3.7 - 3.8													53	33				1.72	19.9	60	6.0															Ditto
3U	4.0 - 4.1																		1.60	24.2	40	4.0															Ditto
4U	4.1 - 4.3																		1.59	25.9																	Ditto
5U	6.0 - 6.1																		1.78	19.8																	Ditto
6U	6.3 - 6.4												9.1	48	21				1.74	21.0	100	Zero															Ditto
7U	6.5 - 6.7																		1.70	22.2																	Ditto
8U	7.0 - 7.1																		1.65	24.4								54.6									Ditto
14E/1U	1.9 - 2.2									100	98	17	8.1	53	27	2.73			1.44	31.0	60	8.2 (10)						37.9							18.0			Box sample. Grey mudstone soil
																					100	Zero															Soft and soft-firm.
2VS	1.9																																		26		Vane shear Ditto
3VS	2.0																																		30		Ditto
4VS	2.0																																		30		Ditto
15E/DS (6)	2.2																						9	8	(Probably conservative values)												Direct shear (in-situ) tests and corresponding moisture content
5W	2.2																			29.5																	samples of closely fractured (slickensided), spheroidally
6W	2.2																			22.4																	weathered, grey mudstone in clayey matrix
16E/1U	1.3 - 1.5																			40.8																	37 mm tube. Soft grey-brown mudstone
2U	1.3 - 1.5																			35.2																	Ditto
17A/1U	1.6 - 2.1	CL-CH*																	1.60	28.4	29	27.9													5.4	(9)		62 mm tube. Soft-firm brown mudstone soil
18A/1U	1.7 - 2.2																		1.85	17.1	120	9.6													3.4	(9)		62 mm tube - mudstone soil

NOTES: (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is..... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under 1 000 kPa, unless otherwise stated.
(6) Sample 15E/DS is composite result of in-situ direct shear test on 4 samples 15E/1DS to 4DS.
(7) Field density and moisture contents obtained from undisturbed triaxial or unconfined compression test specimens.
* Field Classification
(8) Falling Head Permeability (no surcharge)
(9) Consolidation test in Cooma Laboratories. Consolidation results not so annotated are from other laboratories.
(10) This test consolidated, undrained All other triaxial shear tests were undrained condition.

PRETREATMENT

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT . . WABO POWER PROJECT . . . . . .

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

FEATURE . . UG10 - SADDLE DAM FOUNDATIONS . . . . . .

SAMPLE No.	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller: MAX SIZE mm	GRAVEL 9.5 mm	4.75 mm	SAND 2.36 mm	1.18 mm	600 µm	300 µm	150 µm	SILT 75 µm	CLAY 2 µm	Linear Shrinkage %	ATTERBERG w_L %	I_p %	G_s t/m³	COMPACTION (2) MDD t/m³	OMC %	FIELD Density ρ_d t/m³	Moisture Content FMC %	SHEAR (3) Values @ OMC Effective Stress c' kPa	ϕ' °	Total Stress c kPa	ϕ °	Unconfined Compressive Strength Effective Stress c' kPa	ϕ' °	Total Stress c kPa	ϕ °	PERMEABILITY (4) @ 124.5 kPa Settlement %	k $m/s\ 10^{-8}$	@ 622.5 kPa Settlement %	k $m/s\ 10^{-8}$	Consolidation % (5)	Vane Shear kPa	Pocket Penetrometer kPa	REMARKS
19E/1U	1.5 - 1.8	CL*																	1.29	40.7	22	18.2													100 mm Tube. Samples of closely fractured (slickensided) spheroidally weathered grey mudstone in clayey matrix
2U	1.5 - 1.8	CL*																	1.53	25.3	41	15.2													
3U	1.5 - 1.8	CL*																	1.62	22.2	28	14.8													
20A/1U	1.5 - 1.7	CL-CH*																	1.70	17.8							342								Dense, stiff grey mudstone 37 mm tube
2U	1.9 - 2.1	CL-CH*																	1.80	14.9							259								Ditto
21A/1U	1.3 - 1.4	CL-CH*																	1.51	25.2							173								37 mm tube. Blue grey mudstone soil - less dense than 20A
2U	1.5 - 1.6																		-	21.2															75 mm tube - mudstone
113A/1U	9.0 - 9.4															2.74				22.0	100	Zero									9.3			

NOTES. (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is.....unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under 1 000 kPa, unless otherwise stated.
(6) Sample 15E/DS is composite result of in-situ direct shear test on 4 samples 15E/1DS to 4DS.
(7) Field density and moisture contents obtained from undisturbed triaxial or unconfined compression test specimens.

* Field Classification
(8) Falling Head Permeability (no surcharge)
(9) Consolidation test in Cooma Laboratories. Consolidation results not so annotated are from other laboratories.
(10) This test consolidated, undrained. All other triaxial shear tests were undrained condition.

付　録　G

ダイヤモンドボーリングコアの室内試験

SNOWY MOUNTAINS ENGINEERING CORPORATION
P.O. BOX 356, COOMA NORTH, N.S.W. 2629

REPORT OF TEST RESULTS

No. 1411

LABORATORY TESTING OF DIAMOND DRILL CORE

FROM WABO POWER PROJECT

1. SCOPE

Samples of diamond drill core from various locations at the Main Dam site and Saddle Dam were selected for testing to determine strength parameters for design.

2. ROCK TYPES

Rock types in the project area are sandstones, siltstone and mudstones. At the Main Dam two units have been mapped - these are the Era Beds and the underlying, and older, Orubadi Mudstone Beds. At the Saddle Dam rocks of the Orubadi Beds and the Aure Beds are present.

Drill holes in the Main Dam are numbered from DD100 to DD199 and those in the Saddle Dam are numbered from DD200 to DD299. (Not all numbers were allocated).

3. SAMPLING TECHNIQUE

The rock core was enclosed in a plastic tube and the ends of the tube were folded over and then taped to prevent moisture loss. The core was packed in wooden core boxes.

Considerable time elapsed between core recovery at Wabo and arrival at the laboratories in Cooma. When examined at the laboratory the core appeared dry and many of the plastic tubes were found to be punctured and torn. The mudstones and siltstones often exhibited surface cracking and many lengths of core had been broken in transit.

4. SAMPLE PREPARATION

It was decided to carry out most tests on saturated samples as:-

(i) the in situ condition will be close to saturation, and

(ii) there will be a significant difference between wet and dry results.

Selected samples representing the three rock types were prepared in our usual manner. This involved diamond cutting of samples to the required length and then saturation by immersion in water in a vacuum dessicator under a vacuum of 88 kPa for 72 hours. Only samples from DD102, DD103 and DD104, which were logged as sandstones, were suitable for test after preparation. The other samples were of siltstones and mudstone and either were damaged while cutting or broke down during saturation. The siltstones and mudstones were going to be very difficult to prepare and saturate.

Continued 2

Prepared by: BM

Checked by: BM

Form No. 256

Further samples were selected representing the weaker rock types and the method of preparation changed. The rock sample was placed inside of a tightly fitting metal cylinder of the required length and the ends cut and trimmed with a hacksaw and file. The metal cylinder was replaced by a rubber membrane and the sample mounted and then saturated in a triaxial cell which is normally used for soil testing. Saturation with a back pressure to the top and bottom of the sample of 1 020 kPa and a confining pressure of 1 034 kPa was adopted. The value of pore pressure parameter B was determined on a number of samples after 24 hours saturation and these values were in the range 0.96 to 0.98 (B can range from 0.0 for dry samples to 1.0 for fully saturated samples) so 24 hours was adopted as the standard saturation time for these samples. Back pressures and confining pressures were applied in such a way that the effective stress on the sample was always compressive.

Length to diameter ratio ranged from 2 to 3 and was generally 2.25 and the sample ends were plane and perpendicular to the axis of the sample.

Following saturation the samples were then tested in the normal manner. All tests were carried out in a constant temperature and humidity environment.

5. TYPE OF TEST

(a) Uniaxial Compressive Strength These tests were carried out in either a Leonard Farnell triaxial testing machine or an Avery Universal testing machine. Cores tested in the Leonard Farnell triaxial testing machine were strain controlled and a loading rate of 40 microstrain per second was adopted.

(b) Modulus of Elasticity Samples tested in Uniaxial compression in the Avery Universal testing machine were also used for modulus determinations. The samples were loaded slowly in increments of about 0.1 MPa and the load allowed to stabilise before displacement was noted. Displacement was measured between crossarms with dial gauges accurate to 0.0025 mm.

