SPECIAL REPORT

STRATEGIC ENGINEERING STUDY
No. 141

MINDORO (P.I.)

TERRAIN INTELLIGENCE

Prepared by

GEOLOGICAL SURVEY, U.S. DEPARTMENT OF THE INTERIOR

Under direction of

CHIEF OF ENGINEERS, U.S. ARMY

COPY 108

MILITARY INTELLIGENCE DIVISION
OFFICE, CHIEF OF ENGINEERS
U. S. ARMY

OCTOBER, 1944

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ARMY MAP SERVICE, U.S. ARMY, WASHINGTON, D.C., 202310
10-44 1944


200
400
600
800
40°
20°
0°
60°
STATUTE MILES
U S S R
60°
SEA OF OKHOTSK
BERING SEA
KAMCHATKA S.E.S. 99
ATTU
100 200 150
STATUTE MILES
SAKHALIN
S.E.S. 88
KURILE ISLANDS S.E.S. 98
S.E.S. 127 HOKKAIDO
S.E.S. 90 (AIRFIELD SITES ONLY)
LUZON S.E.S. 124
PHILIPPINES
MINDORO
S.E.S. 141
SEA OF JAPAN
KOREA
S.E.S. 126 HONSHU
SAMAR S.E.S. 131
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LEYTE S.E.S. 131
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BOHOL
CHINA
EAST CHINA SEA
KYUSHU S.E.S. 125
PALAWAN
S.E.S. 116
NANSEI-SHOTO S.E.S. 119
S.E.S. 114 BONIN ISLANDS
MINDANAO S.E.S. 86
S.E.S. 137a
S.E.S. 137b
S.E.S. 137c
FORMOSA S.E.S. 100
BORNEO
SULU IS S.E.S. 122
40°
20°
INDO-CHINA
HAINAN
THAILAND
SES 78
SOUTH CHINA SEA
PHILIPPINES (SEE INSET)
MARIANAS ISLANDS S.E.S. 113
GUAM
WAKE
S.E.S. 112
YAP
PALAU S.E.S. 110
S.E.S. 111
CAROLINE
ISLANDS
TRUK S.E.S. 106
PONAPE S.E.S. 109
KUSAIE S.E.S. 108
MARSHALL IS
S.E.S. 107
GILBERT IS
MALAYA
S.E.S. 95
S.E.S. 115
S.E.S. 120
S.E.S. 103
SUMATRA
BORNEO
0°
CELEBES S.E.S. 97
S.E.S. 104
S.E.S. 101
S.E.S. 96
S.E.S. 102
NEW GUINEA S.E.S. 93
SOLOMON ISLANDS
JAVA
TIMOR
AUSTRALIA
120°
140°
160°

CONFIDENTIAL

SPECIAL REPORT

STRATEGIC ENGINEERING STUDY
No. 141

MINDORO (P.I.)

TERRAIN INTELLIGENCE

Prepared by
SECTION OF MILITARY GEOLOGY
GEOLOGICAL SURVEY, U.S. DEPARTMENT OF THE INTERIOR
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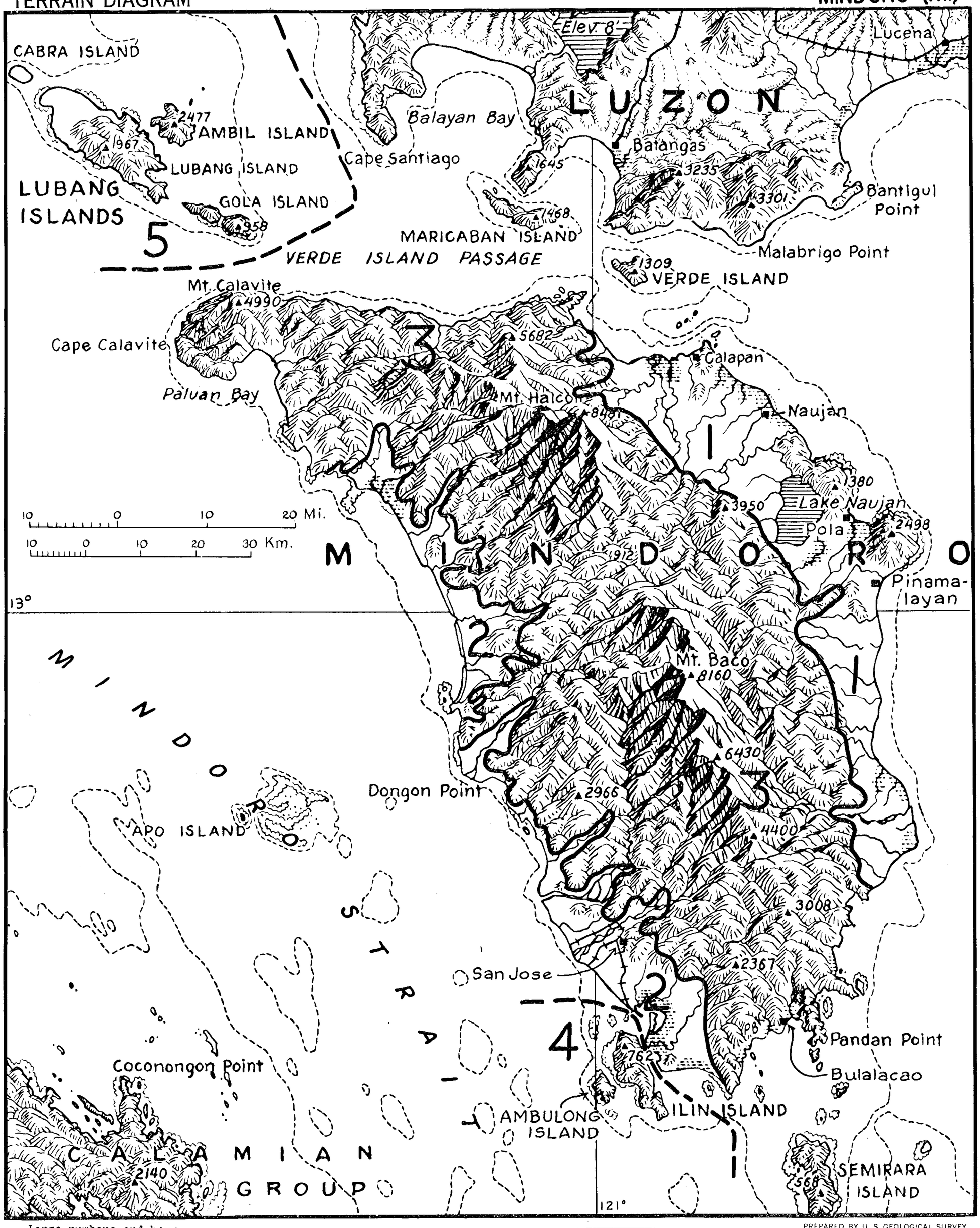
STRATEGIC INTELLIGENCE BRANCH
MILITARY INTELLIGENCE DIVISION
OFFICE, CHIEF OF ENGINEERS
U. S. ARMY

OCTOBER, 1944

ARMY MAP SERVICE, U.S. ARMY, WASHINGTON, D.C., 202310
10-44 1944

TERRAIN DIAGRAM

MINDORO (P.I.)



Large numbers and heavy lines designate Terrain Units described in Terrain Appreciation Table

Terrain diagram drawn on map base on scale of 1:1,000,000, and subsequently enlarged to present scale. Terrain on Mindoro based on Philippine Coast and Geodetic Survey map 10, 1:200,000; geologic sketch map by National development Co.; and U.S. Coast and Geodetic Survey Charts, various scales. Luzon from Military Survey of Luzon, AMS S711, 1:63,360. Topographic map accompanying this report was not available at time diagram was made. Altitudes in feet.

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

MINDORO (P.I.)

SUMMARY OF TERRAIN SITUATION

I. Introduction

A. Mindoro has an area of 3,758 square miles. Population was 131,569 in 1940. There are no large cities on the island. Five municipalities (municipal districts) having populations over 10,000 are Calapan, Naujan, Pinamalayan, Pola, and San Jose (southwest Mindoro). Population is concentrated mainly in or near coastal towns; inland area is largely uninhabited. Chief products are agricultural, but island is a potential producer of coal (near Bulalacao), gold (along Binabay River), and possibly oil.

B. Climate is hot and humid, Annual rainfall from 85 to 125 inches. West side of island has dry season during winter months and very wet season during summer months; east side has no dry season and no pronounced period of maximum rainfall.

II. Topography and Movement

A. East Coast Lowlands (Map Unit 1)

1. Topography: Flat coastal lowlands rise gently inland to low rolling hills and gently undulating country. Rivers are perennial with beds of sand and gravel commonly mixed with mud. Natural levees along rivers are slightly higher than interstream areas. Much land in rice, hemp, and coconut palms with some primary and secondary forests.

2. Movement and Cover: Only first-class road on island parallels coast along most of area. Cross-country movement relatively easy except as impeded by rice fields, mud during rains, and floods. Little cover except in parts of rolling hill country.

B. West Coast Lowlands (Map Unit 2)

1. Topography: Flat coastal lowlands rise gently inland to region of rolling and flat-topped hills of about equal altitude. Sandy and bouldery river beds with well-developed terraces along upper courses of some rivers; streams dry or nearly so during dry season; frequent flash floods.

2. Movement and Cover: No roads, but cross-country movement easy during dry season. Impeded by mud and floods during rainy season. Limited cover in rolling hills and along river banks during dry season.

C. Mountains (Map Unit 3)

1. Topography: Rugged mountains with steep canyons and swift streams. Thick forest stands on east side and grass cover with some trees in valleys on west.

2. Movement and Cover: Movement difficult to impossible for vehicles without building roads. Foot troops can move anywhere but with difficulty in forests and on steep slopes. Cover good.

D. Ilin and Ambulong Islands (Map Unit 4)

1. Topography: Rough, wooded hills with some narrow lowlands along coasts.

2. Movement and Cover: Movement difficult. Cover good.

E. Lubang Islands (Map Unit 5)

1. Topography: Rough, wooded hills and mountains with some coastal lowlands, particularly at northwest end of Lubang Island.

2. Movement and Cover: Movement easy on lowlands, but difficult in hills and mountains. Cover good in hills, poor on lowlands.

III. Water Supply

A. Existing Supply: A few towns have municipal waterworks; developments insufficient to care for existing population. Greater part of water for private use obtained from shallow wells.

B. Combat Supply: Easily obtained throughout most of Mindoro. Surface water abundant, scarce only on west side during dry season. All water polluted.

C. Base-Camp Supply: Adequate supplies readily developed from both surface and ground water. May be difficult at many places to supply large units in western part of mountain area.

IV. Road Construction

A. Existing Roads: Only roads are on northeastern coastal plain; 65 mile surfaced highway with 5 to 10 mile branches to neighboring towns, and a few miles of secondary roads.

B. Construction of New Roads: Roads in coastal plain areas can be constructed with little grading or clearing; hill and mountain roads will require much cut and fill, heavy clearing on east side of island. All roads need base course and surfacing for all-weather use.

C. Major Construction Problems: Soils throughout much of island are moderately to highly plastic and impervious, requiring thick base course under surfacing. Control of high water table in coastal plain and of rapid runoff and seepage in hills and mountains is necessary. Sound bedrock is difficult of access in many areas, and construction of roads in interstream areas on coastal plain may require hauling gravel for distances of 5 to 10 miles. Flash floods may damage roads and bridges.

V. Airdrome Construction Problems:

A. East Coastal Lowlands: Many flat areas on coastal lowlands topographically suitable for airdromes. Construction complicated by heavy rainfall, sticky mud, high water table, and poor drainage; subgrade and drainage better on slightly higher natural levees along rivers. The rolling hill country is better drained and has better subgrade, but there are few large flat areas. Sand and gravel are available along most streams. Hard rock for aggregate not readily accessible.

B. West Coastal Lowlands: Large flat areas on coastal lowland, but large enough flat areas not numerous in rolling hills. Landing mats laid directly on subgrade probably satisfactory during dry season. Construction of base course needed for rainy season; drainage poor in coastal lowlands, good in rolling hills. Sand and gravel available along most streams. Little accessible bedrock suitable for riprap or aggregate. Larger streams have boulders of hard rock suitable for crushing.

C. Specific Sites: There are 15 specific sites on which photographs or maps are available. Eight of these were landing fields in existence in 1941. Of the 4 sites on the East Coast Lowlands, 2 are probably suitable for construction of airdromes, and of the 6 sites on the West Coast Lowlands, 3 appear to be suitable. There is one good site at the northwest end of Lubang Island.

VI. Construction Materials and Fuels

A. Construction Materials: Sand and gravel abundant along streams of coastal plain; smaller amounts along streams in hills and mountains; sound bedrock for crushed aggregate readily obtainable in limestone areas in southern Mindoro, usually accessible only in stream beds in hills and mountains elsewhere. Large timber for heavy construction scarce in most of coastal plain and on west flank of central range, abundant in high mountains and extending down to inner edge of eastern coastal plain.

B. Mineral Fuel: Undeveloped high-volatile sub-bituminous coal near Bulalacao in southern Mindoro; only a few tons available by stripping. Oil seeps known, but no petroleum developed.

