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LAE HYDRO-ELECTRIC PROJECTS, NEW GUINEA

RECONNAISSANCE GEOLOGICAL INVESTIGATION OF THE UPPER RAMU SCHEME

by

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SUMMARY

A geological reconnaissance has been made of the Upper Ramu gorge as a possible site for a hydro electric scheme.

The gorge is cut into hard (?) Palaeozoic metamorphic rock and comparatively fresh granodiorite which should provide adequate foundations for hydro-electric installations.

Less competent formations consisting of Tertiary(?) Limestone, possibly Tertiary volcanics and Pleistocene lake sediments overlie the metamorphics and granodiorite, but on present information, hydro-electric installations would be below the level of these younger rocks.

Additional investigation should await the design of a power scheme and its location on the grouhd; detailed geological mapping and examination of foundations would then be carried out on the sites of weir, pipeline and power station. The diamond drilling programme would be modest.

INTRODUCTION

The Ramu River hydro-electric scheme, a possible alternative to the Sankwep River Scheme, involves the construction of a small dam or weir in the Ramu at the head of a gorge approximately 75 miles north-west of Lae and 7 miles east-north-east of Kainantu, and a pipeline and penstock to a power-station a mile or two downstream. A preliminary geological investigation was made on 3rd and 4th December, 1958, by L.C. Noakes, D.E. Gardner, and D.B. Dow of the Bureau of Mineral Resources, who visited the area in company with R.Gruber of the Department of Works, Port Moresby. Access to the area is by means of the road to the Eastern Highlands via Markham Valley (see Plate 1).

This road has been constructed mainly by Patrol Officers, grades are steep over the Cassan Pass and a number of bridges are not adequate for heavy loads. However, the body of a Junkers Aircraft has been successfully transported by low-loader over this road from Lae to Goroka, and on this evidence, the present road with little improvement could provide access to the Upper Ramu for machinery weighing 10 to 15 tons.

TOPOGRAPHY (Plate 2)

Above its junction with Yonki Creek the valley of the Ramu is relatively shallow. Below the junction for several miles the river flows through a deep gorge and the gradient of its bed is steep. Following is a table showing the approximate fall in river bed level at increasing distances downstream from Yonki Creek.

Distance downstream from Yonki Creek	Fall in river bed level
½ mile	45 feet
2 miles	351 feet
3¼ miles	660 feet

The area is treeless for the most part, and covered by a thick growth of Kunai grass; patches of rain forest occur in most of the gullies and extend along the river itself. (See Plate 2). Rock outcrops are not plentiful except in the lower slopes of the gorge itself.

GEOLOGY (Plate 3)

The upper part of the Ramu Gorge is cut into a meta - morphosed, steeply dipping (?)Palaeozoic sequence which consists of greywacke, chert, lava, tuff and limestone; these contain numerous dykes and probable sills of fine grained gabbro. The silicification of the sediments has been brought about by the basics and to some extent by granodiorite which outcrops in the gorge some 3½ miles downstream from Yonki Creek, and underlies much of the country west from the gorge. The metamorphic rocks have been intensely folded.

In the upper slopes of the gorge, in places, are found limestone and isolated outcrops of andesitic volcanics which appear to be younger than the metamorphics and resting unconformably upon them; the limestone does not appear to be intruded by the granod-iorite and is presumably of Tertiary age.

Above all of these rocks lies a veneer of horizontally bedded Pleistocene lake beds which obscure many of the contacts between one rock type and another.

The proposed hydro-electric scheme will be founded in the metamorphic rocks but could extend into the granodiorite; it would not impinge to any extent onto any of the younger rocks.

METAMORPHIC ROCKS

At the junction between Yonki Creek and the Ramu River, weathered rock at the head of the gorge consists of greywacke with finer grained interbeds of tuff or shale, silicified into hard hornfels. These strike 65° * and dip northwards (upstream) at 50°; they are jointed and in places show minor faults but are not shattered or sheared.