(c) Shear Strength Shear strength was determined in a double shear machine which imposes a failure plane on the sample. The double shear machine was loaded in on Avery Universal testing machine. Recorded strengths are shear strengths of the rock fabric. Displacement was not recorded.

(d) Creep Uniaxial creep was carried at three stresses, that is, 0.4 MPa, 0.8 MPa and 1.6 MPa, on a saturated sample of siltstone. Deformation was measured with a dial gauge accurate to 0.0025 mm. Sample saturation was maintained by enclosing the rock core in a rubber membrane which was liberally coated with silicon grease, then surrounded with cotton wool which was kept moist. The sample failed by sudden collapse during loading to 3.2 MPa.

(e) Physical Properties The physical properties measured were dry density, moisture content after test, and specific gravity of broken core in the saturated surface dry condition.

Continued 3

6. RESULTS

Test results are attached. Figure 1 is a plot of millistrain against time and Table 1 contains the remainder of the test results. Tables 2 and 3 are metricated results of tests carried out by George Wimpey & Co Ltd (Reference 1) and Nippon Kosi Co Ltd (Reference 2).

7. REFERENCES

1. Commonwealth Aluminium Corporation Pty Ltd (CAC) (1960). Report on Site Investigations for proposed Wabo Dam, Purari River, Papua. Lab. Ref. No. S/1922/A, George Wimpey & Co Ltd. December 1960.

2. Nippon Kosi Co Ltd (1973). The lower basin development of the Purari River (Papua New Guinea). Preliminary Report. September 1973.

Prepared by: BM

Checked by: BM

B. Mattick
Testing Officer

Date

Chief Engineer, Engineering Services

LABORATORY TESTING OF DIAMOND DRILL CORE FROM WAB POWER PROJECT

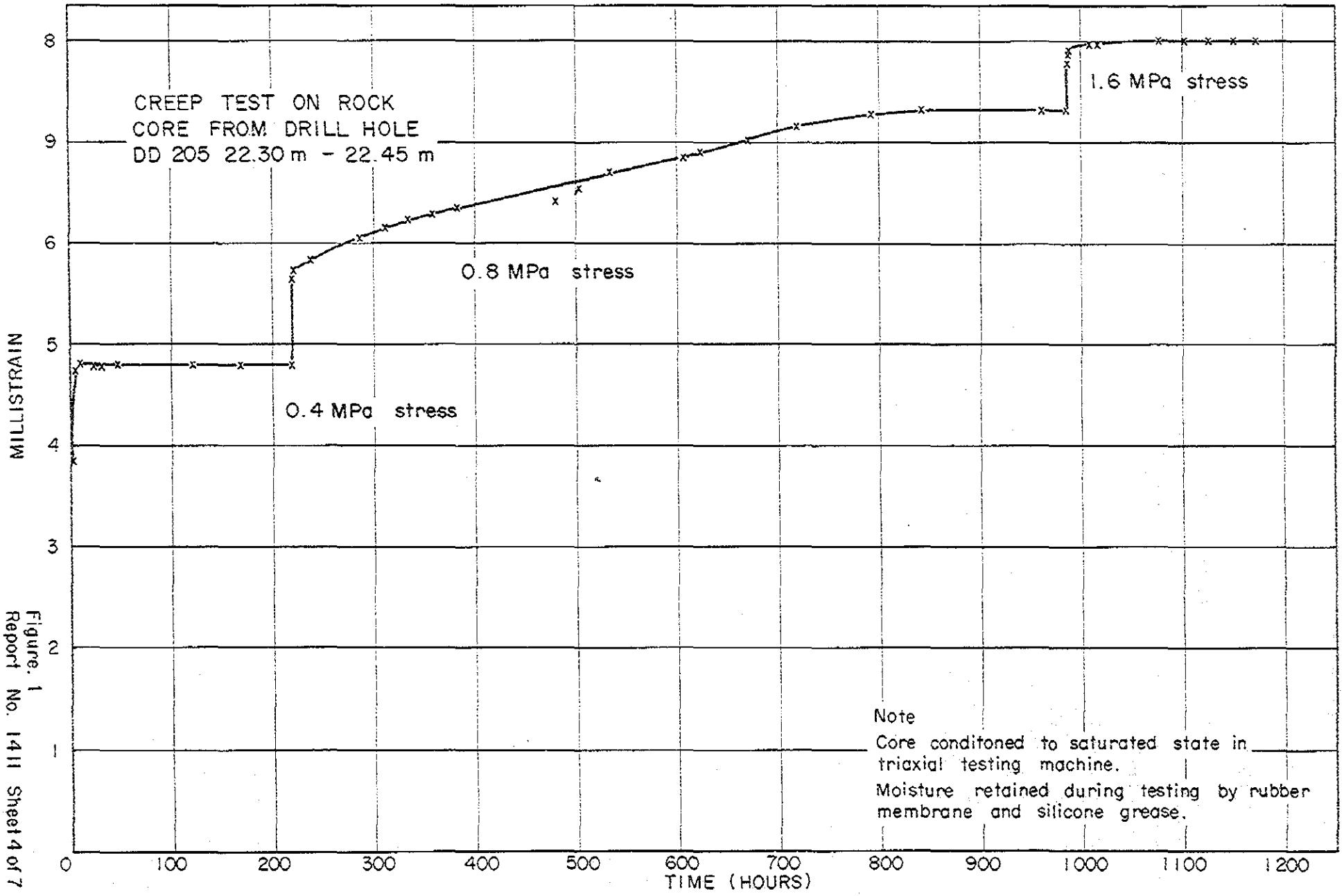


Figure. 1
Report No. 1411 Sheet 4 of 7

TABLE 1

LABORATORY TESTING OF DIAMOND DRILL CORE FROM WABO POWER PROJECT

TEST REPORT No. 1411

DRILL HOLE	DEPTH (m)	LITHOLOGIC DESCRIPTION (1)	SPECIMEN PRETREATMENT	MOISTURE CONTENT % (2)	DRY DENSITY t/m^3	SPECIFIC GRAVITY SSD(3)	ABSORPTION (%)	UNIAXIAL COMPRESSIVE STRENGTH MPa	MODULUS OF ELASTICITY GPa	SHEAR STRENGTH MPa	MODE OF FAILURE
DD102	32.50-32.65	Era Beds, Sandstone, Fresh	Saturated	8.9	2.11	2.29	8.6	25.1	4.0		Sudden collapse
	32.65-32.80	Era Beds, Sandstone, Fresh	Saturated	8.7	2.12	2.31	7.7	23.9	5.0		Sudden collapse
DD103	55.40-55.80	Era Beds, Sandstone, Fresh	Dry	2.5	2.34	*		36.8			Sudden collapse
	80.50-80.90	Era Beds, Silt-Sandstone, Fresh	Saturated	1.9	2.65	2.68	2.2	24.1	10.0		Sudden collapse
DD104	71.20-71.35	Era Beds, Sandstone, Fresh	Saturated	6.6	2.34	2.45	6.5	6.2	1.0		Sudden collapse
	71.35-71.50	Era Beds, Sandstone, Fresh	Saturated	6.4	2.22	2.51	4.8	8.2	2.0		Sudden collapse
DD105	16.70-17.00	Era Beds, Siltstone, Fresh	Saturated	10.0	2.13	2.32	7.9	5.3			Failed on bedding planes
DD111	63.20-63.50	Era Beds, Siltstone, Fresh	Saturated	15.3	2.37	*		1.4			Collapsed into small angular pieces
DD204	10.38-10.48	Mudstone, Fresh	Saturated	25.6	1.74	*		0.08			Plastic failure
DD205	22.05-22.20	Siltstone, Fresh	Saturated	9.8	2.20	*				0.56	
	22.30-22.45	Siltstone, Fresh	Saturated	6.0	2.25						Creep test specimen
	22.55-22.70	Siltstone, Fresh	Saturated	6.9	2.20			6.4	0.9		Sudden collapse
DD207	16.67-16.82	Siltstone, Fresh	Saturated							0.52	
	16.85-16.95	Siltstone, Fresh	Saturated	10.6	2.26	*		5.0			Sudden failure along bedding plane
DD208	42.17-42.33	Mudstone, Fresh	Saturated	16.1	2.08					0.22	
	42.77-42.87	Mudstone, Fresh	Saturated			*		0.65	0.045		Sudden collapse
DD213	11.16-11.26	Mudstone, Fresh	Saturated	21.7	1.86	*		0.03			Sudden collapse
	12.85-12.95	Siltstone, Fresh	Saturated	21.2	1.85			0.0			