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

MINDORO (P.I.)

INTRODUCTION

This report was prepared by the U. S. Geological Survey for the Chief of Engineers, U. S. Army during the period July 17, to September 7, 1944. The report describes those terrain features of Mindoro and nearby islands that are of military significance. Each map of the report and its accompanying table, is devoted to a specialized set of problems together they present a regional picture of the country, the relationship of the terrain and vegetation to movement, airdrome sites, road construction and maintenance, nature and location of principal types of construction materials, and water supply. Climate is considered briefly; other intelligence reports should be consulted for detailed information.

RELIABILITY OF INFORMATION

Many sections of Mindoro have been penetrated only occasionally by white men or are still unexplored. Detailed topographic, geologic and soil reports have been made in only a few small scattered areas. The completeness and reliability of information for different parts of the island differ widely. Reliability ratings given to the various sheets of this report range from Excellent to Poor. On some sheets different parts have been given different ratings.

The whole of Mindoro and nearby islands is covered by a map of scale about 1:360,000 compiled from hachured maps with scales 1:500,000 and 1:200,000, and unpublished contoured coastal maps of scales 1:20,000. These coastal maps show the shoreline and offshore features in detail but show land topography only in a generalized fashion along a narrow coastal fringe. In general, the coast and the position and altitude of the principal peaks appears to be accurate; but the upper courses of some streams and the representation of minor ridges and canyons may be seriously in error.

PRINCIPAL SOURCES OF INFORMATION

Alberding, H., Recent coal exploration in the Philippines: De re Metallica (Montana School of Mines Magazine), vol. 7, p. 20, 1942.

Bautista, Enrique M., A preliminary investigation to determine the feasibility of establishing a waterworks system in Pinamalayan, Mindoro: Philippine Agriculturist, vol. 20, no. 8, pp. 517-525, Laguna, 1932.

Burritt, Charles H., The coal measures of the Philippines: U.S. War Department, Division of Insular Affairs, pp.133-143, Washington, D. C., 1901.

Cox, Alvin J., Heise, George W., and Gana, V. Q., Water supplies in the Philippine Islands: Philippine Jour. Sci., vol. 9, no. 4, pp. 273-412, 1914. Many water analyses.

Dar, Juan T., and Elicano, V., Philippine raw materials for glass making: Philippine Jour. Sci., vol. 14, pp.467-469, 1919.

De Villa, E. M., The coalfields of Mindoro: Sugar News, vol. 21, pp. 7-9, 1941.

----------, The Mesozoic rocks of the Philippines: Sugar News, vol. 22, pp. 7-9, 1942.

Faustino, Leopoldo A., The petroleum resources of the Philippine Islands: 3d Pan-Pacific Sci. Cong. Proc., vol.2, pp. 1745-1748, Tokyo, 1926.

----------, Geographic and physiographic description of the Philippine Islands: Mineral Resources of Philippine Islands 1924-1925, Dept. Agr. and Nat. Resources, Bur. Sci., p. 33, 1927.

Gonzales, Leon Ma., Mineral production in the Philippines: Mineral Resources, Philippine Bur. Mines, pp. 62-66, 1926-1933.

Heise, George W., Water supplies in the Philippine Islands: Philippine Jour. Sci., vol. 10, sec. A, no. 2, pp. 135-169, Manila, 1915. Gives a brief discussion of the brackish character of much of the coastal ground water and data on wells, springs, and streams, with many water analyses.

Heise, George W., and Behrman, A. S., Philippine water supplies: Philippine Bur. Sci., Publ. no. 11, 218 pp., Manila, 1918.

Kienholz, Raymond, Environmental factors of Philippine beaches with particular reference to the beach at Puerto Galera, Mindoro: Philippine Jour. Sci., vol. 36, pp. 199-215, 1928.

Merrill, Elmer D., Ascent of Mt Halcon, Mindoro: Philippine Jour. Sci., vol. 2, no. 3, pp. 179-207, 1907.

Merritt, M. L., The forests of Mindoro: Philippine Bu.Forestry, Bull. 8, 51 pp., 1908.

Merritt, M. L., and Whitford, H. N., A preliminary working plan for the public forest tract of the Mindoro Lumber and Logging Company, Bongabon, Mindoro, P. I.; Philippine Bu. Forestry, Bull. 6, 55 pp., 1906.

Millard, W. J., Binabay River placer deposit. Unpublished report, 1936.

Musgrove, W. E., Sanitary survey of the San Jose' Estate and adjacent properties in Mindoro Island, Philippine Islands, with special reference to the epidemiology of malaria: Philippine Jour. Sci., vol. 9, pp. 137-195, 1914.

Pendleton, Robert L., Soil survey of San Jose' region, Mindoro. Unpublished.

Pratt, Wallace, E., The location of artesian wells in the Philippine Islands from a geologic viewpoint: Philippine Jour. Sci., vol. 10, pp. 231-239, 1915.

----------, Philippine lakes: Philippine Jour. Sci., vol. 11, p. 234, 1916.

Selga, R. Miguel (S. J.), Observations of rainfall in the Philippines, Philippine Islands Weather Bureau, pp. 139-142, 144-145, 157, 160, 164, 1935.

Smith, Warren D., Geology and mineral resources of the Phillipine Islands: Dept. Agri. and Nat. Resources, Bur. Sci., Publ. no. 19, 559 pp., 1924.

Teves, Juan S., The geology of Puerto Galero, Mindoro: Philippine Jour. Sci., vol. 62, pp. 239-251, 1937.

Willis, Bailey, Geologic observations in the Philippine Archipelago: National Research Council of the Philippine Islands, Bull. 13, p. 29, 1937.

Worcester, Dean C., The Philippine Islands and their people, New York,Macmillan Co., pp. 362-434, 1898.

Census atlas of the Philippines, Commonwealth of the Philippines, vol. 5, Manila, 1940.

Coast pilot of the Philippine Islands, Part 1, Luzon, Mindoro and Visayans, U.S. Dept. Commerce, Coast and Geodetic Survey, Ser. no. 613, 3d ed., Manila, 1939.

Geology and oil possibilities of the Philippine Islands, National Development Company, Unpublished report of Petroleum Survey (directed by G. W. Corby), Manila, 1941.

List of rivers of the Philippine Islands, Bureau of Navigation, Division of Port Works, Manila, 1912. Brief descriptions of lower courses of some rivers of value to coastal navigation, including about 17 on Mindoro.

Mineral resources of the Philippine Islands for the years 1926 to 1933 and 1934 to 1938, Philippine Dept. of Agri. and Commerce, Division of Mines, Bur. Sci., Manila.

Quarterly bulletin, Bureau of Public Works, Philippine Islands, 1912-1920; 1921-1936.

Surface water supply of the Philippine Islands, 1908-1922; Bureau of Public Works, Philippine Islands, Water Supply Bull. no. 1, 4 vols., 1924.

U. S. Army, Military Intelligence Division, Strategic report of the Philippine Islands, vol. 2, Central or Visayan Group, December, 1943.

U. S. Army, Military Intelligence Division, Survey of the Philippine Islands (S30-603A), vols. 1 and 2, February, 1944.

U. S. Navy, Office of Naval Intelligence, 93, Field monograph of the Philippines, Part 3, Visayan Islands, January, 1944.

U. S. Army, Military handbook of the Philippine Islands, vol. 3, The Islands of Mindoro, Marinduque, Tablas, Romblon, and Sibuyan.

Other intelligence reports.

Intelligence Reports

Engineering Research Office,Special Report no. 45, Philippines (in 4 volumes).

Maps Consulted

Army Map Service, scale 1:500,000, AMS-3, 2d ed., ND 51-4.

Charts 4257, 4305, 4337, 4338, 4339, 4340, 4344, Coast and Geodetic Survey, Manila , P. I.

Contour map of the Philippine Islands and waters, scale 1:1,000,000, sheet no. 102, Coast and Geodetic Survey, Manila, P. I., 1924.

Mindoro, Sheet no. 10, scale 1:200,000, Coast and Geodetic Survey, Manila, P. I., 1935.

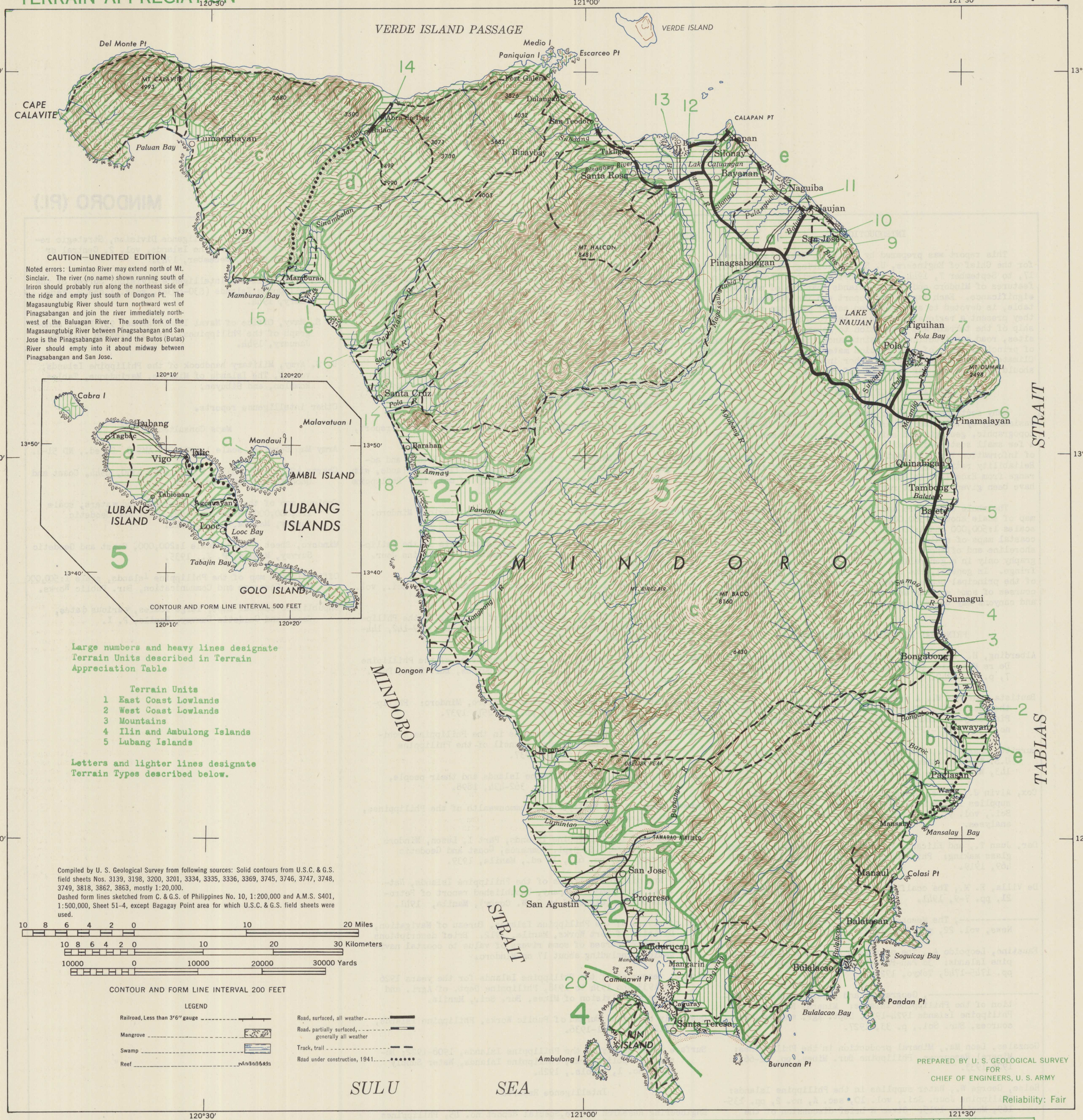
Official road map of the Philippine Islands, scale 1:500,000 Dept. Commerce and Communication, Bur. Public Works.

Unpublished coastal maps, large scales, various dates, Coast and Geodetic Survey, Manila, P. I.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.

TERRAIN APPRECIATION

MINDORO (P.I.)



CAUTION—UNEDITED EDITION

Noted errors: Lumintao River may extend north of Mt. Sinclair. The river (no name) shown running south of Iriron should probably run along the northeast side of the ridge and empty just south of Dongon Pt. The Magasaungtubig River should turn northward west of Pinagsabangan and join the river immediately northwest of the Baluagan River. The south fork of the Magasaungtubig River between Pinagsabangan and San Jose is the Pinagsabangan River and the Butos (Butas) River should empty into it about midway between Pinagsabangan and San Jose.

Large numbers and heavy lines designate Terrain Units described in Terrain Appreciation Table

Terrain Units
1 East Coast Lowlands
2 West Coast Lowlands
3 Mountains
4 Ilin and Ambulong Islands
5 Lubang Islands

Letters and lighter lines designate Terrain Types described below.

Compiled by U. S. Geological Survey from following sources: Solid contours from U.S.C. & G.S. field sheets Nos. 3139, 3198, 3200, 3201, 3334, 3335, 3336, 3369, 3745, 3746, 3747, 3748, 3749, 3818, 3862, 3863, mostly 1:20,000.
Dashed form lines sketched from C. & G.S. of Philippines No. 10, 1:200,000 and A.M.S. S401, 1:500,000, Sheet 51-4, except Bagagay Point area for which U.S.C. & G.S. field sheets were used.

