PLANNING GROUP

2088/5
Folio 16.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

RECORDS 1960 No. 63

MARY RIVER 167.8M DAM SITE, SEISMIC REFRACTION SURVEY, QUEENSLAND 1959.

by

W.A. Wiebenga and B.J. Bamber

RECORDS 1960 No. 63

RECORDS 1960 No. 63

MARY RIVER 167.8M DAM SITE, SEISMIC REFRACTION SURVEY, QUEENSLAND 1959.

by

W.A. Wiebenga and B.J. Bamber

CONTENTS.

		Page
	ABSTRACT	(ii)
1.	INTRODUCTION	1
2.	GEOLOGY	1
3.	METHODS AND EQUIPMENT	1
4.	RESULTS	2
	South-east bank.	2
	River bed and lower flood terrace.	2
	North-west bank.	3
	Accuracy of depth determinations.	3
	Velocities.	4
	Elastic properties.	4
5.	CONCLUSIONS	5
6.	REFERENCES.	5

ILLUSTRATIONS.

Plate 1. Locality map (G331-4).

Plate 2. Layout of traverses (G331-2).

Plate 3. Cross-sections along traverses (G331-3).

ABSTRACT.

This report describes the results of a seismic refraction survey of the Mary River 167.8 Mile dam site near Kenilworth, Queensland. The survey was made at the request of the Queensland Irrigation and Water Supply Commission.

On the steep south-east bank the depth to unweathered rock varies from about 20 to 50 ft. At some places an intermediate layer was found between the highly weathered and the unweathered rock; this layer may be formed by hillside creep.

In the river bed the depth to unweathered rock is 32 $\pm$ 6 ft; at the lower flood terrace between 28 and 49 ft.

On the gently sloping north-west bank, the depth to unweathered rock varies between about 30 and 60 ft.

1. INTRODUCTION.

The Irrigation and Water Supply Commission (I.W.S.C.) of Queensland intends to build a dam on the Mary River about 2 miles south of Kenilworth. The purpose of the dam is to provide water storage, to control the flow of water, and to ensure continuity of the water supply for farms down stream from the dam site. The Commission refers to the dam site as the Mary River 167.8M dam site. The approximate co-ordinates of the centre of the site are 450/200 on the Gympie 4-mile military sheet.

At the request of the Commission, the Bureau of Mineral Resources carried out a seismic refraction survey to determine the depth and if possible the type of foundation rock at the dam site. Geological information on the area was available from a memorandum by R.A. Dunlop (geologist) to the Commission's Senior Planning Engineer.

The survey was carried out by a geophysical party of the Bureau with W.A. Wiebenga, geophysicist as party leader, B.J. Bamber, geophysicist, and J. Piggott, geophysical assistant. It lasted from 15th to 23rd September 1959. The Commission did the topographical surveying and supplied four field assistants to help with the geophysical work.

2. GEOLOGY.

The wide Mary river valley has at the site a steep south-east bank, and a gently sloping north-west bank, with two terraces (plate 3 traverse X). There are many outcrops of metamorphic rock, pebbles, greywacke and sandy slate at the base of the steep S-E. bank. Quartz veinlets are present throughout the metamorphics.

The bedding planes strike at about 140° to 150° magnetic, and dip south-west at 50° to 60°. Outcrops exhibit close jointing and minor faulting; joints and faults are tightly re-cemented with quartz.

The gently sloping N-W. bank consists of soil with many floaters of metamorphic rock. The tailings of an old bore indicate that the country rock consists of greywacke, hard blue slate, and hard green andesite; the order in which these rocks occur is not known.

Alluvium consisting of sand, sand-silt mixtures, and some gravel, is found in the river bed and on the two flood terraces.

3. METHODS.

For a description of the seismic refraction technique used in this survey, reference is made to a recent report of a survey for the Commission by Polak and Mann (1959).

The equipment used was a 12-channel portable shallow-reflection/refraction seismograph manufactured by the Midwestern Geophysical Laboratory of Tulsa, Oklahoma; the Midwestern geophones used have a natural frequency of about 8 c/s, and respond only to vertical movement of the ground.