NOTES

1. Lithologic descriptions from drillhole logs
2. Moisture content determined to AS A89.
3. Specific gravity determined to AS 1141

* Sample pieces collapsed when immersed in water

TABLE 2

LABORATORY TESTING OF DIAMOND DRILL CORE FROM WABO POWER PROJECT

CARRIED OUT BY GEORGE WIMPEY 1959 - 1960

DRILL HOLE	DEPTH (m)	LITHOLOGIC DESCRIPTION	SPECIMEN PRETREATMENT	NATURAL MOISTURE CONTENT (%)	NATURAL WET DENSITY (t/m^3).	SPECIFIC GRAVITY	UNCONFINED COMPRESSIVE STRENGTH (MPa)	YOUNGS MODULUS (MPa)	MODULUS STRAIN RANGE (%)	TRIAXIAL STRENGTH LATERAL PRESSURE (MPa)	TRIAXIAL STRENGTH MAXIMUM AXIAL PRESSURE (MPa)	TRIAXIAL STRENGTH STRAIN AT FAILURE (%)	MODE OF FAILURE
45	14.2- 14.8	Thinly bedded argillaceous fine sandstone		6	2.45	-	10.48	379	0.0-0.5				
								565	0.0-1.0				
								717	0.0-1.4				
				8	2.47					1.72	8.76	2.5	Specimen failed by crushing
	17.1- 17.2	Dark grey carbonaceous silty mudstone		-	2.37	-	1.65	97	0.0-0.5				
								103	0.0-1.0				
								100	0.0-1.5				
	22.1- 22.6	Blue-grey mudstone with bands of sandy mudstone		10	2.34	-	2.34	124	0.0-0.5				
								159	0.0-1.0				
								145	0.0-1.6				
	26.8- 27.4	Blue-grey sandy mudstone with bands of mudstone		9	2.39	-	2.83	121	0.0-1.0				
								141	0.0-2.0				
				8	2.37	-				0.69	5.17	4.5	Specimen failed by crushing
46	32.7- 33.2	Massive blue-grey sandy mudstone		8	2.40	-	4.07	255	0.0-1.0				
	38.6- 39.0	Blue-grey mudstone with sandy bands		12	2.40	-	2.21	214	0.0-0.4				
								165	0.0-1.0				
				8	2.40					0.69	4.55	2.2	
				7	2.39					1.38	4.14	2.1	
	50.1- 50.6	Thinly interbedded fine sandstone sandy mudstone and mudstone		8	2.40	-	4.34	228	0.0-0.5				
								338	0.0-1.0				
	79.2- 79 7	Grey-green argillaceous fine sandy siltstone. Thin mudstone bedding		-	2.42	-	6.48	145	0.0-0.5				
								317	0.0-1.0				
	123.7-124.1	Massive blue-grey dense mudstone		6	2.47	-	10.69	676	0.0-0.5				
								958	0.0-1.0				

TABLE 3

LABORATORY TESTING OF DIAMOND DRILL CORE FROM WABO POWER PROJECT

CARRIED OUT BY NIPPON KOEI 1973

DRILL HOLE	DEPTH (m)	LITHOLOGIC DESCRIPTION	SPECIMEN PRETREATMENT	MOISTURE CONTENT (%)	DENSITY	SPECIFIC GRAVITY	UNCONFINED COMPRESSIVE STRENGTH MPa	STATIC MODULUS OF ELASTICITY GPa	SHEAR STRENGTH C MPa	STRENGTH ∅ degrees	MODE OF FAILURE
		Intact Sandstone		7.45	2.408	2.676	17.50	5.57	3.53	33	
		Sandstone alternated with thin layer of siltstone		6.09	2.418	2.703	11.04	1.53	2.45	15.5	
		Siltstone		-	2.407	2.745	6.33	0.69	1.42	15	

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土質統一分類法（メートル表示）

UNIFIED SOIL CLASSIFICATION SYSTEM (METRICATED)
DATA FOR DESCRIPTION IDENTIFICATION AND CLASSIFICATION OF SOILS

MAJOR DIVISIONS			GROUP SYMBOL	GRAPHIC SYMBOL	TYPICAL NAME	DESCRIPTIVE DATA
COARSE GRAINED SOILS — More than 50% by dry mass, less than 60mm is greater than 0·06mm	GRAVELS — More than 50% of coarse grains are greater than 2·0mm	GRAVELLY SOILS	GW		Well graded gravels and gravel-sand mixtures, little or no fines.	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity; surface condition and hardness of the coarse grains; local or geological name and other pertinent descriptive information; symbols in parenthesis. For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics. EXAMPLE: Silty Sand, gravelly, about 20% hard, angular gravel particles, 10mm maximum size; rounded and sub angular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; light brown alluvial sand, (SM)
			GP		Poorly graded gravels and gravel-sand mixtures, little or no fines.	
			GM		Silty gravels, gravel-sand-silt mixtures.	
			GC		Clayey gravels, gravel-sand-clay mixtures.	
	SANDS — More than 50% of coarse grains are less than 2·0mm	SANDY SOILS	SW		Well graded sands and gravelly sands, little or no fines.	
			SP		Poorly graded sands and gravelly sands, little or no fines.	
			SM		Silty sand, sand-silt mixtures.	
			SC		Clayey sands, sand-clay mixtures.	
FINE GRAINED SOILS — More than 50% by dry mass, less than 60mm is less than 0·06mm	Liquid Limit less than 50%		ML		Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.	Give: typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any; local or geological name and other pertinent descriptive information, symbols in parenthesis. For undisturbed soil add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions. EXAMPLE: Clayey Silt, brown; low plasticity; small percentage of fine sand; numerous vertical root-holes; firm and dry in place, fill, (ML)
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	
			OL		Organic silts and organic silty clays of low plasticity.	
	Liquid Limit more than 50%		MH		Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.	
			CH		Inorganic clays of high plasticity, fat clays.	
			OH		Organic clays of medium to high plasticity.	
HIGHLY ORGANIC SOILS			Pt		Peat muck and other highly organic soils.	

FIELD IDENTIFICATION

Determine approximate percentages of material over 60mm in size, maximum size, shape, surface texture, hardness of material, geological description. Identify on estimated percentage mass of the various fractions.

COARSE GRAINED SOILS
More than half of the material less than 60 mm is larger than 0·06mm

0·06mm is about the smallest particle visible to the naked eye

GRAVELS AND SANDS

GRADATIONS		NATURE OF FINES	DRY STRENGTH	GROUP SYMBOL
GOOD	Wide range in grain size	"Clean" materials (not enough fines to bind coarse grains)	None	GW
POOR	Predominantly one size or range of sizes.			GP
GOOD to FAIR	"Dirty" materials (excess of fines)	Fines are non-plastic (1)	None to medium	GM
		Fines are plastic (1)	Medium to high	GC
GOOD	Wide range in grain size	"Clean" materials (not enough fines to bind coarse grains)	None	SW
POOR	Predominately one size or range of sizes.			SP
GOOD to FAIR	"Dirty" materials (excess of fines)	Fines are non-plastic (1)	None to medium	SM
		Fines are plastic (1)	Medium to high	SC

FINE GRAINED SOILS
More than half of the material is smaller than 0·06mm

SILT AND CLAY FRACTION
Fraction smaller than 0·20mm AS sieve size

DRY STRENGTH	DILATANCY	TOUGHNESS	GROUP SYMBOL
None to low	Quick to slow	None	ML
Medium to high	None to very slow	Medium	CL
Low to medium	Slow	Low	OL*
Low to medium	Slow to none	Low to medium	MH
High to very high	None	High	CH
Medium to high	None to very slow	Low to medium	OH*

Readily identified by colour, odour, spongy feel and generally by fibrous texture — Pt*

Use the grading curve of material passing 60 mm for classification of fractions according to the criteria given under "Major Divisions"

LABORATORY CLASSIFICATION

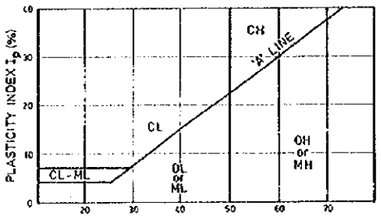
% (2) < 0·06mm	PLASTICITY OF FINE FRACTION	$C_u = D_{60}/D_{10}$	$C_c = (D_{30})^2/D_{10}D_{60}$
0-5	-	>4	between 1 and 3
0-5	-	Fails to comply with above	
12-50	Below 'A' line or I_p <4	-	-
12-50	Above 'A' line and I_p >7	-	-
0-5	-	>6	between 1 and 3
0-5	-	Fails to comply with above	
12-50	Below 'A' line or I_p <4	-	-
12-50	Above 'A' line and I_p >7	-	-