10 8 6 4 2 0 10 20 Miles
10 8 6 4 2 0 10 20 30 Kilometers
10000 0 10000 20000 30000 Yards

CONTOUR AND FORM LINE INTERVAL 200 FEET

LEGEND

Railroad, Less than 3'6" gauge
Mangrove
Swamp
Reef
Road, surfaced, all weather
Road, partially surfaced, generally all weather
Track, trail
Road under construction, 1941

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

Reliability: Fair

Map Unit	Topography	Streams	Movement	Observation and Concealment	Natural Cover
a Coastal Lowlands	East coast: Nearly flat	East coast: Perennial wide, sandy and bouldery beds and flood plains.	East coast: Fair to excellent; impeded by rice paddies, some forest and floods.	East coast: Visibility good; concealment poor most cultivated areas, good in local forests.	East coast: Poor
	West coast: Nearly flat	West coast: Intermittent; sandy and bouldery beds; flash floods.	West coast: Good, impeded by rocky stream beds and flash floods.	West coast: Visibility good; commanded by points in rolling hills. Concealment poor.	West coast: Poor
b Rolling Hills	East: Low rolling hills and undulating land.	East: Perennial; sandy and bouldery beds.	East: Fair to good; poor in thick forests.	East: Visibility poor to good; concealment good locally.	East: Fair
	West: Low rolling and flat-topped hills.	West: Intermittent; bouldery and sandy beds; flash floods.	West: Good impeded some by river beds and flash floods.	West: Visibility good; commanded by mountains. Concealment poor.	West: Fair to good.

Map Unit	Topography	Streams	Movement	Observation and Concealment	Natural Cover
c Mountains	East: Rough steep-walled canyons.	East: Perennial; swift with waterfalls.	East: Difficult; roads required for vehicles.	East: Visibility good; concealment poor.	East: Good
	West: Very rough.	West: Intermittent; flash floods.	West: Difficult.	West: Visibility good; concealment poor, locally good.	West: Good
d Mountain Passes	Two best passes across mountains of Mindoro				
e Mangrove Swamps	Low and flat.	Perennial	Difficult to impossible.	Visibility poor; concealment good.	Poor

14 Locates mouth of navigable river described in text.

MINDORO (P.I.)

TERRAIN APPRECIATION

Reliability: Fair

Map Unit	Topography	Movement[a/,b/]		Observation and Concealment[c/]	Cover[d/]	
		Vehicles	Foot Troops		Natural Cover	Excavation for Shelter
1 EAST COAST LOWLANDS	General: From narrow beaches, which widen near river mouths, the gently sloping coastal lowlands extend several miles inland, where they are broken into a region of low rolling hills. Perennial streams flood suddenly during heavy rains but subside rapidly. Coastal Lowlands: Slope very gently toward coast. Rivers have flat valleys with sandy and gravelly beds and floodplains; natural levees along rivers slightly higher than interstream areas. Flat coastal section has open interstream areas of rice and hemp; coconut palms commonly along streams. Casuarina and screw pine (pandan) common along narrow beaches; local mangrove swamps along coast and fresh-water swamps west and south of Lake Naujan. Rolling Hills: Hills of small relief with about same altitude (approximately 100 to 150 feet) gradually rise to altitude of approximately 200 feet at inner margin; some sections gently undulating; interior mountains rise steeply above inner margin of hills. Shallow valleys with gently sloping sides; large rivers have sandy and gravelly beds. Largely covered with stands of primary and secondary forest in south; cultivated fields in north. Mountains: Interrupt lowlands along coast east of Calapan, east of Lake Naujan, and at Mt. Dumali.	General: Only surfaced road on Mindoro connects Calapan and Bongabong, with side roads to Naujan and Pola. Sudden floods and gravelly river beds impede movement parallel to coast and up stream valleys. Coastal Lowlands: Movement easy in most places on firm beaches through casuarina forests; on some beaches, screw pine (pandan) has to be cleared but is easily cut. Local mangrove swamps on coast and fresh-water swamps west and south of Lake Naujan very difficult. Inland from beaches, clay loams and clays make heavy, sticky mud, which makes rice paddies difficult to move through, particularly for wheeled vehicles; during less rainy season (December to April), ground probably firm part of time. Open interstream country. Sandy loam and silty loam on levees also firm and well drained. Rolling Hills: Ground firmer and better drained than in coastal lowlands, but sticky when wet. Valley slopes gentle and not difficult. Forest stands, particularly in northern part of area, probably require clearing. Mountains: East of Lake Naujan, mountains and hill areas difficult for movement and lack roads.	Can move through entire region, but difficult through swamps, and thick forests and rice paddies during wetter season (May through November); can cross paddies on dikes. In less rainy season, most rivers fordable except near coast.	Observation: Visibility good in cultivated areas; poor in forested sections of rolling hills. Cleared zones at outer edge of hills command parts of coastal lowlands. Mountain sections, as east of Lake Naujan, too forested for clear views from high points. Concealment: Generally poor in cultivated areas. Fair concealment from air observation among coconut palms, which are mostly along river levees. Good from air in casuarina forests along narrow beaches, poor from ground. Forested areas on rolling hills good for concealment from ground and air. May be good in hemp and some secondary forest; locally in grassland.	Coastal Lowlands: Generally poor; trees are large, primarily in mangrove swamps, affording fair cover for troops. Limited cover may be found along stream banks during drier season (December to April). Rolling Hills: Fair in valleys and along river banks during less rainy season. Large trees afford limited cover for personnel. Mountains: Good in local mountain areas.	Coastal Lowlands: Digging easy in thick alluvial soil, but high water table makes drainage difficult; soil tends to slump when wet; needs support. Conditions better on inner margin and on slightly higher river levees. Coconut palms and some secondary forest trees available for support. Rolling Hills: Fairly easy; water table relatively high but drainage generally good; support probably needed to prevent slumping in deep excavations. Timber plentiful. Mountains: Difficult in most places because of thin soils.
2 WEST COAST LOWLANDS	General: Coastal lowlands rise gently inland and are broken at inner margin into low rolling hills. Locally, interior mountains rise directly from narrow lowland belt. Rivers dry or small braided streams during dry season (December to April); sandy and gravelly beds and floodplains; subject to frequent flash floods during rainy season. Alluvial fans probably developed where rivers pass from mountains (Map Unit 3) on to lowlands. Mostly covered with cogon grass; in south around San Jose cultivated to sugarcane; small rice and hemp fields locally near coast. Small trees along some streams; mangrove swamps northwest and southeast of Mangarin Bay and locally elsewhere. Coastal Lowlands: Very gentle slope toward coast with narrow sandy beaches. River beds wide and gravelly in lower courses; natural levees along large river slightly higher than interstream areas. Well-developed terraces, probably 10 to 20 feet high and several hundred feet wide, 6 to 10 miles along larger rivers (Lumintao and Bugsanga). Rolling Hills: Rolling and flat-topped hills; summit altitudes about the same (probably about 100 to 150 feet); abrupt break in slope to coastal lowlands and along inner margin where interior mountains (Map Unit 3) rise steeply. Valleys shallow but with steeper gradient than in similar area (Map Unit 1) east of mountains. Mountains: Small, rough mountain area 6 miles north of Barahan. Locally other small mountain areas.	General: No roads, but cross-country movement easy during dry season (December to April); impeded by mud and flash floods during rainy season. Bouldery stream beds may slow movement parallel to coast even when rivers dry. Cogon grass no obstacle except to small-wheeled vehicles. It is usually burned over during January or February. Coastal Lowlands: Clay loams and clays probably sticky and heavy during rainy season; hard and firm during dry season. Vehicles can avoid boulders and move up beds of large rivers during dry season. Movement impossible through mangrove swamps. Rolling Hills: Easy except perhaps during heavy rains when soil becomes muddy. Drainage good. Steep-sided gullies and small valleys may be obstacles.	Can move anywhere except through mangrove swamps and across rivers during flash floods. May be slow through mud during heavy rains, particularly on coastal lowlands. May be tiring through some cogon-grass areas; grass usually burned during January or February.	Observation: Visibility good unless cogon grass unusually tall. Entire area commanded by points in adjacent mountains (Map Unit 3); coastal lowlands also may be observed from edges of rolling hills; no good observation points on coastal lowlands. Concealment: Little, if any, from air observation except in mangrove swamps around Mangarin Bay. Limited ground concealment for personnel in sugarcane field around San Jose.	Coastal Lowlands: Poor in general; probably good locally along river banks during dry season. Rolling Hills: Fair to good in ravines, small valleys, and along river banks during dry season.	Coastal Lowlands: Digging easy; water table high near coast; deeper near inner margin of area; drainage difficult, and excavations probably need support during rainy season. Slightly higher natural levees along large rivers and terraces better drained. Scattered patches of coconut, mangrove, and casuarina suitable for shelter construction. Some heavy timber nearby in mountainous area. Rolling Hills: Fairly easy; water table not high enough to interfere; well drained. Seepage may necessitate support of deep trenches. Scattered patches of timber.
3 MOUNTAINS	Very rugged hills and mountains trending northwest, with deep, steep-sided valleys; total relief over 8,000 feet. Two main mountain masses centering around Mt Halcon in north and Mt Baco in south. In thickly forested area on east side, steep canyons with waterfalls and swift streams with bouldery beds. West side more dissected than east with extremely rugged, steep-sloped mountains rising abruptly above lowlands; swift streams with waterfalls and bouldery beds. Small lowland sections along north coast and on south coast in vicinity of Bulalacao. Best passes cross the mountain area between Mamburao and Abra de Ilog in north and through north central part of island.	Impossible without construction of roads except in small local areas; thick forests on east side; grassland with some bamboo thickets on west; steep slopes and steep, bouldery stream beds. Grassland easily cleared but most slopes too steep for movement; grass usually burned during January or February. The pass between Mamburao and Abra de Ilog is best one across island; a road is supposed to have been under construction there in 1941, although some reports doubt that construction had actually begun along much of route. A road was proposed through the more difficult pass across the north-central part of the island, but apparently no construction has been started. Several native trails cross mountains south of Mt Baco.	Can move anywhere, but with extreme difficulty on steep slopes and in heavy forests; muddy and slippery during rainy season.	Observation: Peaks on west slopes command lowlands to west and southwest (Map Unit 2); forest cover prevents observation on east. Poor in highest mountains because of forests and cloud caps which hang there much of time. Concealment: Good to excellent in forests on east side and in local forests areas along valleys on west. In January or February most grassland on west slopes is burned over and what little concealment it affords personnel is eliminated.	Valleys and ravines good to excellent except locally along north and south coasts.	Difficult in most places; thin soils on steep slopes on western side of island; subject to wash during heavy rains and to creep and slide; need support. Timber plentiful in east; scattered in west.
4 ILIN AND AMBULONG ISLANDS	Areas of rough, wooded hills similar to the mountain region on Mindoro (Map Unit 3). Maximum relief on Ilin Island more than 700 feet, on Ambulong more than 500 feet. Narrow beaches and mangrove swamps along north and east coasts of Ilin Island; very narrow mangrove swamps on Ambulong Island.	Difficult over entire area.	Can move anywhere, except through mangrove swamps and with difficulty along steep slopes and through forests.	Observation: High points command approaches to island but trees hinder observation. Concealment: Good for vehicles and for personnel.	Good in valleys and ravines.	Soil shallow; blasting probably required for deep excavations. Soil subject to creep and slide. Fairly well drained, but may require seepage control. Timber for construction plentiful.
5 LUBANG ISLANDS	Cabra Island: About 150 feet high on northwest and southeast ends; low coastal sections northeast and southwest of center; steep coast around most of island. Lubang Island: Largest island of group. Lowlands on northeast end and fringing east and south. Central area and most of southern section formed of rough hills and mountains; maximum relief 1,967 feet. Rice paddies on northeast lowlands; forests on hills and mountains. Ambil Island: Narrow beaches north and east of a conical mountain over 2,400 feet high. Golo Island: Long and narrow; rough hills with some narrow beaches and a lowland strip across center. Mandaui and Malayatuan Islands: Very small islands northeast of Ambil Island.	On lowlands, particularly on northwest end of Lubang, hindered by muddy rice paddies during rainy season; ground hard and firm during dry weather. Easy elsewhere on lowlands. Difficult through rough, wooded hill areas; cutting of trails probably necessary.	Can move anywhere, but with difficulty in rough wooded hills.	Observation: Visibility good on lowlands but no high observation points; restricted by forests on hills and mountains. Concealment: Poor on lowlands, good in wooded hill and mountain areas.	Poor on lowlands, good in valleys of hills and mountains.	Digging easy in lowlands, but water table high and drainage poor; difficult in hills and mountains where soils are thinner and subject to creep and slide. Construction timber plentiful in high areas.