To calculate the elastic properties of a refractor the ratio between traverse and longitudinal wave velocities should be measured, together with the longitudinal wave velocity. This is expressed by the following formulae from Leet (1950, p.45):-

$$V_P^2/V_S^2 = (\sigma - 1)(\sigma - \tfrac{1}{2}) \quad \text{and}$$

$$E = V_P^2\, d \cdot \frac{(1 + \sigma)(1 - 2\sigma)}{1 - \sigma}$$

in which V_P is longitudinal wave velocity

V_S is transverse wave velocity

d is density

σ is Poisson's ratio

E is Young's Modulus.

If the first three items are expressed in C.G.S. units, E will be in dyn/cm^2.

To record the arrival time of the transverse waves, S.I.E. horizontal geophones of 6 c/s natural frequency and a T.I.C. 3-component well geophone of natural frequency 19 c/s were used.

4. RESULTS.

Plate 1 is a locality map, plate 2 shows the layout of traverses, and plate 3 shows cross-sections along traverses, with the seismic results.

South-east bank.

The results show that on the steep hillside the thickness of soil or unconsolidated matter (seismic velocity 1,000 ft/sec) is only about 2 to 4 ft. It is slightly greater at station A15 (thickness about 8 ft.), probably owing to a gully.

Below the soil a layer with a seismic velocity of 5,000 to 5,600 ft/sec and a thickness between 20 and 50 ft., represents the highly weathered bedrock, overlying an unweathered bedrock with a seismic velocity of 14,000 to 16,000 ft/sec.

At X7, A8 and A15 an intermediate layer of seismic velocity 8,000 to 10,000 ft/sec was found within the unweathered bedrock mentioned above. This layer probably represents a fractured, partially weathered bedrock and because it is on the steep bank, it may be caused by hillside creep. It may be present elsewhere on traverses X and A, but if so, it is too thin to be detected.

The depth to the unweathered bedrock may be under-estimated by a maximum of 15 to 30 ft. on the remainder of the X traverse where the intermediate layer was not found.

Near X6 and X10 along traverse X, the unweathered rock profile is stepped. At A7 and A15 also there are sharp steps which may be related to the strike of the bedrock (approximately perpendicular to traverse A).

River Bed and lower flood terrace.

In the river bed at X16, the thickness of the water-saturated alluvium overlying unweathered bedrock is 32 ± 6 ft.

On the lower flood terrace, at X20, the thickness of unconsolidated alluvium overlying unweathered bedrock is about 28 ft. The seismic velocity of 920 ft/sec found for this alluvial material indicates that during the survey the alluvium was not saturated with water. A layer of water-saturated alluvium (seismic velocity about 5,400 ft/sec) too thin to be detected by the seismic method employed for this survey could be present, and might result in the depth to unweathered bedrock being under-estimated by as much as 21 ft.

North-west bank.

The area between X23 and X32, in which traverse B is located, is a river terrace. The soil thickness here varies between 2 and 6 ft. Between the surface soil and the unweathered bedrock there is a layer with seismic velocities of between 4,800 and 6,000 ft/sec which may be interpreted as alluvial material. The depth to unweathered bedrock is about 30 ft. near X23, close to the river, and increases to a maximum of 55 ft. at X31.

On the hill slope between X32 and X45, and along traverse D, the soil thickness varies between 4 ft. at X35 and 21 ft. at D21. The seismic velocity found for weathered bedrock varies between 4,500 and 6,000 ft/sec. Along traverses X and A the depth to unweathered bedrock varies between 40 and 60 ft.

The transition between the weathered hillside material (eluvium) and the alluvium of the river terrace could not be recognized from the seismic records.

Accuracy of depth determinations.

In calculations by the method of differences the depth to a seismic discontinuity is expressed as the product of "time-depth" and an apparent velocity :

$$D = TV$$

in which D is depth

T is time-depth

V is apparent velocity

Assuming that errors in D, T, and V may be represented by dD, dT, and dV, the relative error in D is given by

$$(dD)/D = (dT)/T + (dV)/V$$

From the computations it appears that the average error in T, irrespective of sign, is 1.1 millisecond, or that the root-mean-square error in T from 18 observations is 1.3 millisec. The average time-depth for all traverses is about 12 millisec ; if the error dT is taken as 1.2 millisec. then the relative error (dT)/T is about 0.1, or 10 per cent.

It is difficult to estimate the relative error (dV)/V but the variations of seismic velocity in the weathered layers indicate that they too are probably about 10 per cent.

