COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES.

GEOLOGY AND GEOPHYSICS

RECORDS 1957, No. 20

PRELIMINARY REPORT ON GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER, ALICE SPRINGS, N.T., 1956

by

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ILLUSTRATIONS

Preliminary Report on Geophysical Investigations of Underground Water, Alice Springs, N.T. 1956.

The water supply for the town of Alice Springs, N.T., is provided from underground and a geophysical investigation was recently carried out by the Bureau of Mineral Resources to assist further development of the water resources. The survey was conducted during September, October and November, 1956, and was confined to the following three areas (see Plate 1):-

(1) The Basin Area.
(2) The Bungalow Area.
(3) The Farm Area.

(1) The Basin Area.

This area is defined by Owen (1952) as the southern lobe of the shallow Alice Springs river basin and is bounded by the hospital to the north, Heavitree Gap to the south and the exposed bedrock to the east and west (Plate 2).

Hydrological and geological investigations of the Basin, which have been carried out intermittently since 1939, include research into such problems as capacity, salinity, recharge, water-table fluctuations and hydraulic gradients. Reports on some of these problems have been submitted by Owen (1952 and 1954) and data are being collected by the Bureau's Resident Geologist, Alice Springs.

The following summary of the geology of the area is taken from the report by Owen (1954).

Quaternary sediments of soil and alternating layers of unconsolidated silt, sand and gravel overlie Archaeozoic metamorphic and igneous rocks. The southern limit of the basin is Heavitree, where Proterozoic quartzites crop out.

The main purpose of the geophysical survey was to supply further details concerning :

(i) the capacity of the basin,
(ii) the limits of potable water,
and (iii) possible areas of future development.

(i) The capacity depends largely on the thickness and nature of the sediments overlying the bedrock. The seismic method was used at several places to determine the depth to bedrock.

(ii) The electrical resistivity of a formation is a function of the salinity of the interstitial water and the pore volume. By investigating changes in the electrical resistivity across the basin the possible limits of potable water may be indicated.

(iii) By consideration of the known geology and the combined results of the seismic and electrical resistivity surveys, it might be possible to delineate areas meriting investigation for possible future development.

The techniques used included the following :

(a) Using the Wenner configuration of electrodes (that is, constant spacing between the electrodes), resistivity traversing was carried out by moving the configuration as a whole along each traverse and taking ground resistivity readings at 50-foot intervals. A Geophysical Earth Testing Megger was used and electrode spacings of 100 feet and 200 feet were employed along the traverses shown on Plate 2. Electrode spacing of 300 feet was also used along the major portion of Traverse A. The effective depth penetration of the current is of the same order as the electrode spacing used; by using different electrode spacings, it is therefore possible to obtain values of the ground resistivity from the surface to different depths.

(b) Using the results from the resistivity traversing as a guide, sites were selected for resistivity depth probes (see Plate 2). A resistivity meter, designed and made by the Bureau, was used for this work.

(c) Information was collected on bores and wells near the traverses, and the resistivity of bore and well water was determined with a mud cell and a Megger.

(d) At most places where resistivity depth probing was done, seismic refraction surveys were carried out. The equipment used was the portable, 12-channel Midwestern shallow reflection-refraction seismograph with geophones operating at a frequency of 6 cycles/second. Geophone intervals of 10 feet were used, and shot distances ranged from 5 to 300 feet.

The shallow reflection technique was also tested, but the depth to the bottom of the alluvial basin was generally too shallow to obtain conclusive results.

(e) Normal refraction shooting, with geophones at 50 and 100-foot intervals, was done over parts of the area to indicate possible bedrock irregularities.

The resistivity profiles are shown on Plates 3 and 4.

Outstanding features of the profiles are the high resistivity values along traverses in and near the Todd River. These high values are caused by the combined effects of :

(i) a decrease in depth to bedrock, and
(ii) a decrease in the salinity of the interstitial water in the material overlying the bedrock.

To ascertain which effect is predominant, the seismic survey was extended over this area (full details will be included in a final report).

A critical analysis of these results should be made in conjunction with known and expected bedrock contours (Owen, 1954, Fig. 1. and Jones, 1957).

The resistivity contour map for 100-foot electrode spacing (Plate 6) shows a high-resistivity zone coinciding approximately with the Todd River. Reference to the bedrock contours and the zone of fresh water (Jones, 1957) shows that the resistivity high is attributed to fresh water underground, and, north from a point between Traverses C and D, to shallow bedrock. A weak, high-resistivity anomaly coincides approximately with a low part of the basin (Owen, 1954 and Jones, 1957) west of Traverse A. This anomaly is tentatively explained by relatively fresh water in an old river channel.

The resistivity contour plan for 200-foot electrode spacing (Plate 7) shows almost the same pattern as that for 100-foot spacing, except that the weak anomaly west of Traverse A is replaced by an area of almost uniform resistivity. This change may possibly be explained by the greater influence of the bedrock when using the larger electrode spacing.

In the interpretation of the resistivity depth probe data it is not possible to distinguish between the thin layers of sands and clays, as they show up as one formation. Plate 5 shows the preliminary interpretation of the resistivity depth probe curves in terms of depth to discontinuities and resistivity values of the relevant formations. Results from this interpretation may not be precise, but a better estimate of the resistivities of the formations is possible if accurate depth determinations are made. In this way, seismic depth determinations can assist in the resistivity estimates and improve their accuracy.

The normal refraction technique was used to supply depth control for the constant-spacing resistivity profiles and resistivity depth probes.

The seismic results will be discussed in more detail in a final report, but the following may be of immediate practical interest. At Heavitree Gap, the depth to the top of the unweathered rock is 50 feet at the shallowest point (station 1350). The seismic velocity of unweathered rock north of station 1500 is 18,000 ft/sec., indicating metamorphic or igneous rocks; south of station 1500, the seismic velocity in the bedrock ranges between 8,500 and 13,000 ft/sec., indicating shales, sandstones and limestones. At a depth of 10 feet a layer of 5,000 ft/sec. velocity was found. This velocity corresponds to that of a water-saturated sand.

(2) Bungalow Area.

The Bungalow Area is that section of the Todd River valley bounded in the north by the Bungalow native settlement and in the south by the Charles River (Plates 8 and 10). The area is a river valley with river sediments overlying Archaeozoic metamorphic and igneous rocks.

It was requested that geophysical work be conducted in this area to ascertain its potential for development as an additional source of underground water. For this purpose it is required to know roughly the shape of the river basin and to locate any possible shallow bedrock bars across the valley suitable for the construction of a Mexican dam.

One traverse was surveyed along the river bed and several short cross-traverses between the exposed bedrock on both banks (Plate 8).