More than 50% passing 0·06mm	
Below 'A' line	
Above 'A' line	
Below 'A' line	
Below 'A' line	
Above 'A' line	
Below 'A' line	

*Effervesces with H_2O_2

NOTES

1. Identify fines by the method given for fine grained soils.
2. Borderline classifications occur when the percentage of fines (fraction smaller than 0·06mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC



PLASTICITY CHART
FOR CLASSIFICATION OF FINE GRAINED SOILS

FIELD IDENTIFICATION PROCEDURES FOR FINE GRAIN SOILS OR FRACTIONS

These proceedures are to be performed on the minus 0·6mm size particles. For field classification purposes, screening is not intended; simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to Shaking)

After removing particles larger than 0·6mm size, prepare a pat of moist soil with a volume of about 10 cm³. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assists in identifying the character of the fines in the soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing Characteristics)

After removing particles larger than 0·6mm size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic of clays in the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength but can be distinguished by feel when powdering the dry specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency Near Plastic Limit)

After removing particles larger than 0·6 mm size, a specimen of soil, about 10cm³ in size, is moulded to the consistency of putty. If too dry, water must be add ed, if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3mm diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Notes

1. *The above follows the original Unified Classification System (U.S.B.R. Earth Manual) and ASTM Designation: D2487-69 except that it adopts the particle size limits given in AS 1289 and other standards, viz:*

Gravel	*2 - 60mm*
Sand	*0·06 - 2mm*
Silt and Clay	*less than 0·06mm*

the system excludes the boulder and cobble fractions of the soil and classifies only the material less than 60mm in size.

2. *As 60mm, 2mm and 0·06mm sieve sizes are not normally used, the percentages passing these sizes can be obtained from a particle size distribution curve determined from a laboratory test. Alternatively, the percentages passing may be estimated in the field.*
3. *Australian Standard Code of Practice for Site Investigation, Appendix D, and ASTM Designation D2488-69, Tables 1 to 4, contain standard terms and manual tests for describing and identifying soils.*

SNOWY MOUNTAINS ENGINEERING CORPORATION

DEFINITIONS OF ROCK, SOIL, AND DEGREES OF CHEMICAL WEATHERING

(A) GENERAL DEFINITIONS — ROCK AND SOIL

ROCK

In engineering usage, rock is a natural aggregate of minerals connected by strong and permanent cohesive forces.

Note: Since 'strong' and 'permanent' are subject to different interpretations, the boundary between rock and soil is necessarily an arbitrary one.

SOIL

In engineering usage, soil is a natural aggregate of mineral grains which can be separated by such gentle mechanical means as agitation in water.

The two principal classes of soil are:

(a) Residual soils - soils which have been formed in situ by the chemical weathering of parent rock. Residual soil may retain evidence of the original rock texture or fabric or, when mature, the original rock texture may be destroyed.

(b) Transported soils - soils which have been moved from their places of origin and deposited elsewhere. The principal agents of erosion, transport and deposition are water, wind, ice and gravity. Two important types of transported soil in engineering geology and materials investigations are:

(i) Slopewash - a soil, often including angular rock fragments and boulders, which has been transported downslope predominantly under the action of gravity assisted by water. The principal forming process is that of soil creep in which the soil moves after it has been weakened by saturation. It may be water borne for short distances.

(ii) Alluvium - a soil which has been transported and deposited by running water. The larger particles (sand and gravel size) are water worn.

(B) ROCK WEATHERING DEFINITIONS

COMPLETELY WEATHERED ROCK	(CW)	Rock which retains most of the original rock texture (fabric) but the bond between its mineral constituents is weakened by chemical weathering to the extent that the rock will disintegrate when immersed and gently shaken in water. In engineering usage this is a soil.
HIGHLY WEATHERED ROCK	(HW)	Rock which is weakened by chemical weathering to the extent that dry pieces about the size of 50 mm diameter drill core can be broken by hand across the rock fabric. Highly weathered rock does not readily disintegrate when immersed in water.
MODERATELY WEATHERED ROCK	(MW)	Rock which exhibits considerable evidence of chemical weathering, such as discolouration and loss of strength but which has sufficient remaining strength to prevent dry pieces about the size of 50 mm diameter drill core (of inherently hard rock) being broken by hand across the rock fabric. Moderately weathered rock does not ring when struck with a hammer.
SLIGHTLY WEATHERED ROCK	(SW)	Rock which exhibits some evidence of chemical weathering, such as discolouration, but which has suffered little reduction in strength. Except for some inherently soft rocks, slightly weathered rock rings when struck with a hammer.
FRESH WITH LIMONITE STAINED JOINTS	(Fr St)	Joint faces coated or stained with limonite but the blocks between joints are unweathered.
FRESH ROCK	(Fr)	Rock which exhibits no evidence of chemical weathering. Joint faces may be clean or coated with clay, calcite, chlorite or other minerals.

The degrees of rock weathering may be gradational. Intermediate stages are described by dual symbols with the predominant degree of weathering first (e.g., CW-HW).

The various degrees of weathering are not absolute strength parameters as some rocks are weak, even when fresh, to the extent that they can be broken by hand across the fabric.

Fresh drill cores of some rock types, mainly shale, siltstone, and silty or tuffaceous sandstone may disintegrate after exposure to the atmosphere due to slaking, desiccation, expansion or contraction, stress relief or a combination of any of these factors.

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現場並びに室内土質試験結果の概要

PRETREATMENT
MUDSTONE ROCK
MECHANICALLY PULVERISED
TO A SOIL

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT. . WABO POWER PROJECT. . . . . .

FEATURE. . UG3, UG11 and UG13. . . . . No. . . . . .

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

SAMPLE No.	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller											ATTERBERG			COMPACTION (2)		FIELD		SHEAR (3) Values @								PERMEABILITY (4)				Consolidation (5)	
			MAX SIZE mm	GRAVEL 9.5 mm	GRAVEL 4.75 mm	SAND 2.36 mm	SAND 1.18 mm	SAND 600 µm	SAND 300 µm	SAND 150 µm	SILT 75 µm	CLAY 2 µm	Linear Shrinkage %	w_L %	I_p %	G_s	MDD t/m³	OMC %	Density ρd t/m³	Moisture Content FMC %	OMC Effective Stress c' kPa	OMC Effective Stress ϕ' °	OMC Total Stress c kPa	OMC Total Stress ϕ °	OMC Effective Stress c' kPa	OMC Effective Stress ϕ' °	OMC Total Stress c kPa	OMC Total Stress ϕ °	@ 124.5 kPa Settlement %	@ 124.5 kPa k m/s 10^{-8}	@ 622.5 kPa Settlement %	@ 622.5 kPa k m/s 10^{-8}	%	
UG3																																		
1Q/1D	ex tracking	GC/SC		67	57	49	46	44	42	36	20	6	5	33	11	2.69	1.87	14.8			26	35							1.2	0.28	3.1	0.20	4.4	Era Bed Sandstones as received
1Q/1D	trial	SC		77	62	51	50	50	49	43	24	7																						ditto after 5 cycles wetting/drying
UG11																																		
MTT/1W																				11.0														Tracking trial using fresh, grey,
2FOW	ex																1.79	20.7																mudstone rock. Crushed and compac-
3D		CL			100	99	94	90	89	88	83	24	9	47	25	2.68	1.74	18.6			52	23							1.5	0.017	5.6	0.003	11.1	ted by bulldozers
4D	tracking	CL					100	99	99	99	96	28	8	40	17	2.72	1.77	16.5											2.9	0.09	3.6	0.01	11.8	
5W																				19.0														Moisture contents for the 3 compac-
6W	trial																			21.7														tion points in the rapid
7W																				22.7														compaction test
4A/1D	0.1- 3.3	MH				100	90	81	75	66	56	16	9	56	19	2.69	1.42	30.0			58	28							0.8	0.059	4.1	0.03	8.0	Brown mudstone soil
2D	3.3- 4.7	CH								100	96	37	12	63	38																			Grey mudstone soil
11D/1C	3.3- 3.6	CL											9	43	25	2.70				10.4														Fresh, grey mudstone rock
2C	10.5-11.0	CH											19	53	33	2.88				9.1														Fresh, grey mudstone rock
3C	15.5-16.0	CH											14	52	33	2.69				10.0														Fresh, grey mudstone rock
12D/1C	3.5- 4.0	CH											13	67	46	2.68				14.0														Fresh, grey mudstone rock
13E/1D	3.0- 4.0	CH								100	99	36	10	52	28	2.69	1.69	18.6			105	15							1.2	.003	4.2	.001	8.4	Grey, mudstone soil
21A/1D	1.3- 2.1	CH								100	98	35	13	54	29	2.74																		Grey, mudstone soil
UG13																																		
1A/1D	0.1- 3.2	MH				100	92	86	82	79	78	30	16	74	28																					Yellow - brown mudstone soil
2E/1D	0.0- 0.3	CH								100	98	31	12	52	19																				Grey mudstone rock
3E/1D	0.0- 1.0	CL							100	99	94	22	6	47	22	2.67	1.77	17.0		13.0									2.4	0.22	3.6	0.01	15.4	Grey, mudstone soil
5A/1D	0.9- 6.3	CL				100	99	99	99	98	95	20	8	48	24	2.64	1.72	17.4											2.8	0.07	3.0	0.02	11.5	Grey, mudstone soil
11A/5D	0.1- 3.3	MH			100	89	82	81	80	79	76	26	13	60	27	2.80	1.54	22.0											2.9	0.08	3.3	0.01	14.0	Brown, mudstone soil
34E/1D	5.4- 8.5	SC			100	83	70	60	56	50	44	11	9	42	19	2.73	1.74	16.5											3.1	0.01	3.4	0.01	11.5	Grey, mudstone soil
38D/1U	3.9- 4.3	core											11	56	32	2.75		13.8																Fresh, grey mudstone rock
39D/1U	3.6- 3.9	core											13	60	38	2.76		13.1																Fresh, grey mudstone rock
2U	13.3-13.6	core											13	58	36	2.76		14.8																Fresh, grey mudstone rock