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* All Bearings based on magnetic north.

At locality 35, about half a mile downstream, silicified, banded metamorphic rocks are cut by a basic dyke 50 to 60 feet wide, steep to vertical, from which small sills appear to have been intruded between the bedding. Immediately downstream, the metamorphics are shattered in a fault zone four feet wide that trends 10^{o} north of east.

At locality 22 at the edge of the river bed, two miles downstream from Yonki Creek, the country rock consists of black hornfelsed, finely-banded, cherty sediment, which contains thin bands of fine-grained, grey quartzite. The dip ranges from 35^{o} to 50^{o} east, and the change in dip appears to be a result of dragging adjacent to a small meridional fault. At about 80 feet upstream a small basic (?) sill appears to be folded with the sedimentary beds, and within a further 200 feet the succession is made up mainly of fine-grained basic volcanics probably flows, and coarse-grained basic dykes and (?) sills.

At locality 36, some three and a quarter miles down the gorge from Yonki Creek, a bed of limestone over one hundred feet thick has been altered to white marble either by the neighbouring granodiorite or by minor intrusive tongues of basic igneous rock or by both. Both marble and tongues of basic rock are tough compact rocks and form cliffs; the marble shows some contortion but bedding where observed, strikes north-east and dips 80^{o} northward. The attitude of cleavage suggests that the limestone is overturned at this locality. Prominent joint planes trend north and west.

At other places on the lower slopes of the gorge, sporadic outcrops of hard volcanics or hornfelsed sediments occur; comparatively fresh rocks must be close to the surface along these slopes which are too steep to retain more than a veneer of scree or weathered material.

GRANODIORITE

The term 'granodiorite' is used in this report because the igneous rock observed in the gorge appears mainly of this acid-intermediate composition; however, regional work by Bureau geologists in this general area suggests that the granitic rock is a composite body or bodies ranging in type from gabbro (basic) to acid granitic types. In fact, the smaller basic intrusives found in the metamorphic rocks and the granodiorite noted in this survey may be co-magmatic and part of the same intrusive phase.

No petrological details of the granodiorite exposed in the gorge are available but the rock is fairly fresh; the major points trend 0^{o} 30^{o} and range in dip from 5^{o} to 10^{o} to near vertical. Minor joints trend easterly with near vertical inclinations where observed,

?TERTIARY LIMESTONE

Limestone crops out sporadically on the higher slopes of the gorge and in a tributary stream north of the mission station. It appears to be gently folded and to rest unconformably on the metamorphic rocks; the granodiorite appears to be older than the limestone. A creek half a mile north of the mission station disappears underground into the limestone which is honeycombed with solution cavities. The boundaries shown on Plate 3 have been interpreted from air photo.

ANDESITIC VOLCANICS

Many of the spurs leading to the gorge are benched some 400 - 600 feet above the river. At locality 3 (Plate 3) the bench is floored by metamorphic rocks and this probably is the case at other localities. Above the bench, the surface is underlain by clay and no outcrops have been found. On the bench and on the slopes for a short distance below it, detritus of massive andesitic volcanic rock which shows little shearing, is found in fragments that range from one foot or so up to about three feet in diameter. This andesite is not a constituent of the metamorphic rocks inspected in the gorge below, and appears to belong to a younger formation. The weathered rock material above the benches may therefore represent remnants of (?) Tertiary volcanics similar to those mapped by Bureau geologists several miles to the north-east and north, beyond the immediate vicinity of the gorge. The possible boundaries of these volcanic remnants, shown on Plate 3, have been interpreted from air photos.

LAKE SEDIMENTS

These consist of poorly compacted clayey beds, rudely stratified, which occupy a shallow irregular basin in the higher terrain west of the Ramu Gorge. In comparatively recent times, the local streams have cut well below the level of the old lake and continue to actively erode its sediments. The floor of the erstwhile lake shows definite relief but a thickness of about 200 feet of sediment remains, in places, between the head of the gorge and the mission station.