Methods of investigation employed were:

(a) Resistivity traversing with electrode spacings of 100 and 200 feet.

(b) Two resistivity depth probes.

(c) Normal seismic refraction method.

The resistivity profiles are shown on Plate 9. Cross Traverses K, L and M were too short to use resistivity traversing.

The seismic refraction survey along Traverse J determined the depth of the bedrock below the river bed, and a profile along this traverse is also shown on Plate 9. There is a fair degree of agreement between the high resistivity values and decreases in depth to bedrock as shown by the seismic results. This may indicate relatively uniform salinity conditions along the surveyed part of the river, as is to be expected in a valley where the sediments are subject to periodic flushing. Plate 10 is a contour plan of the bedrock prepared from the seismic results, and may be useful as a guide for test drilling investigations.

(3) Farm Area.

The area south of Heavitree Gap is part of the "Farm Area", and is shown on the traverse plan, Plate 11.

The following summary of the geology is taken from a communication from Prichard and Quinlan (1957).

Fresh-water sediments within the basin range from Cretaceous to Quaternary and overlie a basement of Archaeozoic rocks and a continuous sequence of Upper Proterozoic, Cambrian and Lower Ordovician sedimentary rocks which dip steeply to the south. This sequence of quartzizites, limestones, shales, sandstones, etc., occurs south from Mt. Blatherskite Ridge (Heavitree Quartzite). A fault striking east, between Heavitree Ridge and Mt. Blatherskite Ridge, results in a fault contact between Archaeozoic rocks and Upper Proterozoic limestone, and causes a repetition of the geological sequence below the Upper Proterozoic shales. Faulting across the regional strike along the Mt. Blatherskite Ridge is on a bearing of $340^\circ \pm$.

The geophysical investigation in this area consisted of seismic refraction traverses and four resistivity depth probes (see Plate 13).

The seismic refraction survey consisted of:

(a) Six weathering spreads, geophone interval 10 feet and shot point distances between 10 and 500 feet.

(b) Thirteen normal spreads, geophone interval 50 and 100 feet and shot point distances between 50 and 500 feet.

(c) One normal spread, geophone interval 220 feet and shot point distances between 220 feet and 1,220 feet.

Plate 12 shows the results of the seismic refraction survey.

The profile shows formations with seismic velocities ranging from 800 to 18,000 ft/sec. In general terms, it may be said that the higher the velocities, the more rigid and dense (and hence the less weathered) are the rocks. From experience gained in other surveys, the following tentative interpretation of the velocities is made:-

(i) 16,000 to 18,000 ft/sec: unweathered igneous and metamorphic rocks (quartzites), recrystallised limestones.

(ii) 10,000 to 13,000 ft/sec: unweathered sandstones and shales, limestones, and slightly weathered and fractured igneous and metamorphic rocks near the surface.

(iii) 6,000 to 9,000 ft/sec: weathered to unweathered sandstones and shales, weathered limestones or calcareous rocks, and weathered igneous and metamorphic rocks.

(iv) Less than 6,000 ft/sec: unconsolidated rocks, weathered rocks, and alluvial and eluvial deposits.

Velocities of 4,500 to 5,500 ft/sec. are often, but not necessarily, associated with water-saturated, unconsolidated rocks, and hence the depth to groundwater level can often be obtained by measuring the depth to a layer with a velocity of 4,500 to 5,500 ft/sec.

Owen (1954, p. 6) points out that in the shallow basins of Alice Springs, it is possible that a layer of fresh potable water overlies, or floats on, more saline water. He also warns against over-deepening of wells or bores as this may contaminate the near-surface fresh water, unless the saline water-bearing beds are cemented off. Jones (1957, p. 10) mentions that north of Mt. Blatherskite the static water level is 30 feet below the ground surface; elsewhere, the level ranges between 50 and 250 feet below the ground surface. He also notes that the water level in the bores often rises 50 feet or more above the aquifer; in other words, the water is under pressure and may be classified as sub-artesian.

Parker (1955) points out that saline water, if present in basins, concentrates in the lower parts of the basin beneath fresh water. Walker, quoted by Parker (1955, p. 630) states that "In several instances poorly constructed wells, - - -, have extended in saline waters below the fresh water aquifer and acted as conduits for carrying the salty water into the fresh-water aquifers."

Based on the possibility that saline water is present in the Farm Area, it follows, therefore, that the best places to drill for water are not necessarily in the deepest parts of the basin.

Taking the above factors into account, it is considered that the following areas along the line P-Q-R-X-Y should be tested (see Plate 12):-

(i) On P-Q, between stations 00 and 1,000, not deeper than 100 feet, and between stations 2,000 and 2,100, not deeper than 100 feet.

(ii) On Q-R, between stations 500 and 4,000, probably not deeper than 80 feet.

(iii) On X-Y, between stations 1,800 and 3,800, not deeper than 250 feet, and between stations 6,600 and 7,600, not deeper than 250 feet.

It would be particularly inadvisable to drill any deep holes on P-Q between stations 1,000 and 2,000, on Q-R between stations 4,400 and 4,700, and on X-Y between stations 3,800 and 6,600. If such holes were drilled and sub-artesian water encountered, it may contaminate the near-surface with saline water.

The results of the resistivity depth probe at Site 1, near station 1,400 on Q-R (Plate 11), indicate a formation with a resistivity of 16 to 45 ohm-metres, below about 45 feet. On the assumption that the formation has a porosity of 30 (± 10) per cent., the total dissolved solids content (T.D.S.) would range between 400 and 2,500 parts per million (p.p.m.).

The resistivity depth probe at Site 2, near station 2,700 on Q-R, indicates a formation with a resistivity of 20 ohm-metres. On the assumption that the porosity of the formation is 30 (± 10) per cent., the T.D.S. would range between 900 and 3,000 p.p.m.

The resistivity depth probe at Site 3, near station 7,800 on X-Y, indicates a formation with a resistivity of 12 to 25 ohm-metres, below 30 feet. Assuming a porosity of 30 (± 10) per cent., the T.D.S. would range between 700 and 2,500 p.p.m.- probably nearer 700 p.p.m.

The probe at Site 4, about 6,000 feet east of station 4,100 on X-Y, indicates the possibility of fresh water below 70 feet. The formation resistivity is about 25 ohm-metres, and indicates a T.D.S. of between 700 and 1,500 p.p.m. for a porosity of 30 (± 10) per cent.

All data have been reduced, but final checking and critical analyses of results are still to be carried out, together with further correlation with available bore hole information.

REFERENCES.