NOTES: (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is.....unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under ...1...600 kPa, unless otherwise stated.

PRETREATMENT
MUDSTONE ROCK
MECHANICALLY PULVERISED
TO SOIL

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT WADO POWER PROJECT

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

FEATURE UG13, UG15, UG16, UG17 No.

SAMPLE No.	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller: MAX SIZE mm	GRAVEL 9.5 mm	GRAVEL 4.75 mm	SAND 2.36 mm	SAND 1.18 mm	SAND 600 µm	SAND 300 µm	SAND 150 µm	SILT 75 µm	CLAY 2 µm	Linear Shrinkage %	ATTERBERG w_L %	ATTERBERG I_p %	G_s	COMPACTION (2) MDD t/m³	COMPACTION (2) OMC %	FIELD Density ρ_d t/m³	FIELD Moisture Content FMC %	SHEAR (3) Values @ OMC: Effective Stress c' kPa	Effective Stress φ' °	Total Stress c kPa	Total Stress φ °	SHEAR (3) Values @ OMC: Effective Stress c' kPa	Effective Stress φ' °	Total Stress c kPa	Total Stress φ °	PERMEABILITY (4) @ 124.5 kPa: Settlement %	@ 124.5 kPa: k m/s 10⁻⁸	@ 622.5 kPa: Settlement %	@ 622.5 kPa: k m/s 10⁻⁸	Consolidation % (5)	
UG13 (Cont'd)																																	
40D/1C	13.2-13.5	Core											10	56	32	2.61				10.1													All fresh, grey mudstone rock
41D/1C	9.6-10.0	Core											13	57	34	2.75				12.7													
42D/1C	10.1-10.5	Core											12	53	30	2.69				8.7													
2C	3.2- 3.5	Core											6	36	11	2.72				10.2													
43D/1C	3.2- 3.5	Core								100	99	36		65	38				2.28														
2C	10.0-10.4	Core								100	99	38		68	41				2.32														
			% PASSING																														
				175 mm	150 mm	112 mm	75 mm	37 mm	19 mm	9 mm																							
UG15																																	
16E/1C	(Grab)	Rock Fragments		90	90	53	11	2	1	nil						2.16																	
						100	92	64	44	30																								
																	GRAVEL SANDS																
			% PASSING													S.G.	Absorb %		Agg. Crush Value	Los Angeles @ 500 Rev	SOUNDNESS LOSS (6) Gravel Fractions 37~26 mm	26-19 mm	19-13 mm	13-9.5 mm	9-5 mm	Sand Fractions 5-2 mm	2-1 mm	1-600 µm	600-300 µm					
			150 mm	75 mm	37.5 mm	19.0 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	0.60 mm	300 µm	150 µm	60 µm																			
UG16																																	
1T/1D	0.0- 1.8	GW	100	94	62	46	34	27	23	20	15	6	1	1		2.71	1.0		13.3	20.2	.01	.02	.11	.07	.60									
1T/1D	Sand fraction	-														2.53	1.1									0.2	0.4	0.5	2.6				
2T/1D	0.3- 1.5	GW	100	94	72	55	39	31	27	25	19	7	2	2																			
3T/1D	1.5- 2.2	GW	100	97	77	57	39	31	28	25	16	6	4	3																			
4T/1D	4.3- 5.8	GW	100	95	72	54	40	32	26	24	17	5	1	1																			
5T/1D	0.0- 2.6	GW	100	93	63	44	33	29	23	21	16	7	3	1		2.72	1.0			17.8	0	0	1.1	.20	.20								GRAVEL-SANDS
5T/1D	Sand fraction	-														2.74	0.6									0.3	0.2	0.3	1.0				
6T/1D	0.0- 2.2	GW	100	96	59	41	31	25	20	18	15	11	4	2																			
6T/1D	Sand fraction	-														2.79	1.3									0.4	0.3	0.7	2.5				
UG17																																	
1T/1D	0.0- 2.6	GW	100	88	60	42	31	22	18	16	13	5	2	1			1.8		14.7	22.9	0	0	0.2	1.5	0.3								
1T/2D	2.6- 3.1	GW	100	95	75	62	44	36	29	25	14	4	2	1		2.71				29.2	1.3	0.5	0.4	1.0									
1T/3D	0.3-2.6	GW			100	70	46	32	24	19	9	2	1	1																			

NOTES. (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is ..... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under ..... kPa, unless otherwise stated.
(6) Soundness Losses are individual percentage losses.

Before tracking (Sandstone
After tracking (grab sample of
(rock fragments

PRETREATMENT
MUDSTONE ROCK
MECHANICALLY PULVERISED
TO A SOIL

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT....UABO POWER PROJECT.....

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

FEATURE....UG18, UG19, UG20.... No.....

SAMPLE No.	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller: MAX SIZE mm	GRAVEL: 9.5 mm	4.75 mm	SAND: 2.36 mm	1.18 mm	600 µm	300 µm	150 µm	SILT 75 µm	CLAY 2 µm	Linear Shrinkage %	ATTERBERG: w_L %	I_p %	G_s	COMPACTION (2): MDD t/m³	OMC %	FIELD: Density ρ_d t/m³	Moisture Content MC %
			150 mm	75 mm	37.5 mm	19.0 mm	9.5 mm	% PASSING 4.75 mm	2.36 mm	1.18 mm	0.60 mm	0.30 mm	150 µm	60 µm		S.G. (SSD)	Absorb % (SSD)		Agg crush value	Los Angeles @ 500 rev
UG18																				
1T/1D	0.0-2.2	GW	100	91	65	47	36	31	25	21	13	8	4	2		2.73	1.5		11.7	17.9
1T/1D	sand fraction	-														2.75	1.8			
2T/1D	2.6-3.2	GW	100	93	68	46	36	28	23	19	12	7	3	1		2.72	1.0		10.4	16.6
2T/1D	sand fraction	-														2.70	1.2			
3T/1D	0.0-2.3	GW	100	72	37	26	23	22	21	20	18	10	3	1		2.71	1.1			
3T/1D	sand fraction	-														2.70	1.3			
4P/1D	0.0-2.3	GW				100	90	82	74	71	66	54	33	12						
4P/3D	2.3-2.6	GW (7)				100	97	94	89	84	71	39	12	5						
4P/4D	2.3-2.6	GW					100	95	92	87	73	52	25	8						
UG19																				
1T/2D	1.0-2.5	GW	100	86	56	41	28	22	17	12	9	6	3	2		2.73	0.9			
1T/2D	sand fraction	-														2.79	2.3			
UG20																				
1T/1D	0.0-1.6	GW	100	99	90	82	65	49	29	17	6	3	2	1		2.72	2.1		18.1	24.9
1T/1D	sand fraction	-														2.74	0.9			
2T/1D	0.0-1.1	GW	100	96	83	69	52	40	29	19	7	3	2	1						
3T/1D	0.0-2.2	GW	100	98	85	60	33	18	11	6	3	3	2	2						
4T/1D	0.0-1.8	GW	100	86	72	57	38	29	20	15	8	4	2	1						
5T/1D	0.0-1.3	GW	100	89	77	60	38	28	18	13	6	3	2	1						
6T/1D	0.0-2.6	GW	80	60	46	38	30	23	16	11	7	5	2	1						
7T/1D	2.0-3.3	GW	100	95	70	50	38	32	28	25	13	5	1	1						
2D	2.0-3.3	GW	100	95	70	54	36	28	24	22	16	7	3	2		2.71	1.1			16.4
8T/1D	0.0-2.5	GW	100	86	64	53	38	30	25	21	9	3	1	1						
2D	0.0-1.7	GW	100	86	64	46	35	26	23	19	12	4	1	1		2.71	1.1			
9T/1D	0.0-1.8	GW	100	72	45															
10T/1D	0.0-1.5	GW	100	91	66	47		30	27	25	21	9	2	1		2.72	1.1			17.1
10T/1D	sand fraction	-														2.70	1.8			