ENGINEERING GEOLOGY

ROCK TYPES AND FOUNDATION CONDITIONS

Proposed installations would be founded on metamorphic rocks or possibly on granodiorite; Tertiary limestone and lake sediments, and Tertiary Volcanics where extensively weathered, would provide poor foundations, but these, on present data, are above the level of the proposed works.

Metamorphic Rocks

Metamorphics exposed in the gorge are very hard resistant rocks, which will provide good foundations. The slopes are so steep that comparatively unweathered rock is expected close to the surface.

Granodiorite

It seems unlikely that an initial power scheme would extend downstream into the granodiorite but in that event, foundation conditions would still be satisfactory. Although a somewhat deeper zone of weathering can be expected on the slopes in the granodiorite than in the metamorphics, a bench for a pipe line, anchors for penstocks or foundations for a power station should present no difficulties.

Andesitic Volcanics

These are likely to provide poor foundations only where they have been extensively weathered; moreover, on present data any installations would lie below their outcrop in the gorge. They require more detailed study, however, because, if they are in fact younger than the metamorphics, the unconformity between the two formations, e.g. the old land surface on which the volcanics were deposited, will need to be traced; if this old surface had noticeable relief, the volcanics, in places, could extend farther down the slope than suggested in Plate 3, and might in places underlie the pipeline. In this event, the stability and foundation characteristics of the volcanics would be important.

SEISMIC ACTIVITY

The Upper Ramu area has a record of relatively low seismic activity in contrast to the region north of the Markham Valley. The area is some hundred miles distant from two epicentres which have proved to be fairly prolific sources of earthquakes - one to the north-east between Lae and Salamaua and the other on the Purari River to the south-west. Epicentres from which up to three earthquakes have been recorded lie 50 miles to the north-west, 75 miles west and 100 miles north-west of the Upper Ramu.

The few records available of seismic activity within the Upper Ramu area indicate that infrequent tremors of low intensity, perhaps two to three on the modified Mercalli scale, can be expected. However, intermediate-depth earthquakes of fair intensity occurring at either of the prolific sources to the north-east or north-west, mentioned above, might well give rise to an earthquake of intensity 6 on the modified Mercalli scale in the Upper Ramu area; this suggests that, although seismic activity in the area is generally low, it would be wise to allow for earthquake accelerations of at least .075g in designing hydro-electric installations, which should cover an odd shock of medium intensity.

ENGINEERING PROJECTS

Weir

In general, the walls of the gorge are formed in solid rock and the profile near the water level, is narrow and symmetrical. No difficulty is expected in finding a suitable weir site.

One which commends itself is at the gauging station, at the head of the gorge. The right bank is a cliff formed in silicified greywacke, hornfels and probably lava or tuff; the left bank is terraced and suitable abutments would lie some 100 feet back from the river. Immediately upstream from the site there is a useful pondage at the confluence of Yonki Creek with the Ramu River. This and other possible sites would need detailed investigation and diamond drilling.

Pipeline

It is assumed that a pipeline would be installed on the western side of the gorge; this side is the more accessible from the existing road and would provide a shorter route than would the eastern side.

A pipeline starting in the vicinity of the gauging station with a very gentle gradient, would be benched into solid metamorphic rock in the very steep lower slopes of the gorge for some one and a quarter miles along the river; in this distance five small gullies would be crossed.

In the next three-quarter mile, to the long spur situated in the re-entrant made by the river changing course from north to west, the slopes to be traversed by the pipeline are still very steep but are unbroken by gullies. It might be practicable to shorten the length of the pipeline by cutting through the long spur in the re-entrant instead of following the river; the spur is narrow at locality 18 and its crest appears to be not much more than one hundred feet higher than the level of the pipeline at that point; a tunnel two to three hundred feet long might obviate half a mile of pipe line. The route of the pipeline downstream from the long spur would traverse gentler slope in the metamorphics but would cross a number of sharp gullies which might have to be bridged. Gullies likely to need bridging are marked on Plate 2.