Hence (dD)/D is about 20 per cent; that is, the average error in D irrespective of sign, or the root-mean-square error in D, is about 20 per cent. The average error in D may be larger than 20 per cent if a layer is present which is too thin to be detected by the seismic method adopted for this survey. For instance near X20 on the flood terrace, the depth to bedrock could be 49 ft. instead of the 28 ft. indicated on the cross-section.

Velocities.

Although the principal objective of the seismic method is determination of the depth to elastic discontinuities, the seismic velocities are an indication of weathering, jointing, and fracturing of the rock. In general terms it may be said that the higher the seismic velocity the more consolidated the sediments are, or the less fractured, jointed, and weathered the bedrock.

Table 1 lists the interpretation in geological terms of the seismic velocities indicated on the sections of plate 2.

TABLE 1.

SEISMIC VELOCITY IN FT/SEC	ROCK TYPE
800 to 1,800	soil, unconsolidated material
4,500 to 6,000	wet sand or alluvium, consolidated weathered material, highly weathered bedrock, eluvium.
8,000 to 10,000	fractured or jointed bedrock, partially weathered.
13,000 to 18,000	slightly weathered to unweathered bedrock.

Elastic Properties.

The elastic properties (see 3. Methods) of the unweathered bedrock were determined on the N-W bank between X35 and X45 where, according to geological information, the bedrock consists of greywacke, slate, or andesite.

Poisson's ratio was computed from the travel-times of longitudinal and transverse waves, recorded by the 3-component geophone. As usual, charges were fired in shallow shot-holes, and corrections for the depth of the refractor were applied to the observed travel-times. The average Poisson's ratio calculated from three sets of observations was 0.373 ± 0.004.

A Poisson's ratio of 0.37 was calculated also from measurements using horizontal and vertical geophones. The transverse wave recorded by the horizontal geophone was obtained with the moving coil of the geophone vibrating in a plane perpendicular to the line joining shot and geophone.

The value adopted for Poisson's ratio for the unweathered bedrock at this point is 0.37 ± 0.01. With a longitudinal-wave velocity of 17,000 ft/sec, and an estimated rock density of 2.60, Young's modulus is 3.9×10^{11} dyn/cm^2, or 5.7×10^6 lbs/sq in. This result is probably accurate within 5 per cent.

Experimental evidence shows that the values of all elastic properties obtained by dynamical methods (seismic wave propagation) are generally higher than those obtained statically (U.S. Bureau of Reclamation, 1953).

5. CONCLUSIONS

The geophysical survey provided information on the depth to bedrock and on the rock types.

If it is desired to check the geophysical results along traverse X by drilling, the following localities are suggested :-