Jones, N.O., 1957	Preliminary Report on the Groundwater Reserves of the Alice Springs Area. Bur. Min. Resour. Aust., Records 1957, No. 6.
Owen, H.B., 1952	Notes on Water Supply at Alice Springs. Bur. Min. Resour. Aust., Records 1952, No. 21.
Owen, H.B., 1954	Report on Geological Investigations of Underground Water Resources at Alice Springs. Report to Northern Territory Administration.
Parker, G.G., 1955	"Encroachment of Salt water into Fresh" from "Water", The Year Book of Agriculture, 1955, U.S. Department of Agriculture, pp. 615-635.
Prichard, C.E., and Quinlan, T., 1957	Personal communication to Chief Geologist, Bur. Min. Resour., Aust.

PLATE 1

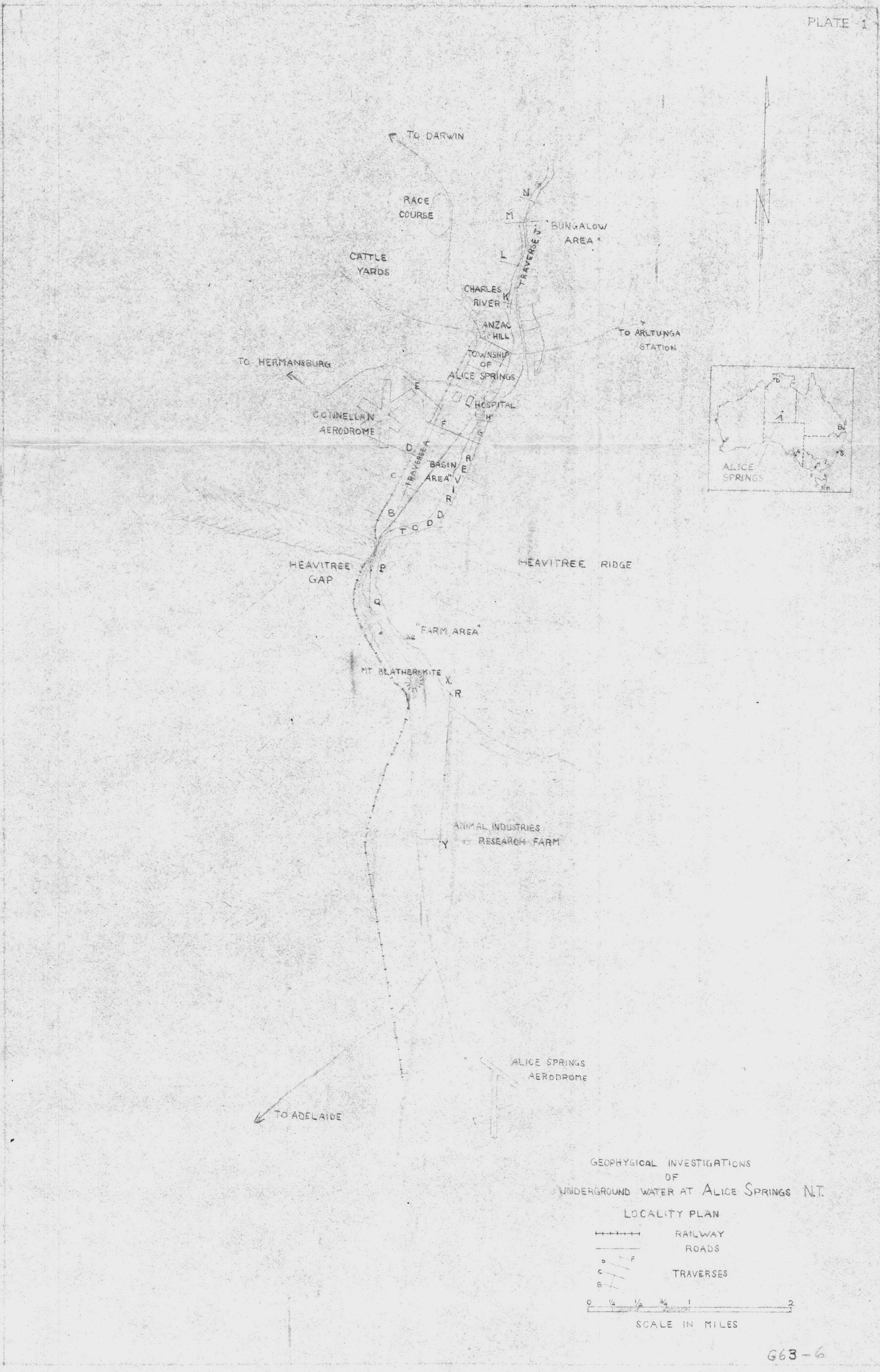
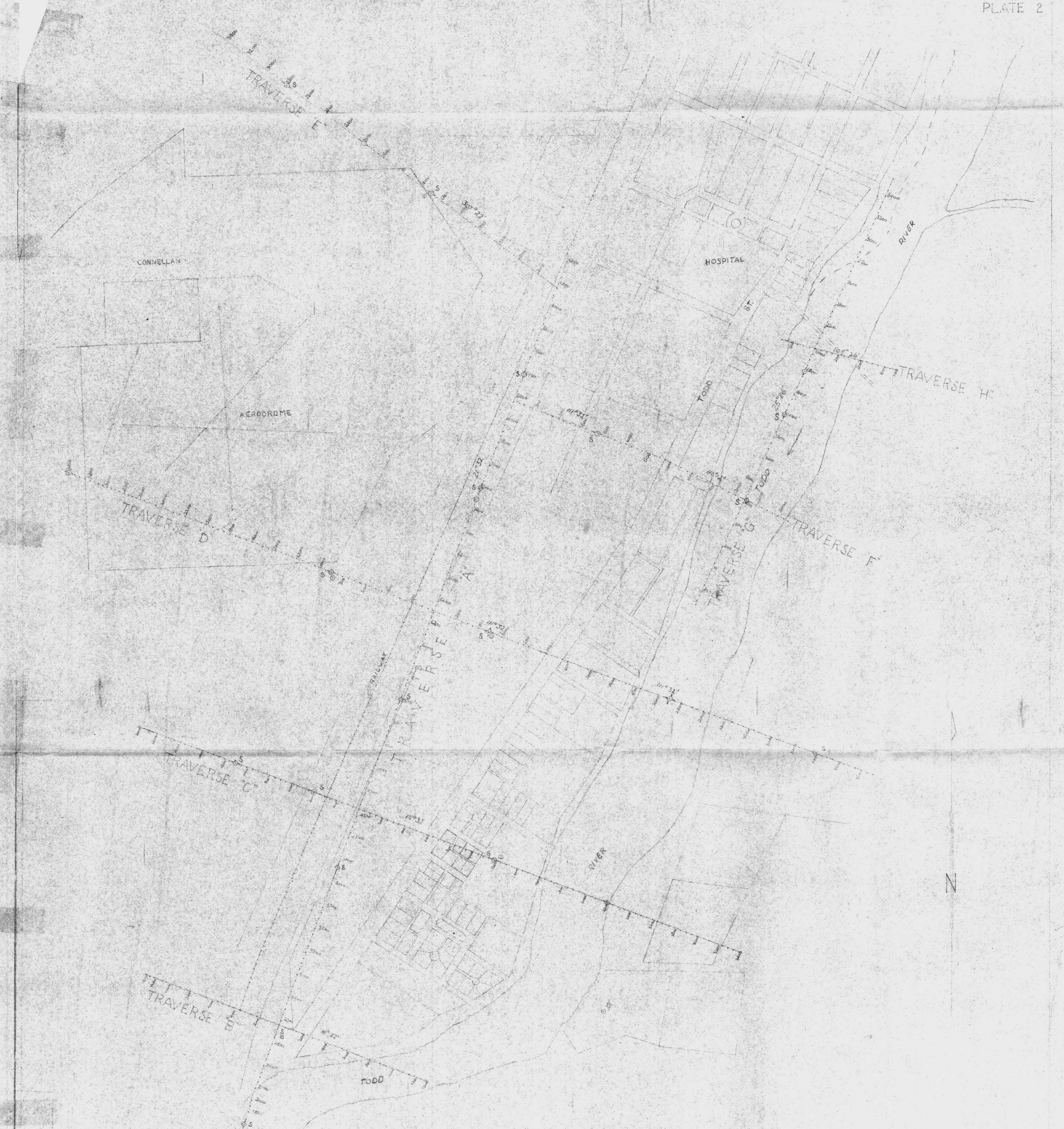