Insufficient geological information is available at present to relate the direction of the pipeline to the strike and dip of the metamorphics along the possible route; in general this relationship is not likely to be critical because the dip of the beds is normally steeper than the inclination of the slopes in which the bench would be cut.

Penstokks and Power Station

No proposed location for these installations has been suggested; in general, foundations on the spurs will be adequate; considerable excavation would be needed to instal a power station in most places because of the steepness of the spurs near river level. One possible site for a station, where a spur flattens somewhat in the vicinity of the river has been indicated on Plate 2; this locality was not examined on the ground but would provide about 600 feet of head from a pipeline starting at the head of the gorge.

ADDITIONAL INVESTIGATION

The reconnaissance has provided sufficient geological information to suggest that the next step should be the design of a scheme, the location of weir site, power station and penstocks and the preliminary pegging of the pipeline. Detailed geological investigation based on this design would then be carried out.

The foundations of all proposed installations would be examined and the geology mapped in detail where it bears directly on the design. Additional geological work, carried out before the scheme is located on the ground is likely to be wasteful.

Detailed investigations would include some drilling of proposed weir and power house sites; the examination of the pipeline would probably entail costeaning and auger holes rather than drilling unless a tunnel were planned. The drilling programme should therefore be very modest, of the order of 1,000 feet.