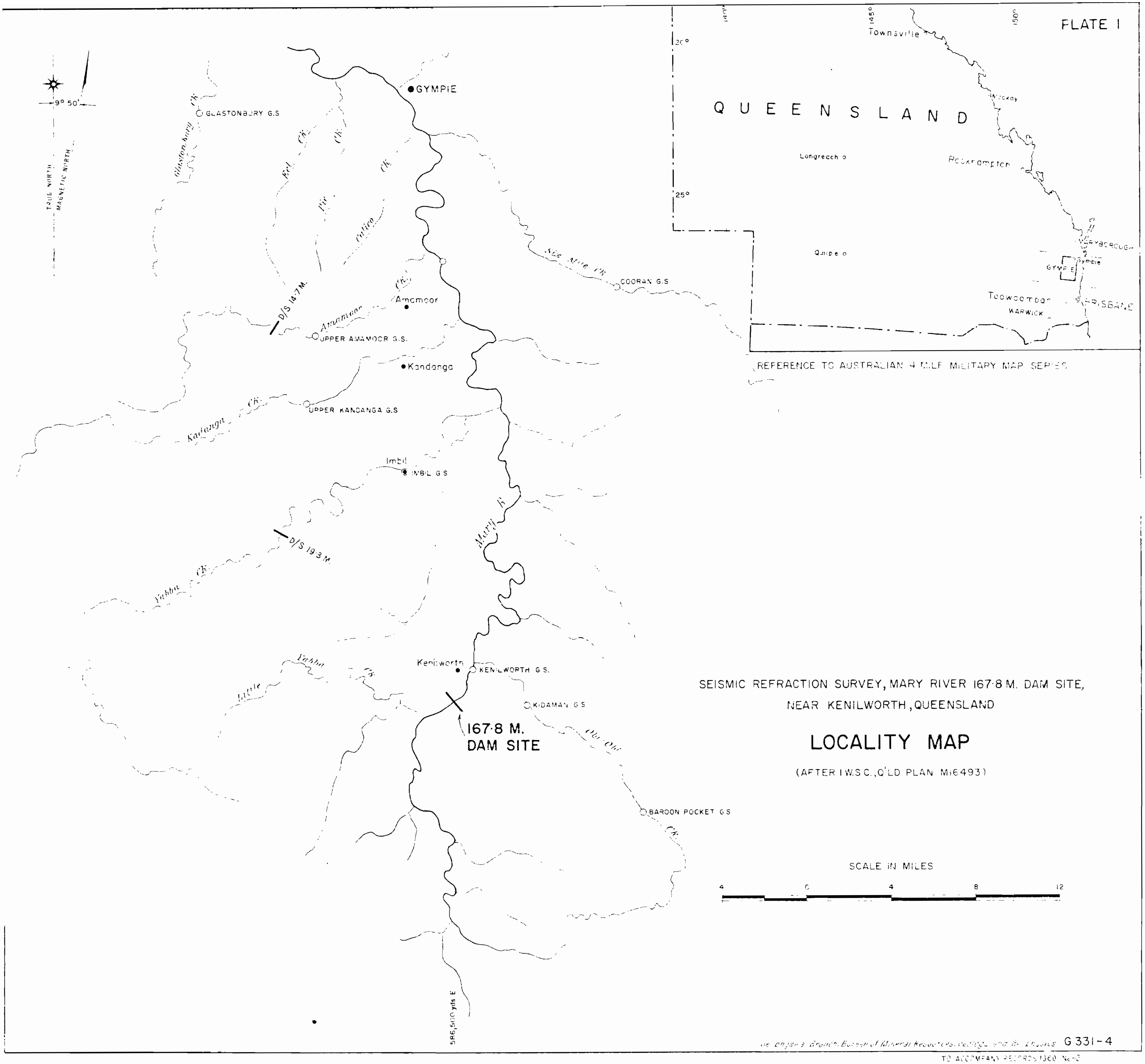
X6	To check the depth of the 8,300 ft/sec layer
X10 and X11	To check the existence of sub-surface platform
X20	To check whether there is a layer between the unconsolidated sand and the bedrock
X25 and X35	To check the nature of the 4,500 to 6,000 ft/sec layer and the depth to unweathered bedrock.