SAMPLE No.	SHEAR (3) Values @ OMC: Effective Stress c' kPa	Effective Stress φ' °	Total Stress c kPa	Total Stress φ °	SHEAR (3) Values @ OMC: Effective Stress c' kPa	Effective Stress φ' °	Total Stress c kPa	Total Stress φ °	PERMEABILITY (4) @ 124.5 kPa: Settlement %	@ 124.5 kPa: k m/s 10⁻⁸	@ 622.5 kPa: Settlement %	@ 622.5 kPa: k m/s 10⁻⁸	Consolidation (5) %	
	SOUNDNESS LOSS (6) Gravel Fractions 37-26 mm	26-19 mm	19-13 mm	13-9.5 mm	Sand fractions 9.5-5 mm	5-2 mm	2-1 mm	1-.600 mm	.600-.300					
UG18														
1T/1D	0.9	1.9	0.2	0.1	0.2									
1T/1D						1.0	1.3	3.5	3.2					
2T/1D	0	0	0	0	0.1									GRAVEL SANDS
2T/1D														Buff, grey, black, mottled
3T/1D														
3T/1D														
4P/1D						0.2	0.2	0.4	0.4					
4P/3D						0.1	0.2	0.7	1.2					
4P/4D						0	0.2	0.3	0.6					
UG19														
1T/2D	0.1	0.1	0.1	0	0.1									
1T/2D						0.2	0.2	0.2	0.8					
UG20														
1T/1D	0.5	0.7	2.4	2.1	3.6									
1T/1D						4.5	2.2	1.2	0.4					
2T/1D														
3T/1D														
4T/1D														
5T/1D														
6T/1D														
7T/1D														
2D	0	0	0.2	0	0.4									
8T/1D														
2D														
9T/1D														
10T/1D	0	0	0	0	0.3									
10T/1D						0.4	0.4	1.1	4.8					

NOTES. (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is..... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under ..... kPa, unless otherwise stated.
(6) Soundness Losses are individual percentage loss figures.
(7) This classification for material in situ.
The grading analysis applies to return from chop pump.

PRETREATMENT
MUDSTONE ROCK
MECHANICALLY PULVERISED
TO A SOIL

SNOWY MOUNTAINS ENGINEERING CORPORATION

PROJECT WAGO POWER PROJECT

SUMMARY OF FIELD & LABORATORY SOIL TEST RESULTS (1)

FEATURE UG20 No.

SAMPLE No.	DEPTH m	UNIFIED/ SMA CLASSIFICATION	GRADATION % of total dry mass smaller: MAX SIZE mm	GRAVEL 9.5 mm	GRAVEL 4.75 mm	SAND 2.36 mm	SAND 1.18 mm	SAND 600 µm	SAND 300 µm	SAND 150 µm	SILT .75 µm	CLAY 2 µm	Linear Shrinkage %	ATTERBERG w_L %	ATTERBERG I_p %	G_s	COMPACTION (2) MDD t/m³	COMPACTION (2) OMC %	FIELD Density ρd t/m³	FIELD Moisture Content I.M.C. %	SHEAR (3) Values @ OMC Effective Stress c' kPa	SHEAR (3) Values @ OMC Effective Stress ϕ' °	SHEAR (3) Values @ OMC Total Stress c kPa	SHEAR (3) Values @ OMC Total Stress ϕ °	SHEAR (3) Values @ OMC Effective Stress c' kPa	SHEAR (3) Values @ OMC Effective Stress ϕ' °	SHEAR (3) Values @ OMC Total Stress c kPa	SHEAR (3) Values @ OMC Total Stress ϕ °	PERMEABILITY (4) @ 124.5 kPa Settlement %	PERMEABILITY (4) @ 124.5 kPa k m/s 10⁻⁸	PERMEABILITY (4) @ 622.5 kPa Settlement %	PERMEABILITY (4) @ 622.5 kPa k m/s 10⁻⁸	Consolidation (5) %	
							% PASSING									S.G.	Absorp		Agg.	Los	SOUNDNESS LOSS (6)												
			150 mm	75 mm	37.5 mm	19.0 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	0.60 mm	300 µm	150 µm	60 µm		(SSD)	%		Crush	Angeles	Gravel Fractions 37-26 mm	Gravel Fractions 26-19 mm	Gravel Fractions 19-13 mm	Gravel Fractions 13-9.5 mm	Sand Fractions 5-2 mm	Sand Fractions 2-1 mm	Sand Fractions 1-.600 mm						
																	(SSD)		Value	@ 500 rev													
UG20																																	GRAVEL SANDS
10T/2D	0.0-1.5	GW	100	91	66	47	35	29	25	23	17	4	1	1		2.70	1.1		13.5	17.5	0	0.6	0	0.1	0.2									Buff, grey, black mottled
11T/1D	0.3-1.5	GW	100	98	82	60	-	33	28	25	18	8	3	2		2.83	1.7								0.3	0.3	1.1	2.3					
11T/1D	Sand-fraction	-																															
11T/2D	0.3-1.5	GW	100	98	82	63	46	36	30	26	16	5	1	1																			
12T/1D	2.2-3.6	GW	100	86	60	49	-	27	21	18	14	7	3	2		2.73	1.2																Fine-medium sand, grey
12T/1D	Sand-fraction															2.79	1.5																
12T/2D	2.2-3.6	GW	100	86	60	46	34	25	19	16	10	5	1	1																			
14G	(Surface)	SM								100	100	85	26	8																			Gravel-sands
7T/2D	Sand-fraction															2.74	3.8								0.5	0.7	1.7	2.6					Sand
3D	1.1-2.0	SM							100	100	99	84	39	13		2.55	2.1																Gravel-sands
8T/2D	Sand-fraction															2.70	1.4																

NOTES: (1) All tests in accordance with Australian Standard AS 1289, unless otherwise stated.
(2) Compaction type is ..... unless otherwise stated.
(3) Shear strength results are from triaxial compression tests, unless otherwise stated. Failure defined by $(\sigma_1 - \sigma_3)$ max.
(4) Permeability tests in accordance with SMEC Standard Procedure.
(5) Consolidation under ..... kPa, unless otherwise stated.