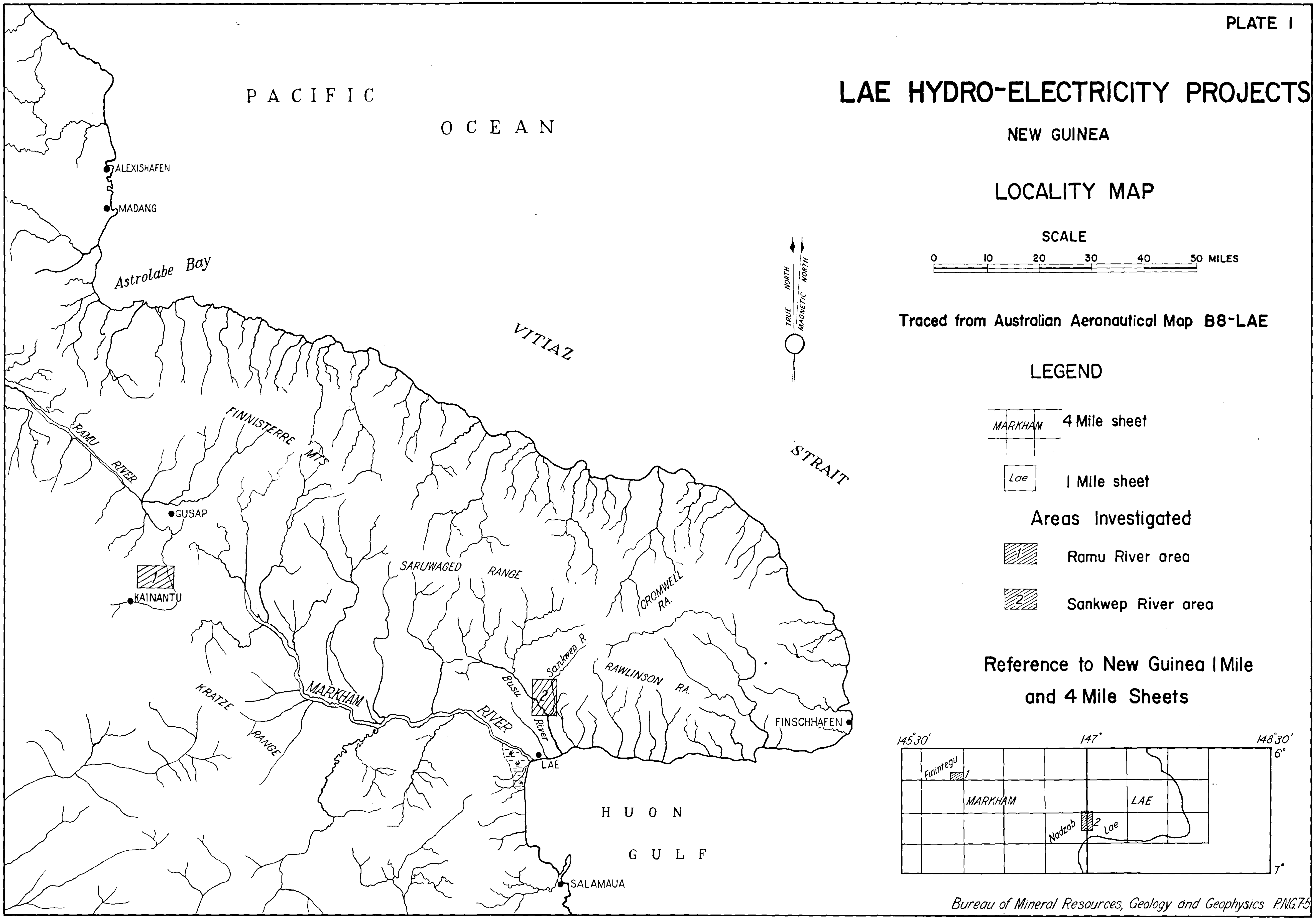
PLATE I
LAE HYDRO-ELECTRICITY PROJECTS
NEW GUINEA
LOCALITY MAP
SCALE
0 10 20 30 40 50 MILES
Traced from Australian Aeronautical Map B8-LAE
LEGEND
MARKHAM 4 Mile sheet
Lae 1 Mile sheet
Areas Investigated
1 Ramu River area
2 Sankwep River area
Reference to New Guinea I Mile and 4 Mile Sheets
145°30'
147°
148°30'
6°
7°
Finintegu 1
MARKHAM
LAE
Nadzab 2 Lae
TRUE NORTH
MAGNETIC NORTH
PACIFIC
OCEAN
ALEXISHAFEN
MADANG
Astrolabe Bay
VITIAZ
STRAIT
RAMU RIVER
FINNISTERRE MTS
GUSAP
KAINANTU
SARUWAGED RANGE
CROMWELL RA.
Sankwep R.
RAWLINSON RA.
Busu River
MARKHAM RIVER
KRATZE RANGE
FINSCHHAFEN
LAE
HUON
GULF
SALAMAUA
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LAE HYDRO-ELECTRICITY PROJECTS
NEW GUINEA–RAMU RIVER SCHEME

Plate 2.

Topographic Map

Scale

0 ¼ ½ ¾ 1 Mile

Photo scale: 1 inch = 0·38 mile *(approximate)*

REFERENCE

- 18 ● 3875 *Spot height*
- *Ridge*
- *Watercourse*
- *Road*
- B *Gully where pipeline may need to be supported by bridge or trestle*

Traced from:
Adastraphotos "Markham Valley Central Highlands Road"
859A, Run 5, 49–51
Run 5A, 5 and 6