TO DARWIN
RACE COURSE
CATTLE YARDS
N
M
L
K
"BUNGALOW AREA"
TRAVERSE J
CHARLES RIVER
ANZAC HILL
TO ARLTUNGA STATION
TOWNSHIP OF ALICE SPRINGS
TO HERMANSBURG
E
HOSPITAL
H
CONNELLAN AERODROME
F
G
D
TRAVERSE A
"BASIN AREA"
C
B
TODD RIVER
HEAVITREE GAP
P
HEAVITREE RIDGE
Q
"FARM AREA"
MT BLATHERSKITE
X
R
ANIMAL INDUSTRIES RESEARCH FARM
Y
ALICE SPRINGS AERODROME
TO ADELAIDE
ALICE SPRINGS
N
GEOPHYSICAL INVESTIGATIONS
OF
UNDERGROUND WATER AT ALICE SPRINGS N.T.
LOCALITY PLAN
RAILWAY
ROADS
TRAVERSES
0 1/4 1/2 3/4 1 2
SCALE IN MILES
G63-6

PLATE 2



LEGEND

DEPTH PROBE RESISTIVITY

DEPTH PROBE RESISTIVITY WITH SEISMIC CONTROL

DRILL HOLES

GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS N.T.

BASIN AREA TRAVERSE PLAN

SCALE IN FEET

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G63-7

PLATE 3

FT. ABOVE S.L.
APPARENT RESISTIVITY IN OHMMETRES
TRAVERSE A'
TRAVERSE A
TRAVERSE B
(A 2660'N)
TRAVERSE C
(A 4930'N)
RESISTIVITY PROFILES:
300 FT. ELECTRODE SEPARATION
200 FT " "
100 FT " "
GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS, N.T.
BASIN AREA
SURFACE AND RESISTIVITY PROFILES
GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
SCALE IN FEET
200 0 200 400 600
VERTICAL SCALES AS SHOWN

G63-8

GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS N.T.

BASIN AREA

SURFACE AND RESISTIVITY PROFILES.

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

G63-9

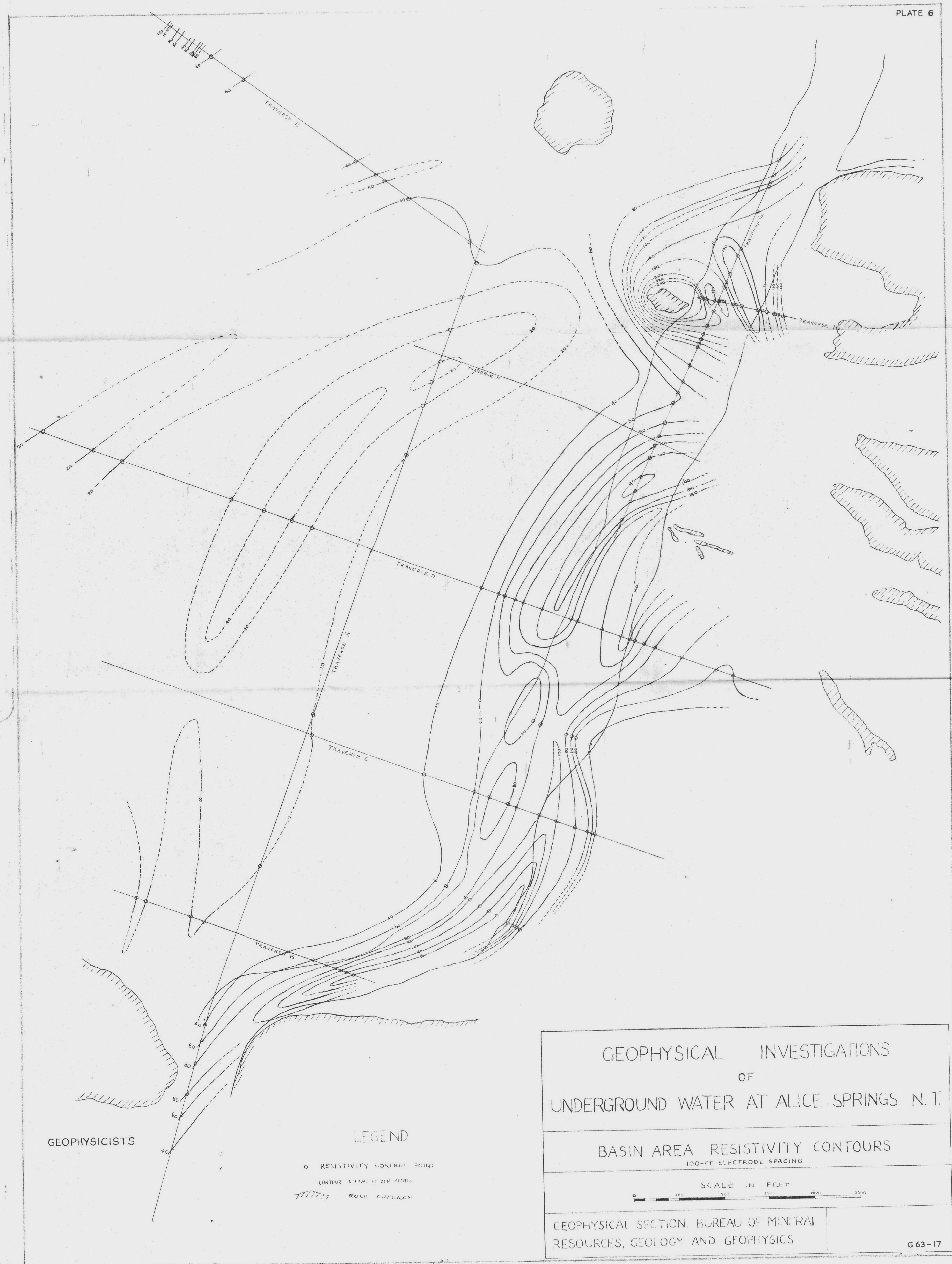
PLATE 5

GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS N.T.