付　録　J

鉱物学的検討用粘土の3試料
AMDEL報告書 NoMP124／74

CSIRO
The Australian Mineral Development Laboratories

Flemington Street, Frewville, South Australia 5063
Phone Adelaide 79 1662, telex AA82520

Please address all correspondence to Frewville.
In reply quote: MP 2/30/0

10th November, 1975

The Chief Engineer,
Engineering Services,
Snowy Mountains Engineering Corporation,
PO Box 36,
COOMA NORTH, NSW 2630

Attention: Mr A.D. Hosking

REPORT MP 1274/76

YOUR REFERENCE:	Undated letter received 23-10-75
MATERIAL:	Three mudstones/clays (Orubadi Mudstone Series)
LOCALITY:	Wabo Power Project, Purari River, Papua
IDENTIFICATION:	UG11/21A/1D, UG13/2E/1D, UG13/1A/1D
DATE RECEIVED:	23-10-75
WORK REQUIRED:	Clay mineral determination

Investigation and Report by: Dr R.N. Brown

Officer in Charge, Mineralogy/Petrology Section: Dr K.J. Henley

for F.R. Hartley
Director

mhb

Appendix J

THREE SAMPLES FOR CLAY MINERALOGICAL EXAMINATION

1. INTRODUCTION

The Engineering Services Section of the Snowy Mountains Engineering Corporation submitted three powdered clay samples for examination, in connection with proposed construction work for the Wabi Power Project, Purari River, Papua. The samples were from the Orubadi Mudstone Series of Upper Miocene to Pliocene age. They were to be examined by X-ray diffraction and electron microscopy to determine the clay mineralogy.

The samples were numbered as follows:

UG 11/21A/1D

UG 13/ 2E/1D

UG 13/ 1A/1D

The first two were grey-blue and relatively fresh material, and the third was weathered surface material corresponding in locality to the second sample.

2. PROCEDURE

Standard X-ray diffraction traces were first recorded using the bulk samples to give the total mineralogy (especially the non-clay mineralogy).

Weighed amounts were then dispersed in water and allowed to sediment, and representative -2 μm e.s.d. material was obtained by the pipette method. This was examined on the plummet balance to determine its solids content, and was then used to produce oriented clay samples on ceramic plates. Two such preparations were made for each sample, both being saturated with Mg^{++} ions, and one in addition being treated with glycerol. After air-drying, these were examined in the X-ray diffractometer, and the plate not glyceroled was re-examined hot, at about 130°C, as a check on the composition of the interstratified material.

Diluted suspensions of the three clay fractions were deposited on electron microscope specimen grids and examined in the electron microscope, mainly in order to seek the presence of halloysite.

3. RESULTS

The results are summarised in Table 1, which lists the following:

(i) The mineralogy of the bulk sample, giving minerals in approximate order of decreasing abundance, using the semiquantitative abbreviations defined below. This is derived from the XRD trace of the unoriented total sample. Information on any non-clay materials should be sought from this section of the table. Information on clay components is likely to be incomplete, and superior information on the clay mineralogy is presented under the clay fraction mineralogy.

(ii) The percentage of the total sample found to disperse into the 'clay' (-2 μm) fraction when the sample was sedimented, as determined by plummet balance.

(iii) The mineralogy of the clay (-2 μm) fraction, again in approximate order of decreasing abundance and using the same semiquantitative abbreviations.

4. REMARKS

The mixed-layer clay (ML) in this case is satisfactorily identifiable as illite-montmorillonite. Signs of regular interstratification have not shown themselves.

The chlorite gave rather broad diffraction peaks and is considered to be a clay chlorite in terms of poor crystallinity and/or small crystallite size.

The kaolin gave 'normal' peaks and showed no sign of the presence of appreciable halloysite. The electron microscope examination substantiated this, tubes of halloysite (although present) being so rare as not to warrant reporting.

'Randomly-interstratified clay' appears to be present in all samples. The same remarks apply as given in Sec. 4.4 of the previous Report MP 838/76.

It will be evident that all three results are very similar indeed, the only notable difference being the absence of calcite and pyrite from the weathered sample UG 13/1A/1D. Any other apparent differences are not regarded as necessarily significant.

5. SEMIQUANTITATIVE ABBREVIATIONS

The semiquantitative abbreviations referred to in Sec. 3 are as follows:-

D = Dominant. Used for the component apparently most abundant, regardless of its probable percentage level.

CD = Co-dominant. Used for two (or more) predominating components, both or all of which are judged to be present in roughly equal amounts.

SD = Sub-dominant. The next most abundant component(s) providing its percentage level is judged above about 20.

A = Accessory. Components judged to be present between the levels of roughly 5 and 20%.

Tr = Trace. Components judged to be below about 5%.

TABLE 1: CLAY AND NON-CLAY MINERALOGY OF THREE MUDSTONES

	UG11/21A/1D		UG13/2E/1D		UG13/1A/1D	
Bulk Mineralogy	C	CD	C	CD	C	CD
	K	CD	K	CD	(Other)*	CD
	(Other)*	CD	(Other)*	CD	Q	CD
	Q	SD	Q	SD	K	CD
	F	A	Cal	A	F	A
	Cal	A	F	A	M	Tr-A
	M	A	M	A		
	Py	Tr	Py	Tr		
Clay fraction, Wt.%	39		40		41	
Mineralogy	ML	CD	ML	CD	ML	CD
	C	CD	C	CD	C	CD
	K	CD	K	CD	K	CD
	RI	CD	RI	CD	RI	CD
	M	A	M	A	M	A
	Q	A	Q	Tr-A	Q	A
			Cal	Tr		

*"Other clays" - see key and text.

Mineral Key:

C Chlorite
Cal Calcite
F Feldspar (sodic)
K Kaolin
M Mica/illite
ML Mixed layer illite-montmorillonite clay

"(Other)"-other clays not determinable here - see clay fraction results
Py Pyrite
Q Quartz
RI Randomly-interstratified clay of indeterminate type (see text)

付　録　K

Purari河砂利試料に関する岩石分類学的検討結果
George Winpey & Co.Ltd.，ロンドン中央試験所報告

APPENDIX K

RESULTS OF PETROGRAPHIC EXAMINATION OF SPECIMENS FROM THE PURARI RIVER GRAVEL

Sir William Halcrow & Partners,
Alliance House,
Caxton Street,
LONDON, S.W.1.

For the attention of Mr F.A. Sharman

Dear Sirs,

Purari River Gravel

We have now examined thin sections of 16 samples of rock selected from the Purari gravels, with a view to establishing the suitability of this material as a source of concrete aggregate, particularly with reference to its liability to alkali-aggregate reactivity. Detailed petrographic descriptions of the specimens are appended, in duplicate. About 80 per cent of the gravel consisted of a hard white limestone, the suitability of which was not in question, and the specimens for examination were selected from the remaining 20 per cent of the material, as well as from suspected fragments of siliceous limestone.

Four of the specimens (Nos. 6, 9, 11 and 12) were found on microscopic examination to contain material potentially liable to alkali-aggregate reactivity. In samples 6, 11 and 12, this took the form of an extremely fine-grained groundmass, which appeared to consist in part of volcanic glass. Sample 9 was a siliceous limestone, in which the silica occurred as chalcedony, permeating and forming nodules within the limestone. Chalcedonic silica, and glassy or cryptocrystalline volcanic rocks are considered potentially capable of causing alkali-aggregate reactions.

The proportion of material capable of containing deleterious minerals was very difficult to assess by visual inspection, owing to the close resemblance between the basalt and hornfels fractions, but it was estimated to be not more than about 10 per cent by weight of the gravel, and to consist predominantly of volcanic lavas and tuffs, of basic to acid-intermediate composition. The remainder of the non-limestone fraction of the gravel consist of sandstone and various metamorphic and deep-seated igenous rocks, which would not normally be regarded as suspect from the point of view of alkali-aggregate reaction.

+ "Concrete Manual", 6th edn,, U.S.S.R., Denver, Colo., 1955.

...2/.

The proportion of siliceous limestones present appeared very small. The limestone specimens were selected for microscopic examination on the basis of their suspected siliceous appearance, but only in sample 9 was silica actually found. It is evident that the siliceous limestones were sufficient rare, in the sample tested, to be discounted as a likely source of deleterious material.

The United States Bureau of Reclamation has found that alkali reactivity can be expected with aggregates containing more than 3 per cent by weight of glassy or cryptocrystalline laves or tuffs, of acid intermediate composition. If a low-alkali cement is used however, the reaction appears to be greatly inhibited, if not prevented. On this basis, the proportion of deleterious material in the Purari River gravel appears to be such that alkali-aggregate reaction might occur with cements of high alkali content. With the use of low alkali cements however, experience in areas affected by reactive aggregates, would lead one to expect negligible risk of deterioration. Low alkali cements are defined as those containing less than 0.6 per cent by weight of sodium and potassium oxides.

Whilst petrographic examination can indicate the presence of mineral necessary to the development of alkali-aggregate reactions, it does not follow that an aggregate suspected on petrographic grounds will necessarily give trouble in practice. Chemical tests can be employed to provide supplementary evidence of reactivity, but it is generally accepted that the only positive test is to observe over an extended period, and under controlled conditions, the behaviour of concrete test bars made from the suspected aggregate.