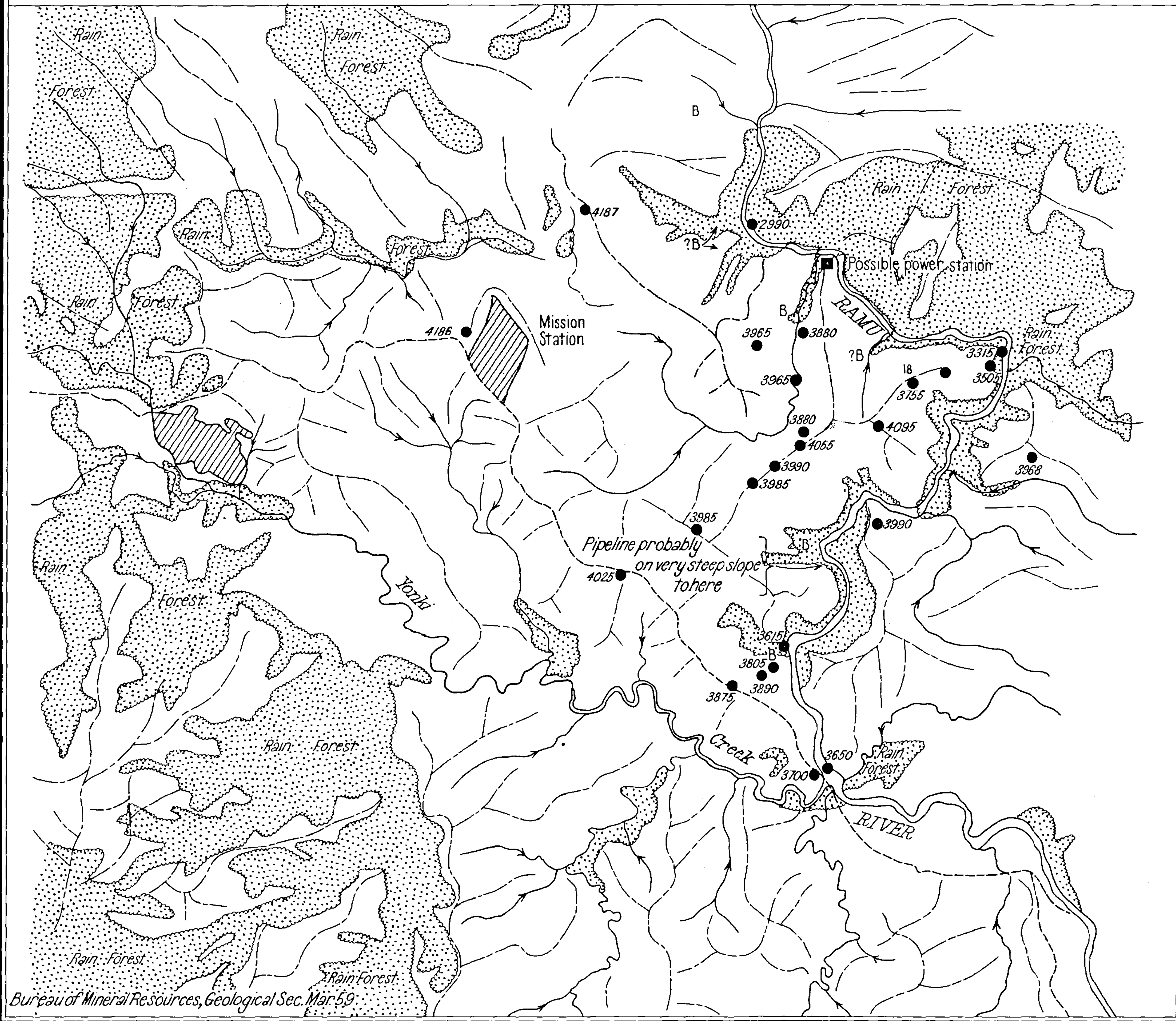

Plate 3.

Geological Sketch Map

by D.E. Gardner and L.C. Noakes

Scale

0 ¼ ½ ¾ 1 Mile

PLEISTOCENE		*Lacustrine sediments*
? TERTIARY		*Limestone*
? POST-MIOCENE		*Dioritic and granodioritic intrusives*
? MIOCENE		*Andesitic volcanic rocks*
? PALAEOZOIC		*Metamorphic rocks*

- *Strike and dip of bedding*
- *Horizontal bedding*

Interpreted from air-photographs

- *Dip of bedding*
- *Inclined jointing*
- *Vertical jointing*
- *Road*
- ◉3 *Field locality number*

True North

Magnetic North