BASIN AREA
RESISTIVITY DEPTH PROBES

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G 63-13



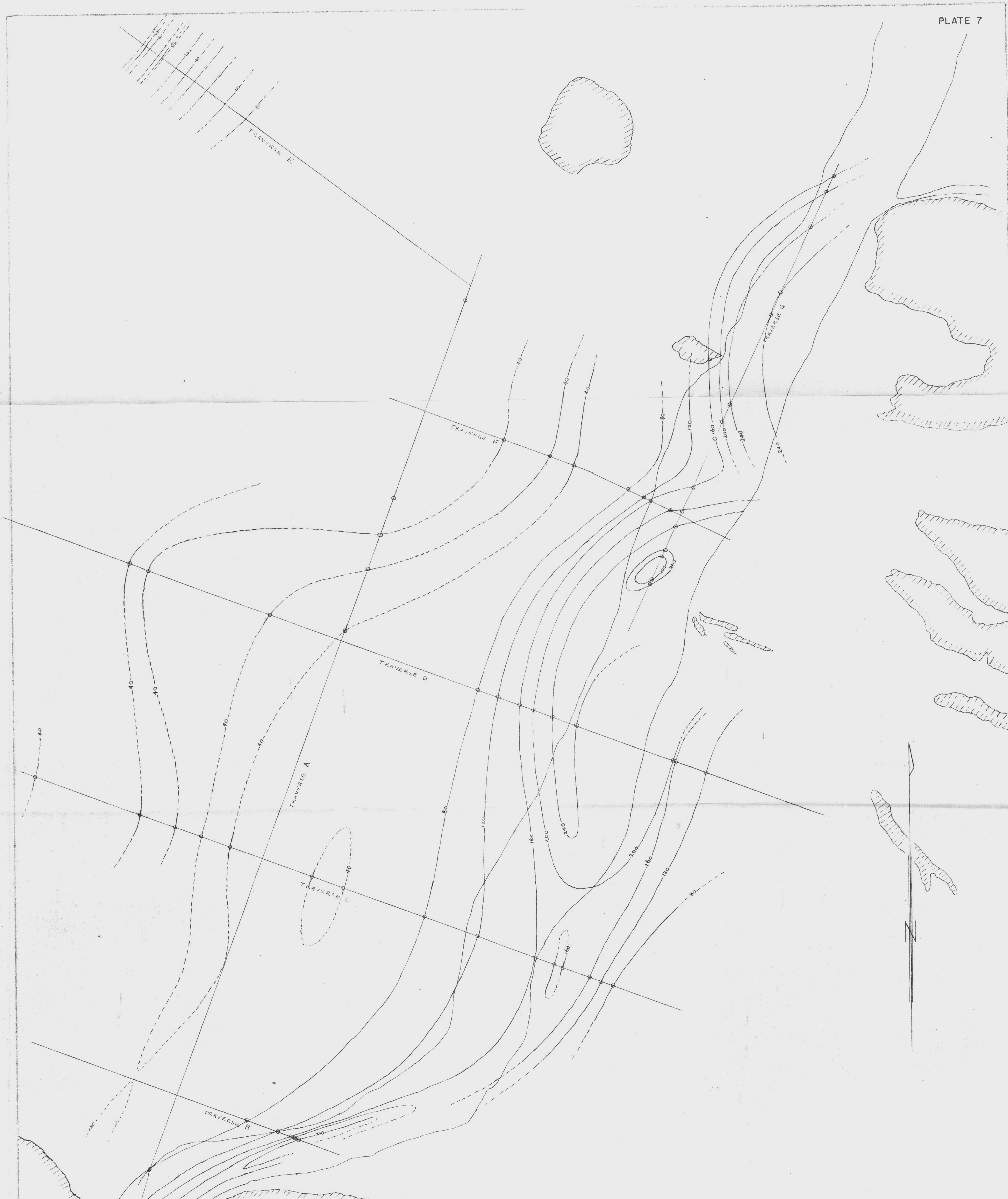
GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS N. T.

BASIN AREA RESISTIVITY CONTOURS

100-FT. ELECTRODE SPACING

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G 63-17



LEGEND

o RESISTIVITY CONTROL POINT
CONTOUR INTERVAL 40 OHM-METRES

ROCK OUTCROP

GEOPHYSICISTS:

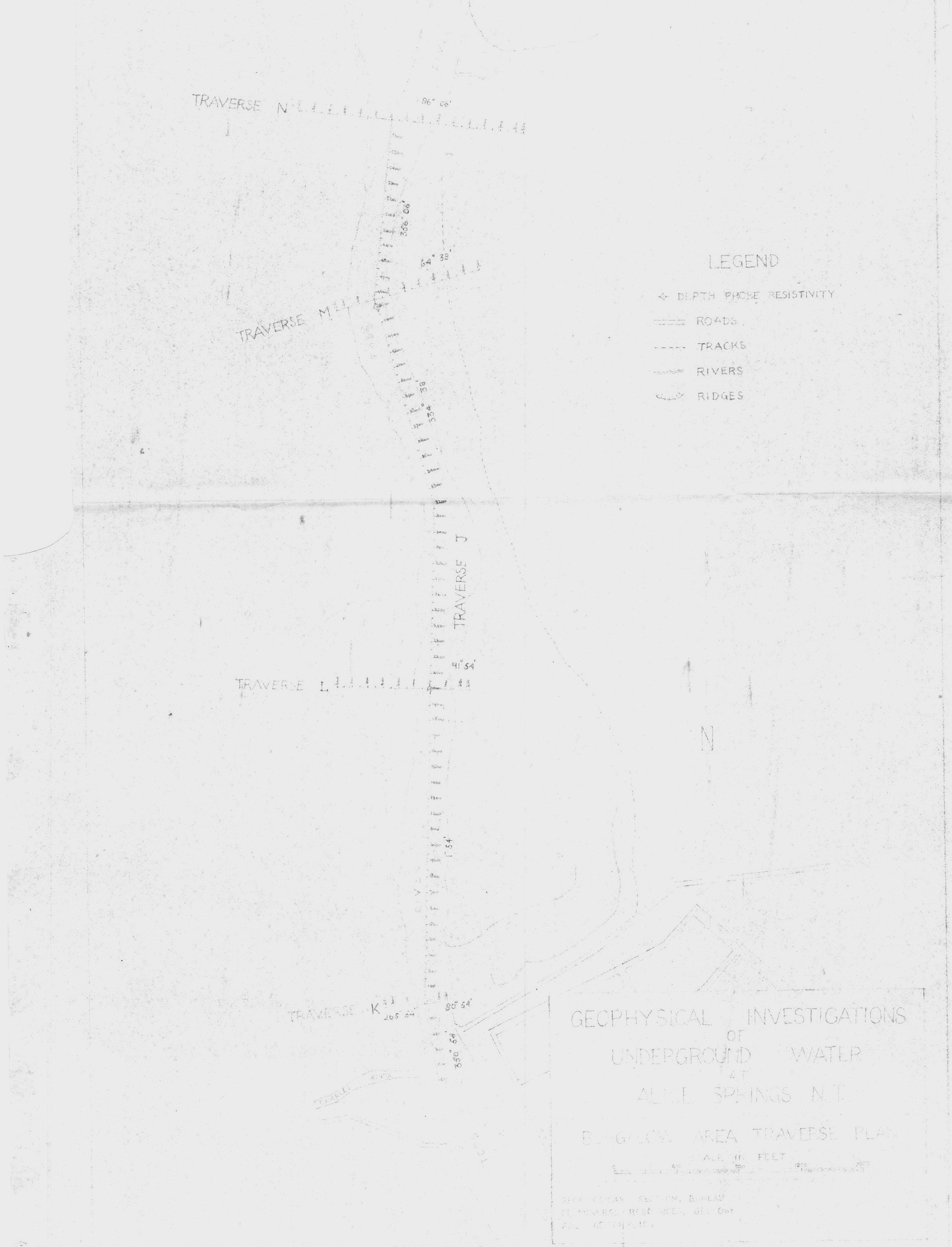
GEOPHYSICAL INVESTIGATIONS
OF
UNDERGROUND WATER AT ALICE SPRINGS, N.T.

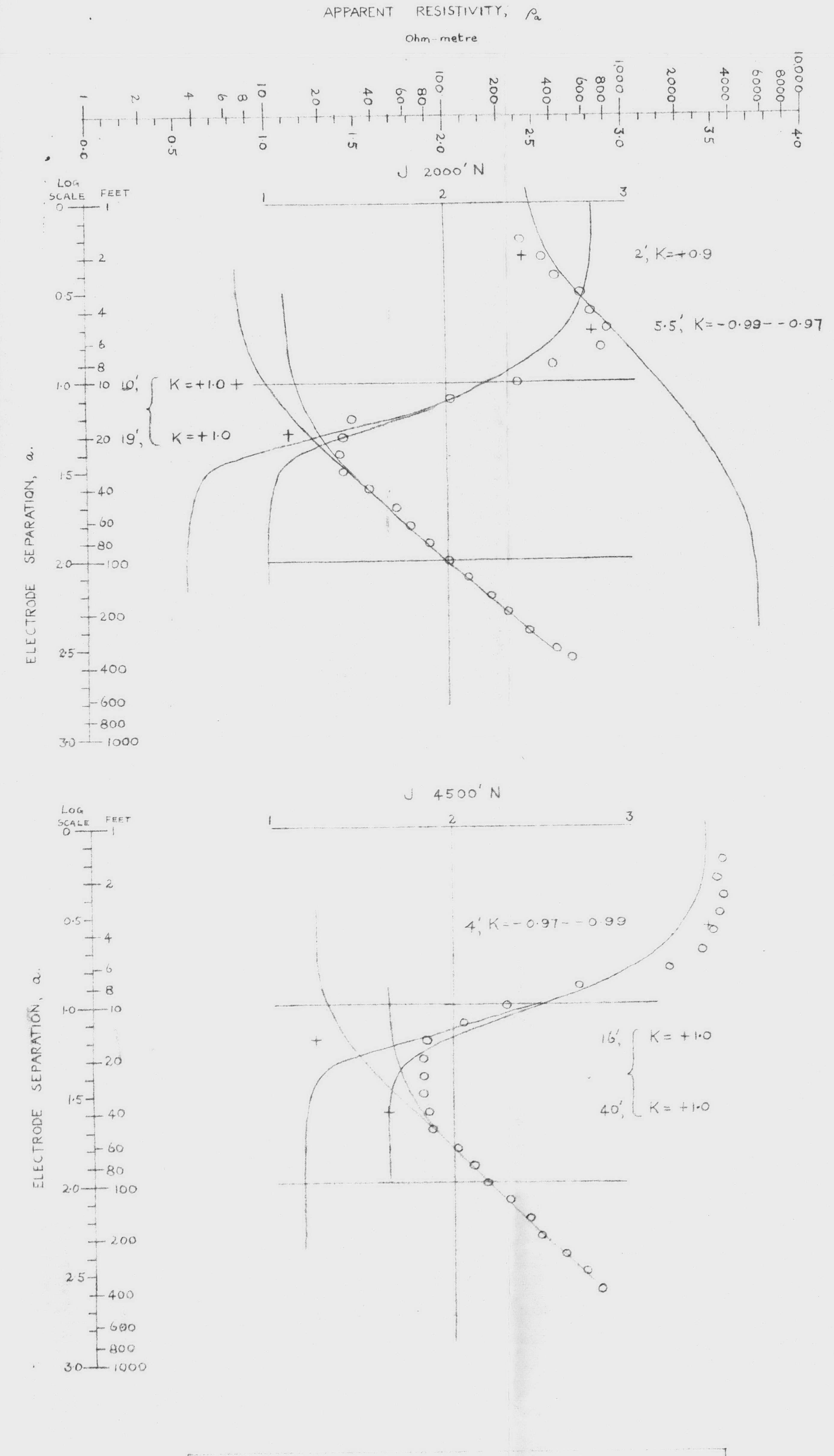
BASIN AREA RESISTIVITY CONTOURS
200-FT. ELECTRODE SPACING

SCALE IN FEET
0 400 800 1200 1600 2000

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G 63-18


TRAVERSE N
86° 06'
356° 06'
64° 38'
TRAVERSE M
334° 38'
TRAVERSE J
91° 54'
TRAVERSE L
1° 54'
TRAVERSE K
265 54
80° 54'
350° 54'
LEGEND
DEPTH PROBE RESISTIVITY
ROADS
TRACKS
RIVERS
RIDGES
N
GEOPHYSICAL INVESTIGATIONS
OF
UNDERGROUND WATER
AT
SPRINGS N.T.
AREA
SCALE IN FEET
0
400
800
1200
1600



GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS, N.T..