Yours faithfully,
GEORGE WIMPEY & CO. LTD.

(Signed) I.E. Higginbottom

Central Laboratory

1. FINE-GRAINED BIOCLASTIC LIMESTONE

Description of hand specimen

Fine-grained buff limestone

Description of thin section

(i) Texture: Clastic, fine-grained

(ii) Composition: Minute calcareous fossils in calcite cement matrix fossils include foraminifera, broken polyzoa, corals, mollusca. Sparse angular quartz crystals.

2. HORNFELS

Description of hand specimen

A hard, very fine-grained, pale greenish grey rock, with well developed crystals of pyrite.

Description of thin section

(i) Texture: Anhedral crystal aggregates studding cryptocrystalline groundmass, giving a speckled appearance. Some zones of greater concentration of speckling within the main mass, bounded by uniformly curved surfaces. Sparse porphyroblasts of pyrite, up to 0,6 mm diameter.

(ii) Constitutent minerals:

(a) Porphyroblasts: Pyrite, in euhedral crystals showing hexagonal cross section. Ottrelite, tabular subhedral crystals, showing alteration to chlorite.

(b) Groundmass: Intergrown aggregates studding the groundmass Graphite, as dust associated with chlorite aggregates. Quartz, cryptocrystalline, probably the principal component of the groundmass. Limonite, staining the groundmass, probably from the weathering of pyrites. Sericite, distributed in minute crystals throughout the groundmass.

3. QUARTZ SUB-GREYWACKE

Description of hand specimen

Fine-grained grey sandstone

Description of thin section

(i) Texture: Fine-grained (with some coarse and medium particles), clastic, sub-rounded to sub-angular particles with interstitial calcareous cement. Calcite veining.

(ii) Composition: Crystal particles mostly quartz, orthoclase felds and calcite, with accessory biotite, chlorite, hornblende, magntite, and olivine. Lithic particles mostly limestone, siltstone and fine-grained volcanic rocks.

4. FINE-GRAINED BANDED LIMESTONE

Description of hand specimen

Very fine-grained brown banded limestone.

Description of thin section

(i) Texture: Microcrystalline, no distinct crystal boundaries.

(ii) Composition: Calcite, some sparse foraminifera. Limonite staining gives banded appearance.

5. QUARTZ MICRO-MONZONITE

Description of hand specimen

A medium grained greenish irgneous rock. Colour index about 40. Visible crystals of hornblende, feldspar, biotite.

Description of thin section

(i) Texture: Hypidiomorphic-granular, medium grained.

(ii) Constituent minerals:

(a) Principal: Both alkali and plagioclase feldspar, well sericitised, in approximately equal quantities. Hornblende; as twinned corroded tabular crystals. Quartz; as anhedral grains, probably less than 10 per cent of rock. Biotite; as tabular crystals, sometimes bent.

(b) Accessory: Muscovite, chlorite, sericite and magnetite (corroded).

6. HORNBLENDE ANDESITE

Description of hand specimen

Fine-grained leucocratic porphyritic rock. Colour index about 10 Phenocrysts of hornblende.

Description of thin section

(i) Texture: Porphyritic, with a cryptocrystalline groundmass. Phenocrysts up to 2 mm, in length.

(ii) Constitutent minerals:

(a) Principal phenocrysts: Feldspar; zoned and twinned crystals, euhedral, in the oligoclase range. Hornblende; var. lamprobolite. Euhedral crystals showing psuedohexagonal cross section. Corroded margines with magnetite concentration.

(b) Accessory phenocrysts: Enstatite, as small euhedral crystals. Magnetite. Biotite, as corroded tabular crystals.

(iii) Groundmass: Sub-vitreous appearance, some feldspar appears discernible.

7. GREEN HORNFELS

Description of hand specimen

A hard, very fine-grained green quartziferous rock. Iron stain with ferruginous granular quartz veining.

Description of thin section

(i) Texture: Microcrystalline, poorly foliated. Some phenocrysts.

(ii) Constituent minerals:

(a) Phenocrysts: Haematite, as euhedral crystals and scaley masses, sparse. Also as a constituent of quartz haematit vein.

(b) Groundmass: Quartz, as euhedral poorly defined grains. Chlorite, as prismatic crystals and scaley aggregates.

8. PEBBLE CONGLOMERATE

Description of hand specimen

A conglomerate with sub-angular pebbles of fine-grained rock embedded in a greenish matrix.

Description of thin section

(i) Texture: Clastic, with sub-angular and sub-rounded pebbles in an arenaceous and microcrystalline matrix.

(ii) Constitutent minerals:

(a) Pebbles: Quartz, plagioclase feldspar, chert, hornfels, and fine-grained volcanic rocks.

(b) Matrix: Angular quartz, feldspar and lithic fragments, cemented by chlorite.

9. SILICEOUS LIMESTONE

Description of hand specimen

Fine-grained pale buff limestone with a brown siliceous nodule.

Description of thin section

(i) The limestone: A bioclastic limestone (similar to specimen 1).

(ii) The nodule: A chalcedonic aggregate, permeating the limestone and showing replacement of fossils, with the development of spherulic structures.

10. HORNBLENDE TRACHY-ANDESITE

Description of hand specimen

Fine-grained porphyritic leucocratic rock. Colour index about 25 Visible phenocrysts of feldspar and hornblende.

Description of thin section

(i) Texture: Porphyritic with microcrystalline groundmass.

(ii) Constitutent minerals:

(a) Phenocrysts: Orthoclase feldspar, as subhedral much sericitised crystals forming approximately half of total feldspar. Plagioclase feldspar; as tabular zoned and twinned phenocrysts in the andesine - labradorite range. Strongly sericitised.
Hornblend; as subhedral corroded crystals.
Green biotite; as corroded tabular crystals.
Magnetite; as small euhedral crystals.

(b) Groundmass: Obscured because of sericitisation throughout rock. Probably chiefly feldspar and quartz, with chlorite.

11. VESICULAR OLIVINE BASALT

Description of hand specimen

Blue-grey vesicular basalt

Description of thin section

(i) Texture: Microporphyritic in amorphous groundmass.

(ii) Constituent minerals:

(a) Phenocrysts: Olivine; as euhedral crystals.
Augite. Plagioclase feldspar, as lamellar crystals in the andesine range.

(b) Groundmass: Dark sub-vitreous texture, some feldspar microlites.

12. VESICULAR OLIVINE BASALT

Description of hand specimen

Blue-grey vesicular basalt.

Description of thin section

(i) Texture: Microporphyritic in amorphous groundmass.

(ii) Constituent minerals:

(a) Phenocrysts: Plagioclase feldspar, as lamellar crystals in the andesine range. Olivine. Augite.

(b) Groundmass: Feldspar microlites, in a dark sub-vitreous matrix.

13. CHLORITINED GRANITE

Description of hand specimen

Yellowish-green medium grained igneous rock

Description of thin section

(i) Texture: Originally medium to coarse holocrystalline, but chloritisation of the ferromagnesian minerals and feldspars has resulted in relict quartz in a pseudo-ophitic relationship to chlorite.

(ii) Constituent minerals: Chlorities in fine granular form and in conjunction with sericite, replacing feldspars; in coarser grained aggregates replacing ferromagnesian minerals. Quartz. Magnetite.

14. FINE-GRAINED CLASTIC ORGANIC LIMESTONE

Description of hand specimen

Fine-grained pale buff limestone

Description of thin section

(i) Texture: fine-grained, bioclastic detrital.

(ii) Composition: Fossil fragments (foraminifera and bryozoa) with angular and rounded grains of crystalline limestone, in a dark cryptocrystalline calcareous matrix. Fine veins of crystalline calcite.

15. FINE-GRAINED FORAMINIFERAL LIMESTONE

Description of hand specimen

Fine-grained buff limestone

Description of thin section

(i) Texture: Fine-grained, bioclastic.

(ii) Composition: Numerous foraminifera in a dark cryptocrystalline calcareous groundmass. Fine veins of crystalline calcite.

16. VERY FINE-GRAINED LIMESTONE

Description of hand specimen

Fine-grained buff limestone

Description of thin section

(i) Texture: Cryptocrystalline.

(ii) Composition: Sparse foraminifera in a dark cryptocrystalline calcareous groundmass. Some fine crystalline calcite veining.

(Signed) O.G. Price

Central Laboratory