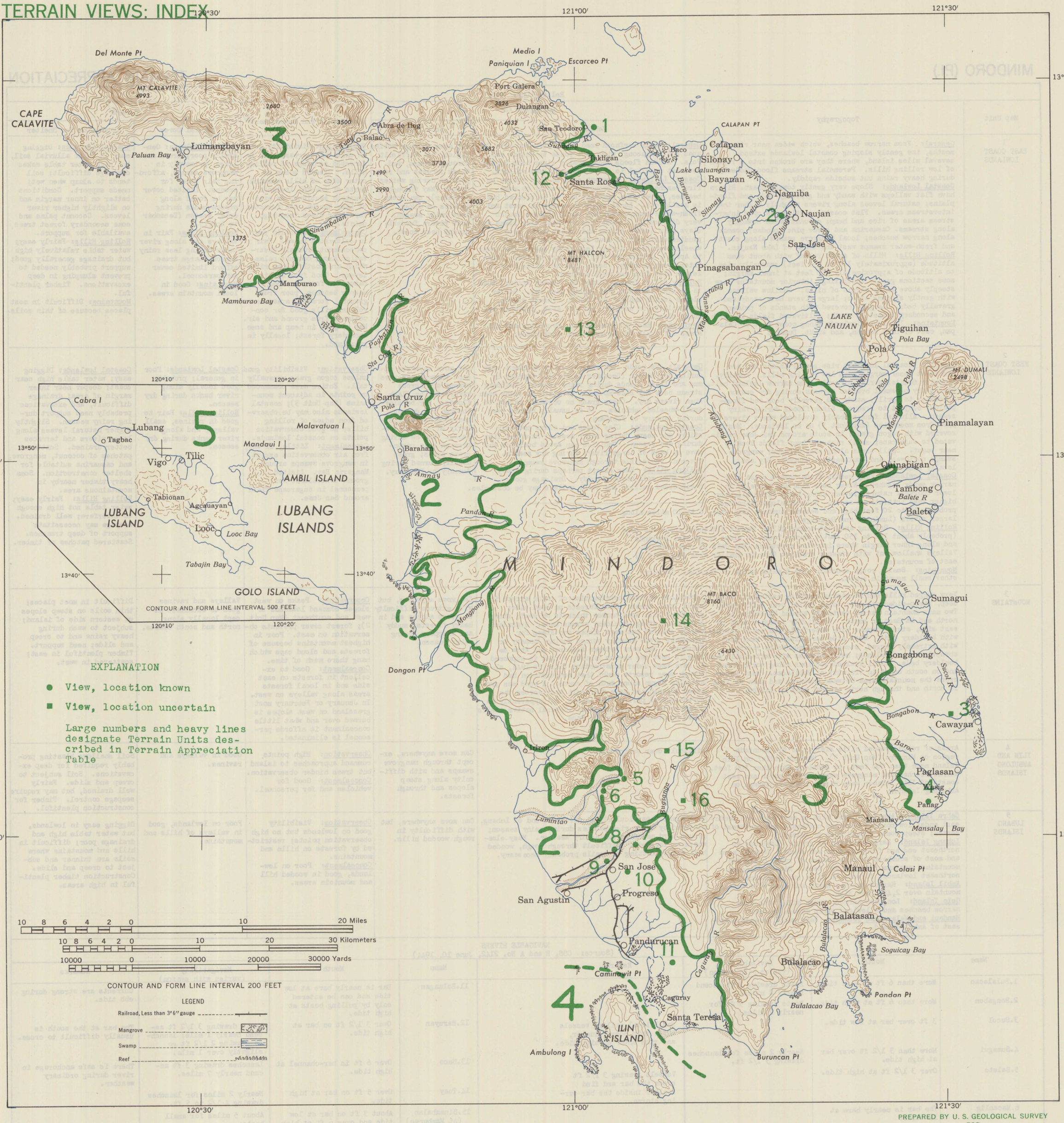
NAVIGABLE RIVERS
(Source: OSS, R and A No. 2142, June 10, 1944)

Name	Mouth	Navigability (varies with season)	Remarks	Name	Mouth	Navigability (varies with season)	Remarks
1.Bulalacao	More than 6 ft at high tide.	Boats drawing 3 ft ascend nearly 2 miles.		11.Baluagan	Bar is nearly bare at low tide and can be entered only by pulling boats at high tide.		Currents are strong during ebb tide.
2.Bongabon	More than 6 ft at high tide.	Boats drawing 3 ft for nearly 2 miles.					
3.Sucol	3 ft over bar at low tide.		Small local sailing vessels which ship copra, lumber, and rice enter at high tide.	12.Baruyan	Over 3 1/2 ft on bar at high tide.	Boats drawing 3 1/2 ft ascend nearly 1 mile; launches drawing 2 1/2 ft go slightly over 1 mile.	The bar at the mouth is usually difficult to cross.
4.Sumagui	More than 3 1/2 ft over bar at high tide.	Nearly 2 miles for launches drawing 3 1/2 ft.		13.Baco	Over 6 ft in bar-channel at high tide.	Launches drawing 3 ft ascend nearly 7 miles.	There is safe anchorage in river during ordinary weather.
5.Balete	Over 3 1/2 ft at high tide.		Vessels drawing 3 1/2 ft cross the bar and find shelter inside the bar during storms.	14.Tuay	Over 5 ft on bar at high tide.	Nearly 2 miles for launches drawing 4 1/2 to 5 ft.	
6.Macanlig	The bar is nearly bare at low tide.			15.Sinambalan (at Mamburao)	About 3 ft on bar at low tide and over 6 ft at high tide.	About 5 miles for small boats.	
7.Pula	The bar is bare at low tide.			16.Pagbahan	Bar at mouth.	About 5 miles for launches drawing 3 ft.	
8.Fola(east coast)	2 feet over bar at low tide.	Boats drawing 3 feet ascend over 1 mile.	Launches drawing 6 1/5 feet ascend at high tide and anchor safely in ordinary weather.	17.Santa Cruz	Over 6 ft on bar at high tide.	Launches and boats drawing 3 1/2 ft cross the bar anytime and ascend 5 miles.	
9.Buts	Empties into Magasaungtubig River.	Small boats navigate from the sea to Lake Naujan via the lower Magasaungtubig and Buts Rivers.	A 28-foot cabin cruiser, drawing 3 1/5 feet, is reported to have made this trip.	18.Amnay	Launches drawing 3 ft or 4 ft cross bar at high tide.		The bar is very changeable and difficult to cross.
10.Magasaungtubig River	The bar is nearly bare at low tide.	Small boats ascend to mouth of Buts River and up it to Lake Naujan.	One of the largest rivers in northeast Mindoro.	19.Bugsanga	Launches drawing 3 1/2 ft cross bar.	About 1 mile for launches.	The current is swift at mouth.
				20.Caguray	Over 5 ft on bar at high tide.	5 to 8 miles for launches, depending on season.	

a/ For details on roads see Road Construction and Maintenance Sheet.
b/ For details on ground conditions see Soils Sheet.
c/ For details on vegetation see Vegetation Sheet.
d/ For details on bedrock see Geology Sheet and Construction Materials Sheet.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

TERRAIN VIEWS: INDEX



EXPLANATION

- ● View, location known
- ■ View, location uncertain

Large numbers and heavy lines designate Terrain Units described in Terrain Appreciation Table

10 8 6 4 2 0 10 20 Miles

10 8 6 4 2 0 10 20 30 Kilometers

10000 0 10000 20000 30000 Yards

LEGEND

- Railroad, Less than 3′6″ gauge
- Mangrove
- Swamp
- Reef

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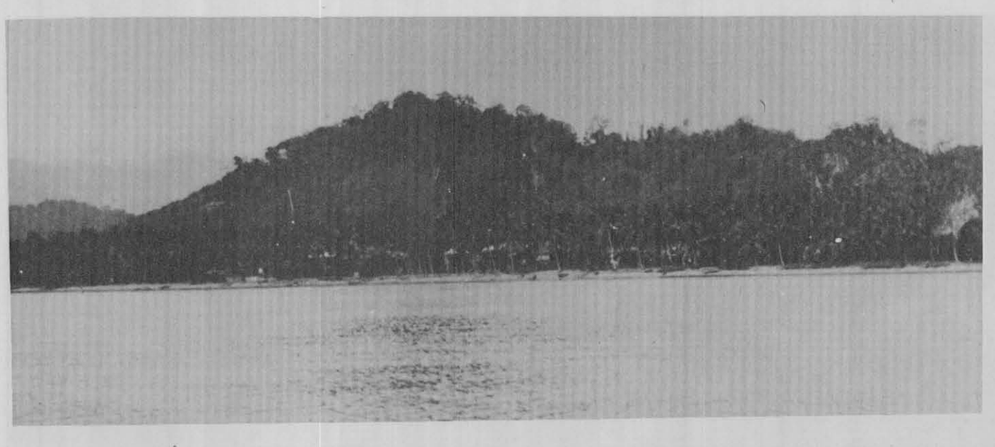
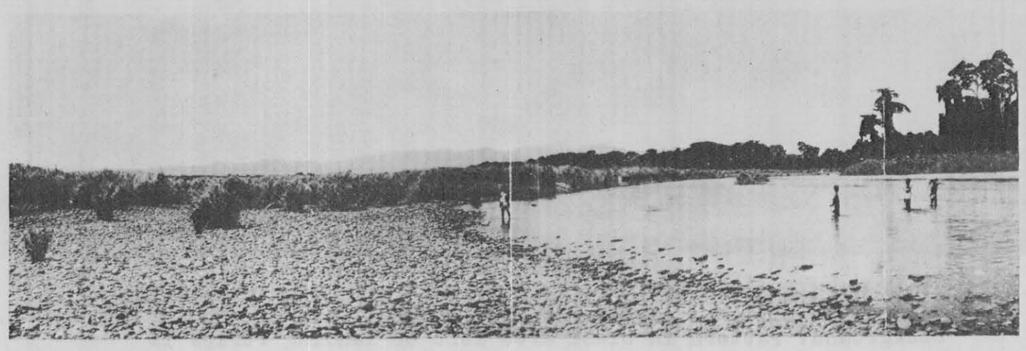
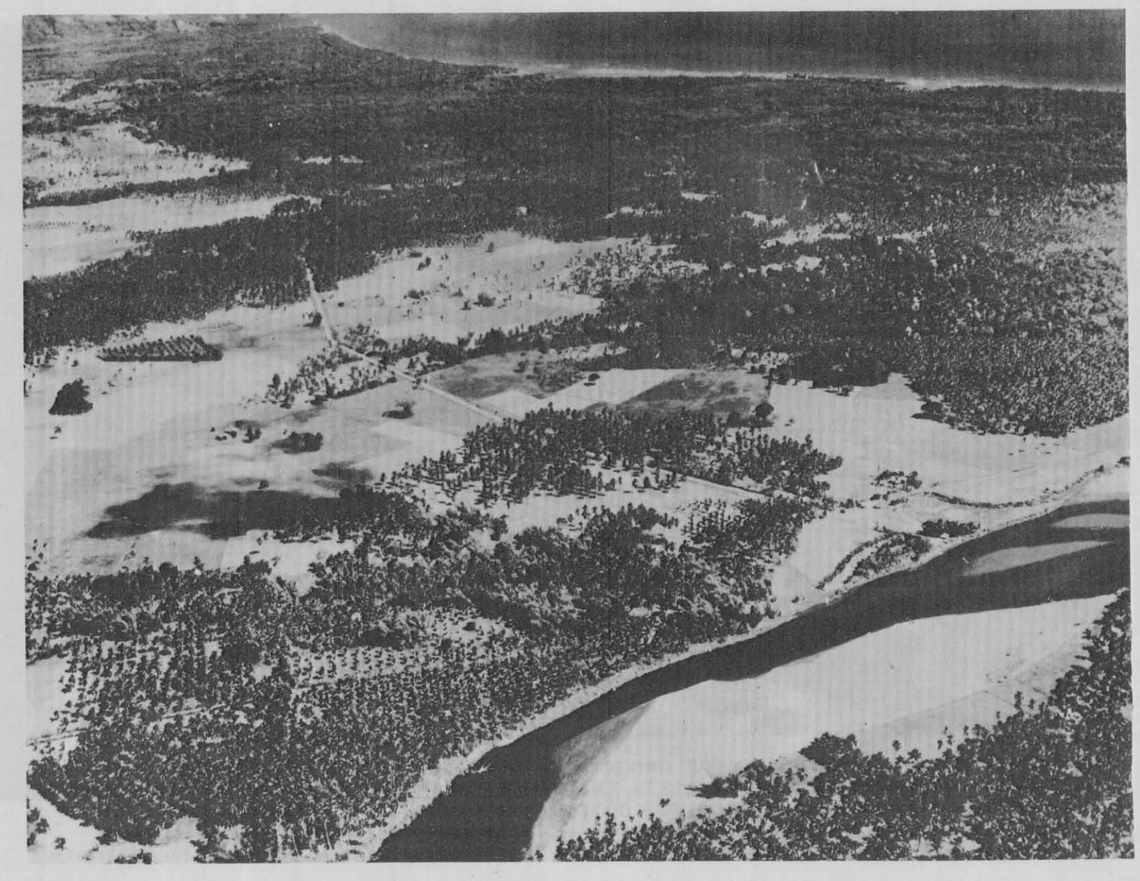


1 Narrow beach (Map Unit 1) planted with coconut palms, backed by wooded hills and mountains (Map Unit 3). Looking southwest toward San Teodoro. (ONI 272-438)



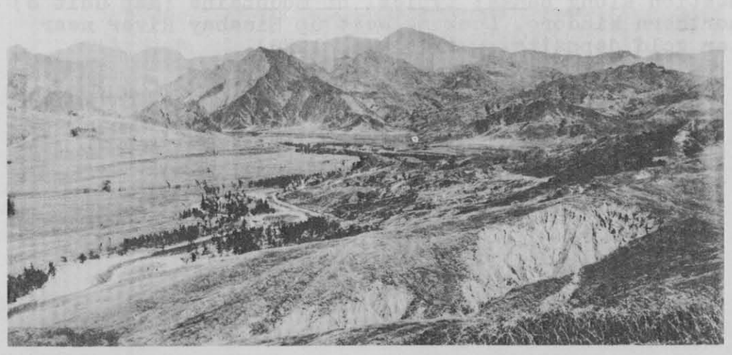
3 Bouldery stream bed in flat coastal lowlands (Map Unit 1) along Bongabon River. Howard Mountains (Map Unit 3) in background. Looking west. (Merritt and Whitford, 1906)

4 Beach fronting eastern coastal lowlands (Map Unit 1) in foreground; rough mountains (Map Unit 3) in far background. Foreground shows southern edge of mangrove swamp and Wasig landing field. Looking southwest across Mansalay Bay. (21250 A. C.)