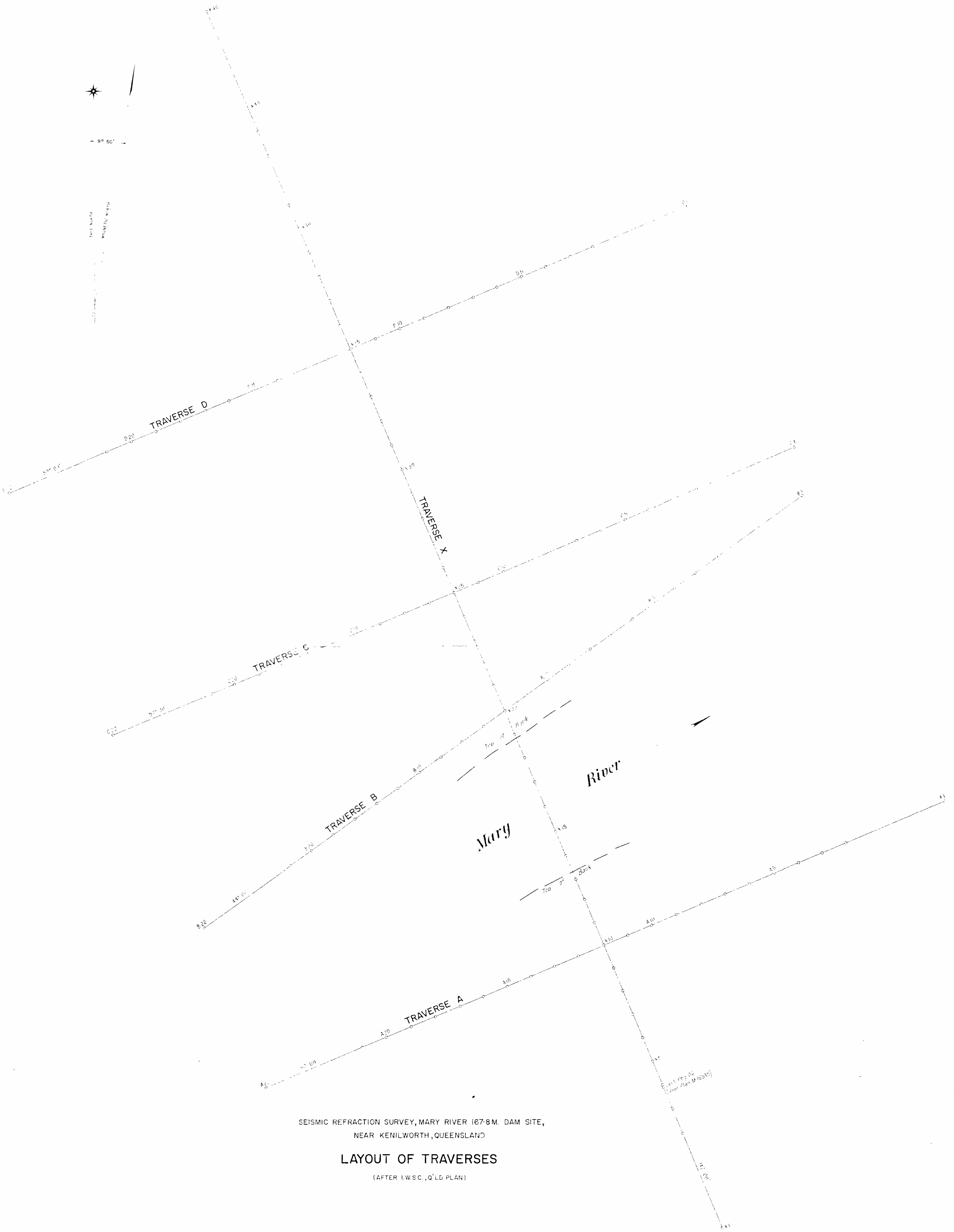
6. REFERENCES

LEET, L.D., 1950 - EARTH WAVES. Harvard University Press, Cambridge, Mass.

POLAK, E.J., and MANN, P.E., 1959 - A seismic refraction survey at the Moogerah dam site near Kalbar, Queensland. Bur. Min. Resour. Aust. Rec. 1959/62.

U.S. BUREAU OF RECLAMATION, 1953 - Physical properties of some typical foundation rocks, concrete laboratory, S.P.39.


FLATE I
QUEENSLAND
Townsville
Mackay
Longreach
Rockhampton
Quilpie
Maryborough
Gympie
GYMPIE
Toowoomba
BRISBANE
WARWICK
20°
25°
145°
150°
REFERENCE TO AUSTRALIAN 4 MILE MILITARY MAP SERIES
TRUE NORTH
MAGNETIC NORTH
9° 50'
GYMPIE
GLASTONBURY G.S
Glastonbury Ck.
Eel Ck.
Ck.
Calico Ck.
Six Mile Ck.
COORAN G.S
D/S 14·7 M.
Amamoor Ck.
Amamoor
UPPER AMAMOOR G.S.
Kandanga
Kandanga Ck.
UPPER KANDANGA G.S
Imbil
IMBIL G.S
Mary R.
D/S 19·3 M.
Yabba Ck.
Little Yabba Ck.
Kenilworth
KENILWORTH G.S.
KIDAMAN G.S
Obi Obi
167·8 M.
DAM SITE
BAROON POCKET G.S
Ck.
SEISMIC REFRACTION SURVEY, MARY RIVER 167·8 M. DAM SITE,
NEAR KENILWORTH, QUEENSLAND
LOCALITY MAP
(AFTER I.W.S.C., Q'LD PLAN M16493)
SCALE IN MILES
4
0
4
8
12
586,500 yds E
G 331-4
TO ACCOMPANY RECORDS 1960 No.2



SEISMIC REFRACTION SURVEY, MARY RIVER 167·8M. DAM SITE,
NEAR KENILWORTH, QUEENSLAND

LAYOUT OF TRAVERSES

(AFTER I.W.S.C., Q'LD PLAN)

SCALE IN FEET

100 0 100 200 300 400

AZIMUTH DATUM MAGNETIC

PLATE 3

SEISMIC REFRACTION SURVEY, MARY RIVER 167.8 M. DAM SITE,
NEAR KENILWORTH, QUEENSLAND

TRAVERSES X, A, B, C AND D SECTIONS

(AFTER I.W.S.C. (QLD.) PLAN)

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G331-3
To accompany Records 1960, No. 63