BUNGALOW AREA

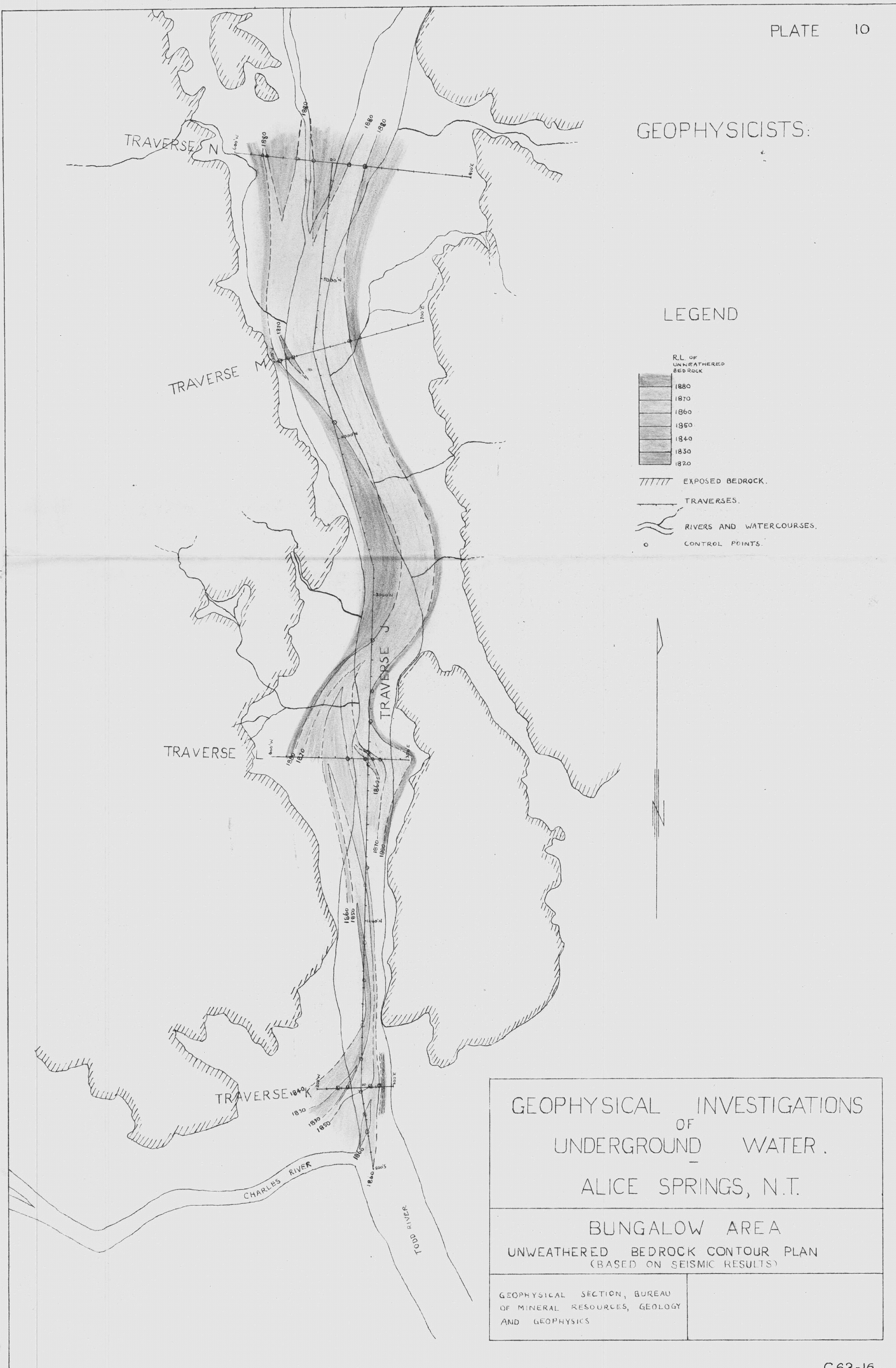
SEISMIC AND RESISTIVITY PROFILES.

RESISTIVITY DEPTH PROBES.

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

G63-11

PLATE 10



GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER.

ALICE SPRINGS, N.T.