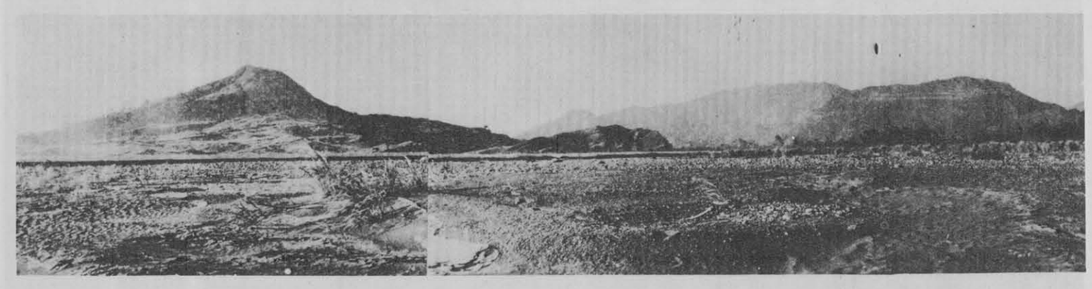
2 Coastal lowlands (Map Unit 1) west of Naujan. Coconut palms planted on better-drained natural levees along rivers; probably rice paddies on poorly drained interstream areas; coconut palms mixed with casuarina and perhaps screw pine in sandy beach sections nearer shore.Much sand and probably some gravel banks along river in foreground. Hills east of Calapan (Map Unit 1) in left background. Looking northwest. (A. C. 21257)

5 River channel cut below terraces along Lumintao River (Map Unit 2) with mountains (Map Unit 3) rising steeply above lowlands. Such terraces are common in Map Unit 2. (See View 7). (MIS 1648.245)

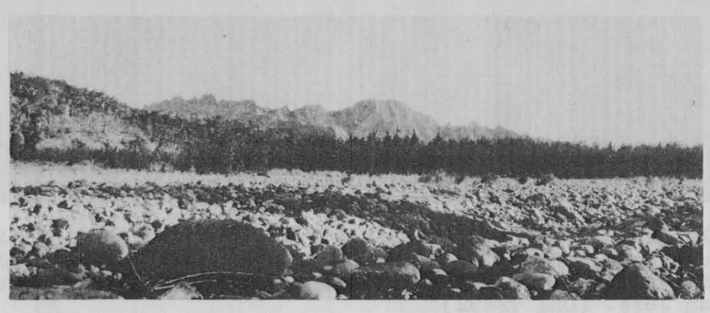


6 Valley of Lumintao River (Map Unit 2) with mountains rising sharply from valley flat Map Unit 3). Looking northeast. (MIS 1648.248)

7 Grass-covered terrace common along streams in southern part of Map Unit 2. River floodplain to the left of terrace; southern mountains in background (Map Unit 3). Terrace bordering Bugsanga River,near site of Tamarao airfield. (ONI 322-684)



8 Sandy and gravelly bed of Bugsanga River (Map Unit 2) in foreground; edge of terrace and high hill on terrace in middleground; mountains (Map Unit 3) right background. Looking north. (MIS 1648.267, 1648.267A)



9 Bouldery bed of Bugsanga River (Map Unit 2) during dry season; mountains (Map Unit 3) on left and in background. Such bouldery beds are characteristic of the streams near and in the foothills. Looking northeast. (MIS 1648.250)

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10 San Jose and sugar central on west coastal lowlands (Map Unit 2); low undulating hills (Map Unit 2) in middleground on which is San Jose airfield. Cultivated fields are in sugarcane. View to south towards Mangarin Bay. (21204 A. C.)

11 West coastal lowlands (Map Unit 2) with Mangarin Field in foreground, mangrove swamps along shore. Ilin Island in background. Pattern in black area left of landing strips is in burned cogon grass. Looking south. (ONI 320-253)

12 Typical swift stream with boulders in bed and thick vegetation along banks; typical of mountains (Map Unit 3) of northern Mindoro. Looking west up Binabay River near placer gold deposits. (Millard, 1936)

13 Rugged forested mountains(Map Unit 3) of northern Mindoro; many ridge crests are grass covered. Probably looking towards Mt Halcon. (ONI 50554)

14 Extremely rugged grass-covered mountains (Map Unit 3) in southwestern Mindoro. Such terrain prevents operations in much of the interior of the island. Looking north from northeast of San Jose. (ONI 72892)

15 Lower mountain slopes (Map Unit 3) in southern Mindoro. Most ridge tops grass covered with trees in ravines. (MIS 1648.261A, 1648.261, 1648.261D)

16 Mountainous upland (Map Unit 3) in southern Mindoro; mostly grass covered with trees in valleys and ravines; high cloud-covered mountains in left background. Note trail along ridge crest, typical of most mountain routes. (MIS 1648.261C, 1648.261B)

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WATER SUPPLY

MINDORO (P.I.)

CAUTION—UNEDITED EDITION

Noted errors: Lumintao River may extend north of Mt. Sinclair. The river (no name) shown running south of Iriron should probably run along the northeast side of the ridge and empty just south of Dongon Pt. The Magasaungtubig River should turn northward west of Pinagsabangan and join the river immediately northwest of the Baluagan River. The south fork of the Magasaungtubig River between Pinagsabangan and San Jose is the Pinagsabangan River and the Butos (Butas) River should empty into it about midway between Pinagsabangan and San Jose.

Compiled by U. S. Geological Survey from following sources: Solid contours from U.S.C. & G.S. field sheets Nos. 3139, 3198, 3200, 3201, 3334, 3335, 3336, 3369, 3745, 3746, 3747, 3748, 3749, 3818, 3862, 3863, mostly 1:20,000.
Dashed form lines sketched from C. & G.S. of Philippines No. 10, 1:200,000 and A.M.S. S401, 1:500,000, Sheet 51-4, except Bagagay Point area for which U.S.C. & G.S. field sheets were used.

10 8 6 4 2 0 10 20 Miles

10 8 6 4 2 0 10 20 30 Kilometers

10000 0 10000 20000 30000 Yards

CONTOUR AND FORM LINE INTERVAL 200 FEET

LEGEND

Railroad, Less than 3'6" gauge
Mangrove
Swamp
Reef
Road, surfaced, all weather
Road, partially surfaced, generally all weather
Track, trail
Road under construction, 1941

CONTOUR AND FORM LINE INTERVAL 500 FEET

Reliability: Fair

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EXPLANATION

1 — Large supplies can be easily and quickly developed from surface or ground water, or both.

2 — Moderate to large supply can be developed with difficulty from surface and ground water.

3 — Small to moderate supply can be developed with difficulty from surface and ground water.

4 — Small to moderate supply can be developed from surface water.

5 — Surface water plentiful but not easily accessible.

12 Baco — Town with municipal supply described in text.

MINDORO (P.I.)

WATER SUPPLY

Reliability: Shown for each map unit in first column of table.

GENERAL STATEMENT

Precipitation: Generally heavy, 85 to 125 inches annually. West half of Mindoro has dry season from December through April with less than 3 inches monthly; east half has no dry season, but rainfall is less from January through April. Average number of rainy days annually about 200 on east half; about 145 on west half. For additional details on rainfall see Climate Sheet.

Topography and Geology: Central high rugged mountain range of granite-like rock, slate, marble, and other hard rocks; flanked on both sides by rough to rolling hills of sedimentary rocks (sandstone, shale, limestone). Coastal plain broad and continuous on east coast; discontinuous and irregular on west side; not present on southeast and north coasts where shores are steep and locally cliffed.

Lubang Islands are mountainous continuation of the central mountain mass of Mindoro. Broad flat coastal plain on northwest end of Lubang Island. Ilin and Ambulong Islands are high rounded hills of limestone.

Existing Water Supplies: Some of the larger towns of Mindoro now have municipal water works. Many obtain water from deep wells, others from improved springs or from mountain streams. Some wells flow, others must be pumped; water from springs and mountain streams either flows by gravity or is pumped into town. Distribution systems generally are supplemented by public hydrants and public wells equipped with hand pumps. Inhabitants in outlying districts obtain water from shallow dug wells, springs, or streams; in some districts on the east coast rain water is collected.

Potential Supplies: On the east side of Mindoro surface water is plentiful throughout all the year; on west side plentiful only during rainy season. Rivers shallow and swift; overflow banks in flash floods. Water generally low in dissolved mineral matter; polluted; requires complete purification treatment by filtration and chlorination. Water from fresh-water swamps generally has bad taste and odor, colored with much organic matter; thorough treatment often fails to make it satisfactory for drinking.

Springs are numerous. Water generally usable for most purposes although more highly mineralized than surface or deep well water; often polluted.

Large supplies of ground water can be developed by large diameter dug wells or drilled wells on the coastal plains. Most areas in which shallow wells may be dug are subject to floods. Drilled wells can generally be located on sites above flood levels. Many deep wells are artesian; some flow at the surface. All water, whether from shallow or deep wells, should be thoroughly chlorinated.

To avoid contamination by salt water, wells near shore and on small islands should be drilled no more than a few feet below sea level and never pumped to capacity. (See Figure 2).

Map Unit and Reliability of Data	Topography and Geology	Surface Water	Ground Water	Recommended Supply	Equipment Needed
1 **Reliability good** Summary: Large supplies for combat and base-camp use can be easily developed. Surface or ground water or both, plentiful. Terrain favorable for distribution cross-country from water points.	Broad continuous coastal plain on east side, discontinous on west; rises from low coastal flat to low rolling hills inland. Small coastal plain on northwest end of Lubang Island. Mangrove swamps locally along coast; some fresh-water swamps. Alluvium: interbedded boulders, gravel, sand, silt, and clay; near coast some coral limestone interbedded with sand and clay.	Many creeks and small rivers; most are perennial on east coast though with marked decrease in flow during period from February through May. Only larger streams on west coast continue to flow throughout year; smaller streams become dry during period from December through May. Streams shallow and swift, many rapids inland; bottoms gravelly and sandy, locally bouldery, broad gravel washes common; banks steep. Over-bank floods sudden and destructive, but of short duration. Several lakes in northeastern part. Mangrove and fresh-water swamps and marshes common along coast. All surface water polluted requiring thorough purification treatment. Water often turbid; brackish near ocean. Water in lakes contains much organic material but is suitable for most uses after thorough treatment. Water in fresh-water swamps and marshes contains much organic acid, has bad taste, and unpleasant odor; its use not recommended. Many good locations for water points along streams; few around lakes which are often bordered by marshy areas. Terrain well-suited for distribution of water by pipeline and trucks.	Springs: Numerous springs reported, probably many others exist. Generally located near or in hills and mountains of adjoining Map Unit areas. Some large enough to supply nearby towns. Spring 2 1/2 miles SSE of Calapan estimated to flow 14.5 gpm. Improvement will generally increase flow. Water generally warm (about 85°F), moderately hard, and uncontaminated. Complete chemical and bacteriological analysis should be made before water from springs used. Water from wells near Naujan contains hydrogen sulfide. A few springs are hot (about 120°F) and highly mineralized, Shallow Dug Wells: Large supplies from large-diameter shallow wells. Capacities to several hundred gpm; all should have high yields. Test holes should be drilled to insure proper locations. Best locations are near rivers as far inland as possible (1/2 mile or more) but well above flood level. Water levels and capacities of shallow wells on both coasts will drop during dry season; wells not properly located will become dry. Drive-Point Wells: Many good locations for development of small supplies by drive points. Best locations are on river flood plains within a few miles of coast. Locations farther inland will probably be difficult to develop because of coarse bouldery gravel interbedded in flood-plain deposits. Deep Wells: Successful wells have been drilled and jetted in towns on both east and west coasts. Many artesian wells; some flow at the surface. Wells located near shore yielded brackish water and were abandoned. Best locations are half mile or more inland. Large supplies can be developed by wells less than 300 feet deep. Materials penetrated will be interbedded clay, sand, and gravel; near shore some thin beds of coral limestone may be present. To avoid salt-water contamination wells located within a half mile of shore should be drilled no deeper than sea level and never pumped to capacity (see Figure 2, Diagrams B and C). Casing is required for entire depth of hole; screens needed in loose-sand sections.	Combat Supply: Surface water. Permanent Supply: Drilled wells or large-diameter shallow wells.	Hand-digging tools, drive points, low-lift pumps. Rotary-drilling rigs best suited for drilling deep wells, but cable-tool rigs are satisfactory; casing, screens, turbine pumps. Portable purification equipment, tanks.
2 **Reliability fair** Summary: Moderate to large supply can be developed with some difficulty from both surface and ground water. Terrain unfavorable for distribution from water points.	Rough, hilly to mountainous; steep-walled valleys with small rapid streams. Rocks include: limestone, mainly thin-bedded to massive, cavernous; some sandstone, silt, shale, and locally coarse conglomerate; folded and faulted.	Moderate to large supply can be developed. Many small perennial streams. Locations for impounding reservoirs numerous. All installations should be well protected against sudden floods. Very little surface water on Ilin and Ambulong Islands. Streams flow only for short time after rains.	Springs: None reported. Proabably numerous. Flows may be 5 to 10 gpm. Water supply of Bulalacao probably from spring. Wells: Small to large supply can be developed by deep drilled wells. Individual wells will yield from a few gallons per minute to more than 100 gallons per minute, depending on the number of fractures and cavities encountered during drilling. Drilling may be difficult, formations are tilted; shale sections may cave, requiring casing. Areas of shale outcrops should be avoided. Geologic reconnaissance should be made before drilling to insure proper locations of wells. Alluvial deposits (not indicated on map) are probably present along some of the stream valleys. Shallow dug wells or drive points in these deposits will yield small quantities of water. Construction of ground-water dams (see Figure 1) in dry stream beds will increase yields of drive points. Shallow wells may become dry during dry season (December through April).	Combat Supply: Surface water. Permanent Supply: Drilled wells, surface water.	Hand-digging tools, drive points, low-lift pumps. Rotary-drilling rigs equipped with rock bits, or cable-tool rigs; casing; turbine pumps. Purification equipment, tanks.
3 **Reliability poor** Summary: Small to moderate supply can be developed. Smaller streams dry during dry season; development of ground-water uncertain and may be difficult. Distribution from water points easy to difficult.	Low rolling hills to rugged mountains. Rocks include interbedded loosely-cemented to unconsolidated sandstone, shale and clay, some thin beds of limestone; folded and faulted.	Most streams intermittent, a few large perennial streams; currents swift, stream beds gravelly and bouldery, flash floods common. Smaller streams become dry during dry season. Water plentiful during wet season. Many locations for impounding reservoirs but constant supply of water very uncertain.	Springs: Only spring reported is a salt spring about 3 miles west of Obelisk Peak in southern Mindoro. Probably numerous fresh-water springs that may become dry during dry season. Wells: Small to moderate supply can probably be developed by deep drilled wells. Dug wells probably would not yield an adequate supply. Capacities of individual wells will vary considerably, most will be low. Water levels will lower during dry season. Ground water may be salty locally. Best locations for wells are in areas of thick sections of sandstone. Thorough geologic reconnaissance should be made before drilling to insure proper location of wells.	Combat Supply: Surface water during rainy season; imported water during dry season. Permanent Supply: Surface water supplemented by drilled wells.	Rotary-drilling rigs equipped with rock bits, casing, high-lift pumps. Portable purification equipment tanks.
4 **Reliability poor** Summary: Small to moderate supply can be developed from surface water. Distribution from water points very difficult.	Rough hills and mountains; valleys narrow and deep. Hard mudstone and shale with some hard, well-cemented sandstone and conglomerate.	Streams shallow and swift; many are perennial, often difficult of access.	Springs: None reported. Probably many small springs. Wells: Construction of either deep or shallow wells not recommended. Transportation of heavy equipment into area very difficult and completion of successful wells unlikely.	Combat Supply: Surface water. Permanent Supply: Surface water.	Back-pack purification equipment.
5 **Reliability fair** Summary: Surface water plentiful; often difficult of access. Distribution of supply very difficult. Surface water less plentiful on Lubang Islands.	High rugged mountains. Complex of granite-like rock, slate and marble.	Streams small, shallow, rapid; locally flow through narrow deep gorges. Water clear; requires little treatment.	Springs: Probably numerous small springs. Wells: None. Not recommended.	Combat Supply: Surface water. May be inadequate for large groups away from main streams, particularly on west side of island. Permanent Supply: Surface water.	Back-pack purification units.

(continued)

WATER SUPPLY

MINDORO (P.I.)

Reliability: Sources given below.

MUNICIPAL SUPPLIES [a]

1. Abra de Ilog: Gravity-type system (probably piped from spring), 14,400 gpd capacity, 350 customers. Date of information 1930.
2. Bulalacao: Gravity-type system (probably piped from spring), 43,200 gpd capacity, 700 customers. Date of information 1926.
3. Calapan: Pumping-type system, 57,600 gpd capacity, 2,500 customers. Water piped from Bulusan Spring 1.25 miles (2 km) from town. Pump tested in 1917 furnished an average of 110 gpm against an effective head of 135 feet of water (58 lbs/sq inch). Concrete reservoir of 41,000 gallon capacity on low hill 0.6 mile east of town. Water pipe 1.5 miles to dock. System completed in 1918. Date of latest information 1930.
4. Calapan Army Cadre: Pumping-type system (either drilled wells or spring), 5,000 gpd capacity, 200 customers. Date of information 1931.
5. Naujan: Two 3-inch and two 2-inch wells. Well at presidencia 177 feet deep flows 4.8 gpm; well 330 feet west of presidencia 180 feet deep flows; well near shore 200 feet deep flows. Water contains much hydrogen sulphide gas; disliked by many inhabitants who collect rain water and use surface water. Date of information 1915.
6. Pinamalayan: One drilled well and 8 shallow wells in town furnish brackish water, seldom used. Four flowing drilled wells 160 feet deep, located near new townsite, furnish more than 2,000 gpd; water of good quality; distributed in cans by water carriers. Gravity water system planned in 1932, but not constructed: water was to be piped to town from stream 3 3/4 miles north of town, intake 321 feet above town level, minimum flow of stream during driest months, March, April and May 140 gpm. Date of information 1932 and 1939.
7. Pola: Shallow dug wells and driven wells. One well has 3 gpm capacity. Water polluted and brackish. Date of information 1915. Spring north of town flows 5 gpm.
8. Puerto Galera: Gravity system. Water obtained from spring in hills and piped 0.75 mile to town. Concrete intake tank at spring. Water distributed by two public hydrants. Date of information 1916.
9. Silonay: Two wells equipped with hand pumps. Capacity 1 gpm each.
10. San Jose: Four drilled wells about 250 feet deep; capacity 3 gpm each; located at sugar mill and at residence of officials; furnish only part of supply. Additional water obtained from shallow wells and river. Date of information 1914.
11. Naguiba (Nag-iba): One well with pump. Capacity 1 gpm. Water slightly brackish.
12. Baco: Supply obtained from river.

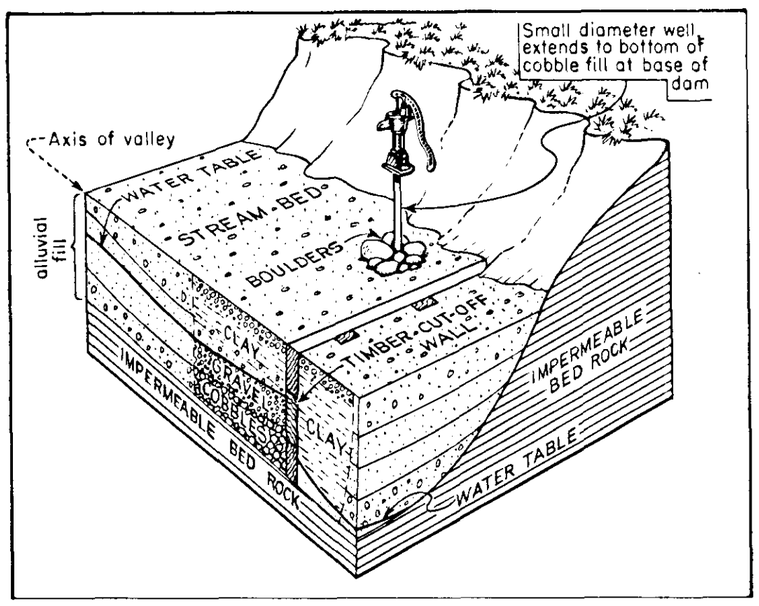
WATER ANALYSES

Sample	Temperature °F	Alkalinity	SO_3	Na_2CO_3	$CaCO_3$	Fe	Cl	Hardness	Date
Naujan									
Well at presidencia	86°	44	10	24.0	22.0	-	-	-	1915
Well 130 feet west of presidencia	-	57	-	30.0	28.5	-	-	-	1915
Well near shore	-	50	-	20.0	30.0	-	-	-	1915
Pinamalayan									
Well near new townsite	-	20	22	0.0	20.0	-	-	60	1915
Stream 1 1/2 mile from town	-	-	-	-	60.0	T	-	93	1915
Pola									
Well near presidencia	-	160	-	-	160	-	-	174	1915
Shallow well 150 to 250 feet from beach	-	300	-	-	300	-	-	369	1915
Tiguihan River	81°	-	-	-	60	0.1	-	65	1915
Calapan									
Spring southeast of town	86°	405	-	-	405	0.25	55	420	1915
Shallow well	-	-	-	-	-	-	110	-	1915

Sample	Acidity	Total Solids	SiO_2	Fe	Cl	Ca	Mg	Na	K	CO_3	HCO_3	SO_4
Calapan -from spring (1907)	-	-	80	-	520	170	220	2900	355	38	980	580
Puerto Galera (1910)	2900	4600	40	450	420	32	40	-	-	-	-	3000

Sample	Total Solids	Cl	Free Ammonia	Albuminoid Ammonia	Nitrates	Nitrites	Hardness	Date
Bulalacao - Monsalay spring	476.4	38.1	.004	.014	T	T	64.3	1914
San Jose - Mindoro Development Co. plantation well.	146.4	12.85	.055	.067	.093	T	16.6	1914

FIGURE 1



Cross section showing simple method of obtaining filtered water from the alluvial fill in the channel of an intermittent stream. Site is selected where stream flows in fairly narrow channel cut through impermeable rock. Alluvial fill is excavated to bedrock entirely across valley. Timber cut-off wall, sized rock, and clay are emplaced as indicated in diagram. Water can be pumped by small hand pump connected with 2-inch pipe perforated at lower end. Pump can be placed at side of valley and protected from floods by boulders. The quantity of water obtainable in this manner is limited to the amount of ground water flowing through the alluvial fill; probably not more than a few thousand gallons per day for small streams. However the water, unlike water from the stream itself, is naturally filtered and always available.

* Sources of information: Analyses 1 to 10, Heise, George W., Water Supplies in the Philippines; II. Phil. Jour. Sci., vol. 10, sec. A, p. 166, 1915.
Analyses 11 and 12, Cox, Alvin J., and Heise, George W., Water Supplies in the Philippine Islands: Phil. Jour. Sci., vol. 9, no. 4, pp. 273-412, 1914.
Analyses 13 and 14, Heise, George W., and Behrman, A. S., Philippine Water Supplies: Dept. of Agriculture and Natural Resources, Bureau of Science. Publication no. 11, pp. 144-145, 1918.

a/ Abbreviations used: gpd = gallons per day.
gpm = gallons per minute.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.

FIGURE 2

OCCURRENCE AND DEVELOPMENT OF GROUND WATER SUPPLY IN COASTAL AREAS AND ON SMALL ISLANDS

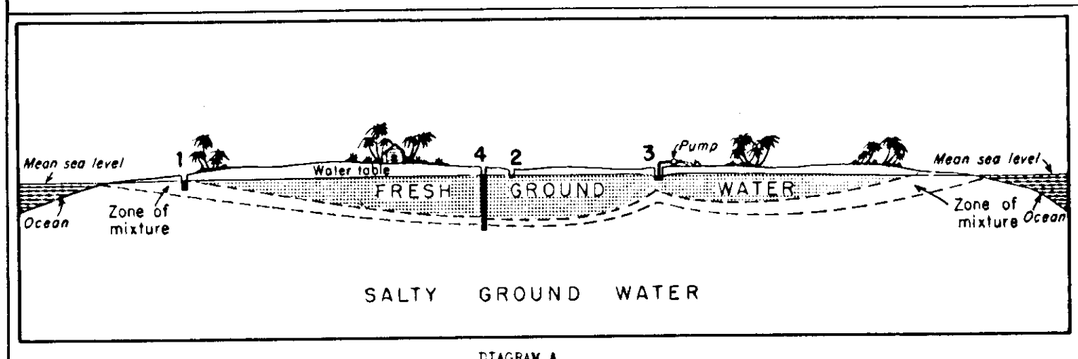


DIAGRAM A

Occurrence of ground water on small island composed of pervious materials. Fresh ground-water layer, derived from local precipitation, floats in hydrostatic equilibrium upon salty ground water, with a narrow intervening zone of brackish ground water (zone of mixture). Vertical scale is about twice the horizontal scale. Shallow wells near shore (well 1) may encounter brackish water; wells in the central part of island (wells 2 and 3) will obtain potable supplies. On very small islands no fresh ground water may be obtainable. Note that the rise of salt water under a well during pumping (well 3) is many times the draw-down of the water table. Well 4 is too deep, and will yield salty water.