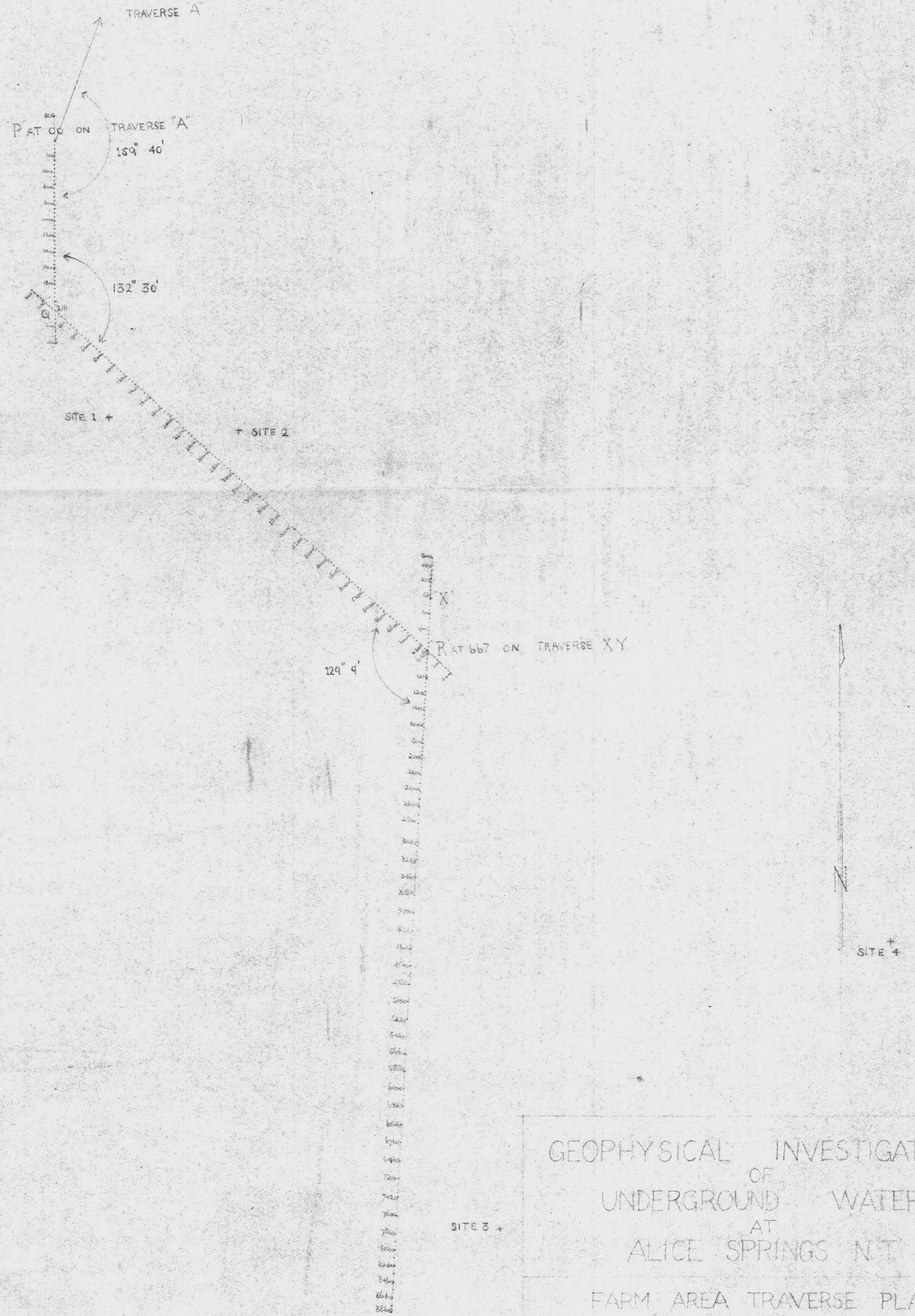
BUNGALOW AREA

UNWEATHERED BEDROCK CONTOUR PLAN

(BASED ON SEISMIC RESULTS)

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

G63-16



GEOPHYSICAL INVESTIGATIONS OF UNDERGROUND WATER AT ALICE SPRINGS N.T.

FARM AREA TRAVERSE PLAN
RESISTIVITY PROBE SITES Nos 1, 2, 3 AND 4.

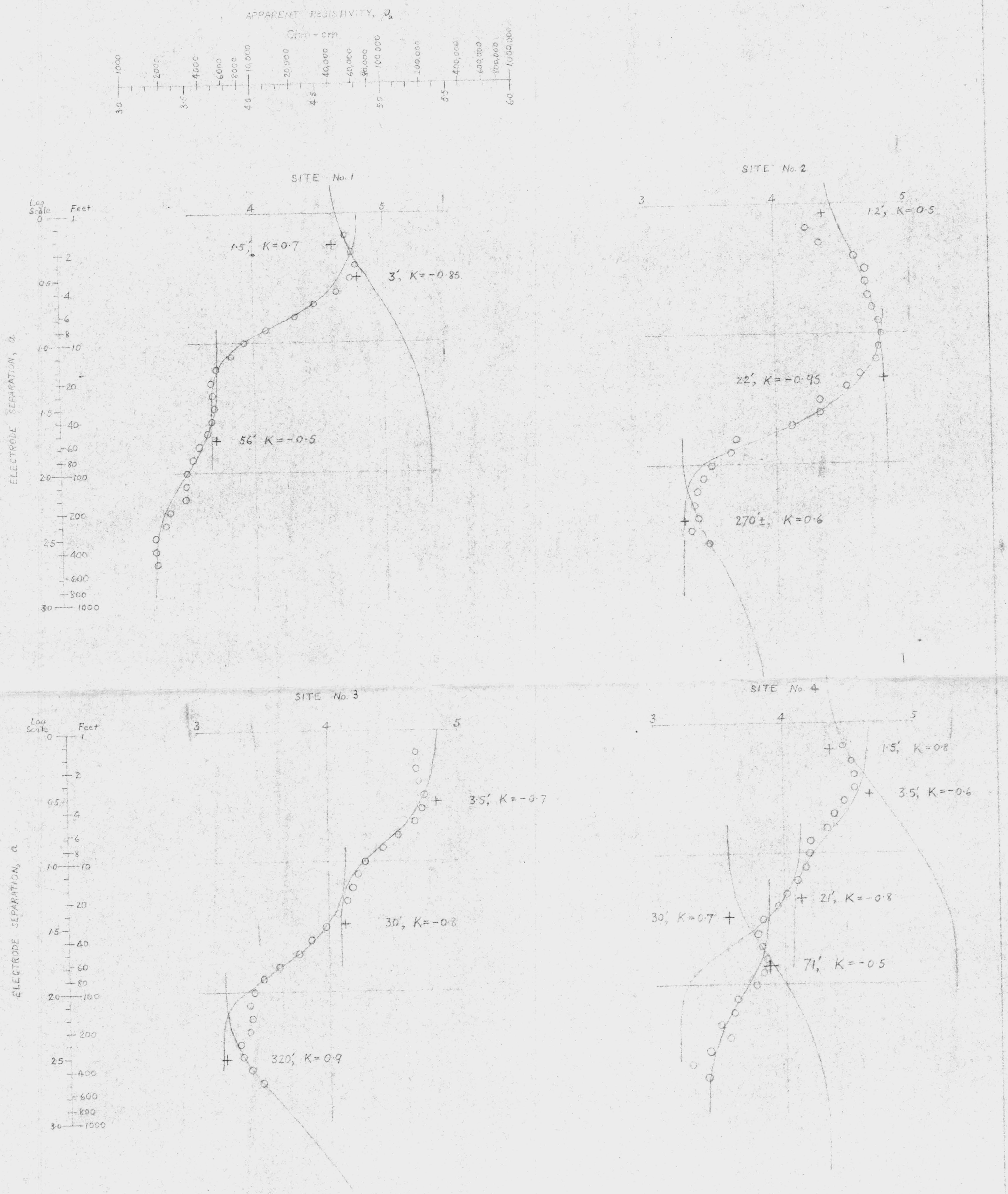
SCALE IN FEET

0 1000 2000 3000 4000

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

G63-12


P
Q
O
R
F
F
X
Y
(3600)
(5600)
(10,500)
(10,000)
(12,000)
(12,300)
(8,700)
(7,850)
(8,350)
(8,050)
(8,300)
(11,000 - 11,000)
(12,000)
GEOPHYSICAL INVESTIGATIONS
OF
UNDERGROUND WATER AT ALICE SPRINGS, N.T.
FARM AREA
SEISMIC REFRACTION PROFILES
SCALE
HORIZONTAL
VERTICAL
0 50 100 200 300 400
0 50 100 200
(3600)
F — — — — F
FAULT
G63-14



GEOPHYSICAL INVESTIGATIONS
OF
UNDERGROUND WATER
AT
ALICE SPRINGS N.T.

FARM AREA
RESISTIVITY DEPTH PROBES

GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

G 63-15