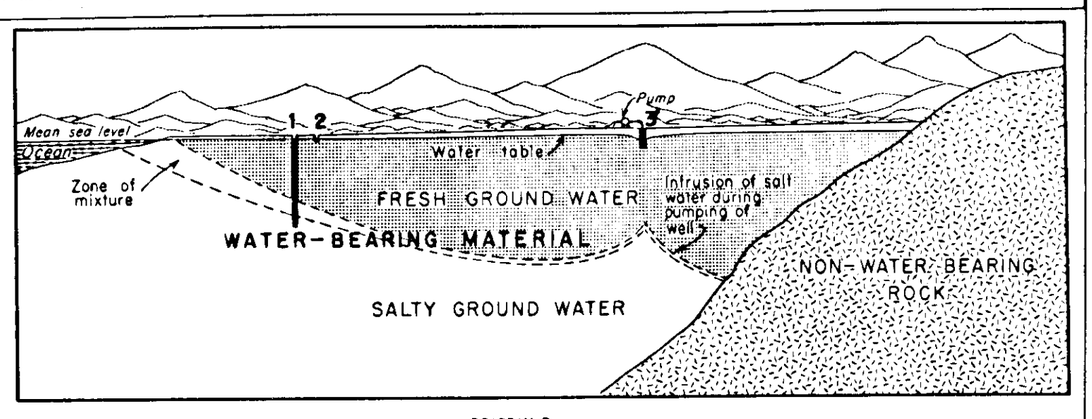


DIAGRAM B

Occurrence of ground water along a sea coast underlain by permeable material. Similar to conditions in diagram A except that fresh-water layer normally is thicker. A deep well near the shore (well 1) will penetrate zone of mixture and salt water zone, although small supplies of fresh water can be obtained from shallow wells (wells 2 and 3). Well 3 shows conditions during pumping. Vertical scale about twice the horizontal scale.

EXPLANATION

Occurrence of fresh ground water: Fresh ground water can generally be found slightly above sea level in coastal areas and on small islands formed of pervious materials. This water is derived from and replenished by rainfall. It forms a body of fresh water which, because of its smaller density, floats upon a concave surface of salt water. The depth to salt water is roughly a function of the height of the water table above mean sea level and the density of the sea water. Theoretically, the fresh water extends 40 feet below sea level for each foot that it rises above sea level. That is, if the water table is one foot above sea level, the salt-water surface will be about 40 feet below sea level and the fresh-water layer will be about 41 feet thick.

Actually the fresh-water layer is always thinner because, owing partly to diffusion but chiefly to tidal fluctuations, the fresh and salt water along the fresh-water salt-water contact become mixed. The amount of this mixing increases rapidly as the tidal fluctuation increases. The zone of mixture is thickest near the shore and thins inland. It is thicker in very permeable materials such as cavernous limestone, and thinner in less permeable material, such as sand. On small permeable islands and narrow coastal belts that are exposed to high tides the mixing may be so extensive that no potable ground water is recoverable.

The quality and quantity of ground water available on islands and in coastal areas also depend upon a number of other factors, the most important of which are:

(1) Recharge to the water-bearing formations. The accumulation of a thick body of fresh ground water is favored by high, evenly distributed rainfall. On the alluvial plains of streams the recharge from rainfall is generally augmented by seepage losses from the streams. In areas of light rainfall the fresh ground-water body is likely to be thin or absent. After heavy rains the ground water freshens, and during dry periods it becomes progressively more salty.

(2) Permeability of the water-bearing formations. The fresh-water layer is generally thin in highly permeable rocks, and is subject to mixing as a result of high waves and large tidal fluctuations. Moderately permeable materials are more likely to have a usable ground-water layer, especially on small islands. On many coral islands there is a layer of nearly impermeable cemented sand (beach rock) around part or all of the island between high and low tide level which retards the movement of fresh ground water from the island and promotes the accumulation of a thick fresh-water layer. Layers of mud or ooze along the fronts of deltas or in mangrove swamps bordering the shore serve a similar purpose.

(3) Width of the island or coastal area. Other things being equal the greater the width of an island or coastal plain the greater is the likelihood of getting fresh ground water, partly because the total rainfall entering the ground is greater, and partly because the water level must rise inland to maintain a gradient seaward. It is not possible to state the minimum width of an island or coastal lowland which will provide a supply of potable water without evaluating all of the factors. An island a quarter of a mile wide composed of sand would probably provide a small usable supply, but an island of the same size of coral would probably supply only brackish water. However, in tropical climates moderately salty water (up to 500 ppm of chloride) is probably beneficial for drinking as the salt compensates for the high loss of salt from the body by perspiration.

The foregoing statements refer chiefly to areas where the rocks have more or less uniform permeability. On islands or coastal areas where permeable and impermeable rocks alternate, giving rise to artesian or semi-artesian conditions, the occurrence of ground water is much more complex, and the problems involved are not considered here. In such areas, development of ground-water supply should be made upon recommendations of a competent ground-water geologist after field study.

Selection of sites for wells and other collecting works: On narrow coastal areas wells should be located as far as possible from the shore; on small pervious islands, as near the center of the island as possible. (See Diagram A.) Where the water-bearing materials are very permeable (such as coral rock), the distance from shore should be several hundred yards. However, if the material is sand, fresh water commonly can be found much nearer the shore. Especially favorable locations are on stream deltas, behind mangrove swamps or behind beach rock. Vegetation may aid materially in indicating the quality of the ground water where it is near the surface. For example, taro plants grow only where the ground water is fresh or slightly brackish; mangroves and nipa palms grow only where the ground water is salty.

Latrines, garbage dumps, burial grounds and other possible sources of pollution should be located shoreward and at considerable distance from wells and other collecting works.

Construction of Wells: On small islands and narrow coastal plains wells should not extend more than one foot below sea level (see Diagram A and B). On larger islands where the wells are more than a mile from the shore, they may be deeper, but except where artesian conditions prevail they should not extend more than a few feet below sea level. On low sandy islands, drive points or batteries of drive points can be used (see Diagram C), but on limestone or other hard rock islands, drilled wells or dug wells can be more easily constructed. Dug wells are generally more satisfactory than drilled wells or drive points, because they provide a larger yield with the same drawdown. Where the fresh water lens is very thin, it is advisable to obtain water from ditches dug to about one foot below sea level, or where ditches are not practicable, from galleries driven from the bottom of a shaft (see Diagram E). If large supplies are needed and there is sufficient room, it is desirable to construct a battery of several drive points spaced 50 feet apart, or several dug wells, infiltration galleries, or ditches spaced 200 feet or more apart. Ditches or galleries should be constructed parallel to the shore to obtain the largest yields.

Pumping: Excessive pumping draws salt water into the wells (see Diagram D). In order to minimize this danger pumps should be regulated so that the water level will not be lowered below sea level. Frequent measurements of the water level and daily titrations of the water to determine the chloride content will aid materially in establishing the safe rate of pumping from each well. On small islands it may be necessary to pump only at low tide. If water supplies are planned for large establishments, especially on small islands, storage should be provided to carry over drought and periods of especially high tides when pumpage may have to be reduced. If wells should become salty as a result of over pumping, they can sometimes be freshened by allowing them to rest, especially during rainy weather.

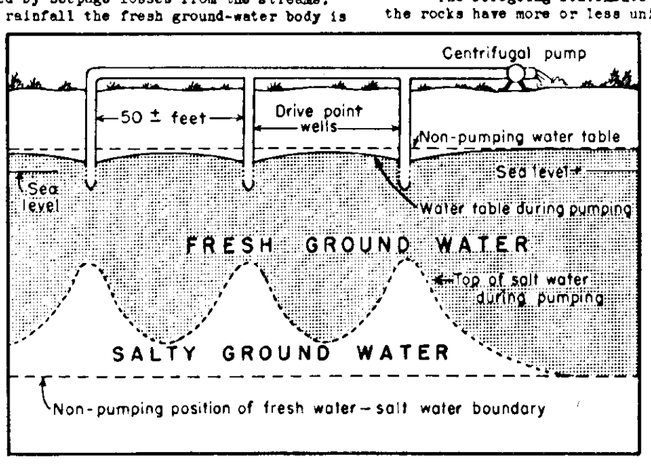


DIAGRAM C

Battery of driven wells (drive points) to spread pumpage and decrease draw-down, thereby minimizing danger of salt-water contamination. Perforations must be below water level so that suction will not be broken during pumping. Wells should be about 50 feet apart and should not extend more than a foot or two below sea level. Diagram is not to scale. Zone of mixture not differentiated.

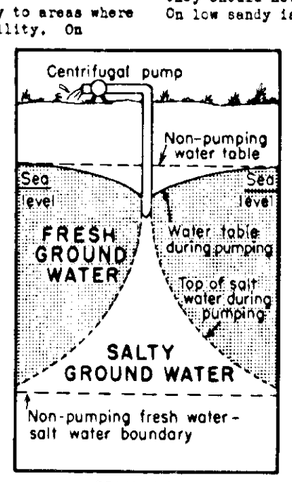


DIAGRAM D

Showing contamination of a well owing to excessive pumping. If well is too deep, contamination is more likely to occur than if well is shallow. Wells that have become contaminated may freshen if allowed to rest. Diagram not to scale.

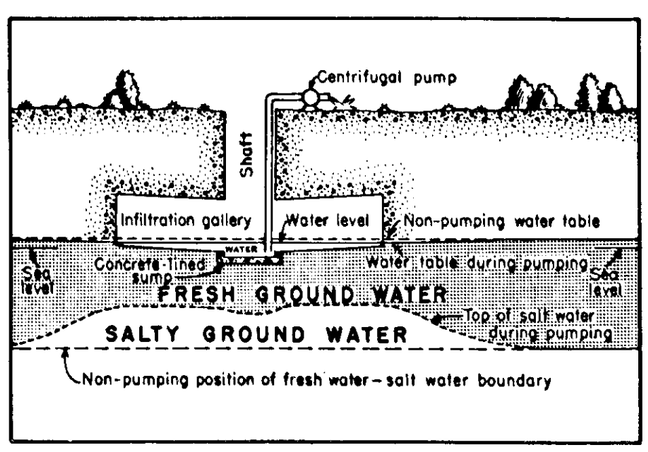


DIAGRAM E

Infiltration gallery used to skim fresh water from top of salt water where fresh-water zone is thin. For equivalent pumpage, rise in salt water is much less than when small-diameter wells are used. Shaft is sunk about 2 feet below sea level and bottom is lined with impermeable material to form a sump. Galleries are driven from near bottom of shaft parallel to shore and with a slight grade so that water will flow to sump. Lowest part of gallery should not be more than a few inches below sea level. If galleries are in caving material, adequate timbering must be provided. Diagram is not to scale.

PREPARED BY U S GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U S ARMY

SUITABILITY FOR AIRDROMES

MINDORO (P.I.)

CAUTION—UNEDITED EDITION

Noted errors: Lumintao River may extend north of Mt. Sinclair. The river (no name) shown running south of Iriron should probably run along the northeast side of the ridge and empty just south of Dongon Pt. The Magasaungtubig River should turn northward west of Pinagsabangan and join the river immediately northwest of the Baluagan River. The south fork of the Magasaungtubig River between Pinagsabangan and San Jose is the Pinagsabangan River and the Butos (Butas) River should empty into it about midway between Pinagsabangan and San Jose.

Compiled by U. S. Geological Survey from following sources: Solid contours from U.S.C. & G.S. field sheets Nos. 3139, 3198, 3200, 3201, 3334, 3335, 3336, 3369, 3745, 3746, 3747, 3748, 3749, 3818, 3862, 3863, mostly 1:20,000.
Dashed form lines sketched from C. & G.S. of Philippines No. 10, 1:200,000 and A.M.S. S401, 1:500,000, Sheet 51–4, except Bagagay Point area for which U.S.C. & G.S. field sheets were used.

10 8 6 4 2 0 10 20 Miles
10 8 6 4 2 0 10 20 30 Kilometers
10000 0 10000 20000 30000 Yards

CONTOUR AND FORM LINE INTERVAL 200 FEET

CONTOUR AND FORM LINE INTERVAL 500 FEET

LEGEND

Railroad, Less than 3'6" gauge
Mangrove
Swamp
Reef
Road, surfaced, all weather
Road, partially surfaced, generally all weather
Track, trail
Road under construction, 1941

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CHIEF OF ENGINEERS, U. S. ARMY

Reliability: Fair

EXPLANATION

Areas discussed in text

- Ia — East Coastal Lowlands. Includes sites 1,2,3.
- Ib — Eastern Rolling Hills. Includes site 4.
- IIa — West Coastal Lowlands. Includes sites 5,6,7,8,9.
- IIb — Western Rolling Hills. Includes site 10.
- III — Coastal Lowlands on the Lubang Islands. Includes sites 11, 12, 13, 14, 15.

(7) Site discussed in detail in text.

Designates site containing airfield in existence in 1941.

Hilly or swampy terrain, unsuitable for airdromes.

Reliability: Fair

INTRODUCTION

General: Extensive areas on Mindoro and Lubang Islands are suitable for construction of airdromes.

The flat lowlands that form about half of the coastal areas of the islands have long stretches between rivers that can accommodate runways, dispersal areas, and hardstandings. Sandy loam and silt loam on natural levees adjacent to the streams are good foundations, but the heavy clay soil of the interstream areas commonly require drainage, scarification perhaps with the introduction of bitumen, construction of base courses, and surfacing to produce dromes satisfactory for year-round use[a/]. Clearance around most lowland areas is good.

In the rolling hills back of the coastal flats, soil is much better suited for subgrades than that in the lowlands, and some sections are flat enough for the construction of runways without too extensive grading. The proximity of the higher hills and mountains makes approaches hazardous.

Trees, mainly coconut palms, must be cleared locally in the eastern part of Mindoro, but most areas in the western part of Mindoro and on Lubang Island are grass-covered and can be cleared by burning[b/].

Sand and gravel aggregate for fill and for concrete are available along most river beds and banks; sand can also be obtained from beaches. Locally, coral mud, sand, and rock can be dredged from fringing coral reefs. Limestone, hard sandstone, and conglomerate suitable for crushing to aggregate are found in places in the hills and low mountains[c/].

All surface water is polluted, although usable for construction work. Plentiful water supplies may be obtained from shallow dug wells or from drilled wells, half a mile or more inland[d/].

Weather Conditions: Rainfall is heavy on Mindoro during the rainy season from May through November. The eastern half of the island has no definite dry season but has less rain in the period from December through April, an interval of thunderstorms. This is the dry season on the west coast. Floods are common during the rainy season but the water subsides rapidly after a heavy rain.

The wind is steady from the northeast from November through April; intermittent from the southwest, from May through October. Calms are infrequent.

Existing Airfields: Eight airfields were in existence on Mindoro Island in 1941. Most were small and suitable for emergency use only. The longest runway, at the Tamaroa field, had a length of 4,920 feet. The locations are listed as follows:

Calapan	Site 1
Wasig	Site 3
Caguray	Site 5
Mangarin	Site 6
Tamarao	Site 7
Barahan	Site 8
Mamburao	Site 9
San Jose	Site 10

Sites: Suitability for location and construction of airdromes is discussed in general terms for the east coastal lowlands (Area Ia), the eastern rolling hills (Area Ib), the west coastal lowlands (Area IIa), and the western rolling hills (Area IIb) on Mindoro Island, and for the coastal lowlands on the Lubang Islands (Area III).

Detailed discussion is given of construction problems and possible expansion of the eight fields in existence in 1941 (Sites 1, 3, 5, 6, 7, 8, 9, 10), and of construction problems at suggested Sites 2 and 4 on Mindoro Island and Sites 11, 12, 13, 14, 15 on Lubang Island.

AREA Ia. EAST COASTAL LOWLANDS

General: Many large sections flat enough for good sites. Construction easiest during drier season (December-April), although frequent rains may keep ground muddy. Poor drainage and high water table in heavy soils, except in natural levees along rivers.

Location and Accessibility: Low coastal areas along east side of Mindoro Island. Fairly accessible to road connecting Calapan and Bongabong. Boats can probably be unloaded at Calapan wharf, in Pola Bay, and in Mansalay Bay.

Topography and Grading: Nearly flat; requires little grading except to fill ditches and shallow gullies. Difficult in the heavy soil to fill deep ditches or terraced rice fields and maintain a level surface as compaction and settling are entirely different in filled zones.

Foundation and Drainage: Clay loam and clay poor foundation; sandy loam to silt loam in natural levees fair to good foundation. If necessary, fair subgrade can be made from clay soils by pump drainage, diking to keep out surface floodwater, and by scarifying with accompanying introduction of bitumen. For year-round use, runways require thick base course with hard surface

Construction Materials: Sand and gravel available from beds or banks of most large rivers, and sand from beaches. Conglomerate and hard sandstone, which may be crushed for riprap or for concrete aggregate, are available in hills near Manaul, at Mt Dumali, and in mountains east of Lake Naujan.

Clearing and Grubbing: Most of the area has been cultivated to rice, hemp, coconut palms, or fruit trees; abandoned fields have grown up in secondary forests or grass. Little clearing necessary in cultivated sections; dozers can push over trees. Abandoned sections may require more clearing. Possibly some scattered stands of primary forests may remain; will require heavy clearing and grubbing.

Water Supply: Adequate surface water for construction; often turbid, polluted. Plentiful ground water easily developed from shallow dug wells or from drilled wells; best locations half a mile or more inland.

SITES IN AREA Ia

Site 1. Calapan

One northwest-southeast runway (1938), 2,640 feet by 330 feet; cannot be extended to accommodate combat planes unless re-aligned; might be used for emergency landings.

Location and Accessibility: Approximately 1 1/3 miles northeast of Calapan; accessible by road.

Topography and Grading: Fairly flat with gentle rise from southeast for about 2/3 length of strip, then gently sloping down to northwest. Little grading necessary in vicinity of field.

Foundation and Drainage: Sandy loam good foundation; surface drainage good but water table high.

Construction Materials: Sand and some coarse angular gravel available on beaches; stream beds contain gravel mixed with mud. Bank run dredged from coral reef flat along northeast side of point north of field bonds rapidly as surfacing, makes good base course. Rock from quarry near Calapan good for riprap and concrete aggregate when crushed.

Clearing and Grubbing: Mostly coconut palms that can be pushed over with dozer; brush cleared by dozer and scraper. Probably no grubbing required.

Water Supply: Plentiful from shallow dug wells.

Site 2. Naujan (See Terrain View 2)

Proposed site for landing field (1935); best alignment for runways probably northeast; area probably large enough for strips to accommodate heavy bombers; trees form only approach hazards.

Location and Accessibility: Along north side of Magasaungtubig River about 1 mile west of Naujan. First-class road to town of Naujan with ford across river; 10 1/2 miles by first-class road to Calapan.

Topography and Grading: Broad natural levees along rivers (areas of coconut trees in view); lower and wetter regions between rivers. Mostly flat, but some cut and fill necessary to smooth local irregularities.

Foundation and Drainage: Natural levee area, fine sandy loam to silt loam; bearing ratio of surface loam fair to good; probably sticky if worked when wet; aggregate needed for base course probably available from gravel banks along river. Surface drainage good; loam readily stabilized at optimum moisture content when surface drained. Lowland areas between rivers, clay loam or clay, 1 to 2 feet deep, underlain by clay; poor foundation. High water table and very poor drainage; would require pumping to drain. Runoff from slightly higher levees along sides is into lower sections, so protecting dikes and bordering ditches needed to carry off water. Drained, soil could be scarified with the introduction of bitumen to make an emergency subgrade. Landing mats might be used with fair success during the drier part of the year, but base course and surface needed for rainy season.

Construction Materials: Sand and gravel bank is probably along Magasaungtubig River and other streams near; sand also available on beaches. Hard sandstone and conglomerate suitable for crushing, can probably be obtained 15 miles south in the hills east of Lake Naujan.

Clearing and Grubbing: Coconut palms on natural levees cleared with dozer. Few other trees to be removed.

Water Supply: Adequate surface water for construction; polluted. Plentiful ground water easily developed from shallow dug wells and from drilled wells; best locations 1/2 mile or more inland.

Site 3. Wasig (See Terrain View 4)

One existing runway in 1939; 2,640 feet by 165 feet, aligned northeast along beach. Extension of this strip not practical; mangrove swamps north and northeast; hills on point along northeast side of Mansalay Bay offer obstruction on southwest.

Location and Accessibility: Existing strip on beach between Panag and point on northeast side of Mansalay Bay. Material might be landed on beach or in Mansalay Bay.

Topography and Grading: Sandy beach; little or no grading required. Building new strips or runways on lowlands back of beach would probably require grading to fill shallow gullies and ditches.

Foundation and Drainage: Sandy foundation of existing strip excellent; surface drainage good but water table just below surface. Clays and clay loams on lowlands back of beach poor foundation; might be scarified with the introduction of bitumen. High water table probably necessitates pumping for drainage, or elevation of subgrade. Water table nearly at surface (at least during rainy season); dikes would help keep outside surface water off site.

Construction Materials: Sand and gravel easily obtainable from Waigan Creek and Baroc River just north of site. Sandstone and conglomerate suitable for crushing for base course and for concrete aggregate may be available in hills southwest of site.

Clearing and Grubbing: Very little clearing necessary along southwest end of existing strip; probably more in lowlands back of beach. Secondary forests, fruit trees, and grass, most of which could probably be cleared with a dozer.

Water Supply: Adequate surface water for construction; polluted. Plentiful from shallow dug wells or from drilled wells. Best locations 1/2 mile or more inland.

AREA Ib. EASTERN ROLLING HILLS

General: Topography not as suitable for airdromes as on coastal lowlands. Some flat sections may be large enough, and a few of the more gently undulating sections may be leveled without much cut and fill. Areas adjacent to higher mountains may have restricted or hazardous approaches.

Location and Accessibility: Along eastern part of Mindoro between coastal lowlands and interior mountains. Lower margins accessible to road along eastern side of island.

Topography and Grading: Low rolling hills or gently undulating country with hill altitudes about the same. Some relatively flat areas probably large enough for runways with grading necessary to smooth undulations. Even flat sections locally cut by gullies that need filling.

Foundation and Drainage: Foundation fair to good in clay loam with some gravel lenses; bearing ratio fair to excellent; good compaction at optimum moisture content. Probably require at least 3 inch base course and bitumen surface. Soils of low permeability; may require control of seepage water. Surface drainage good.

Construction Materials: Sand and gravel available from beds and banks of streams. May be some hard sandstone and conglomerate in hills and mountains west of area.

Clearing and Grubbing: Intermittently cultivated sections, mainly in northern half of area, require little clearing. Much of southern half has stands of primary forests which require extensive clearing and grubbing.

Water Supply: Adequate surface water for construction; polluted. Plentiful ground water easily developed from shallow dug wells or from drilled wells.

SITE IN AREA Ib

Site 4. Pinamalayan

Proposed site for landing field (1935); probably large enough to build airdrome suitable for medium and heavy bombers. To permit approach clearance at both ends runway would probably have to be oriented northwest; range of hills with maximum altitude of 640 feet is obstacle along northwest side of site. Adequate space for dispersal area and hardstandings, but coconut palms probably only concealment.

Location and Accessibility: One mile west of Pinamalayan at junction of road south to Bongabong and northwest to Calapan. Easily accessible by this road.

Topography and Grading: Very gently undulating country; would require considerable grading to get to necessary level, but no deep gullies to fill or high areas to cut.

Foundation and Drainage: Good foundation with high bearing ratio over most of site. Drainage good except in few lower areas where there are some rice paddies. For use during rainy period (May through November) base course with surface needed.

Construction Materials: Closest sand and gravel in any quantity reported 5 1/2 miles west on Pula River. May be hard sandstone and conglomerate in hills just southwest of site; when crushed makes suitable aggregate for base course and for concrete.

Clearing and Grubbing: Little necessary; mostly coconut palms which can be cleared with dozer.

Water Supply: Little surface water in immediate area; polluted. Supply from shallow dug wells and from drilled wells; best locations 1/2 mile or more inland.

(continued)

a/ See Soils Sheet.
b/ See Vegetation Sheet.
c/ See Construction Materials Sheet.
d/ See Water Supply Sheet.

SUITABILITY FOR AIRDROMES

MINDORO (P.I.)

Reliability: Fair

AREA IIa. WEST COASTAL LOWLANDS

General: Many flat sections large enough for good airdrome sites. Construction difficult on heavy clay soils but ground firm during dry season (December through April). Clearance for glide angles ample over most of area, but along upper parts of large streams may be limited by hills and mountains.

Location and Accessibility: Lowlands along west coast of Mindoro Island. No roads, but movement inland easy during dry season; equipment could probably be landed along beaches. Wharf at Caminawit Point on Mangarin Bay; harbor sanded by currents from north, and wharf may need extending before it can be used.

Topography and Grading: Almost flat with slightly higher natural levees along rivers; bouldery stream beds. Terraces along large rivers (Lumintao and Bugsanga; see Tamarao field on latter) should make good sites if clearance is adequate over nearby hills. Little grading necessary other than to fill small ditches and gullies.

Foundation and Drainage: Clay loam and clay poor foundation for use during rainy season. During dry season landing mats can probably be used directly on soil; in grass-covered areas, high grass should be burned but mat of roots just beneath surface left undisturbed unless grading necessary. Gravelly sands of terraces good foundation; drainage also good. For rainy season use runways must have base course and hard surface; coral rock and sand dredged from fringing reefs might be used locally for surfacing. Drainage poor in clay loam and clay areas; dikes easily built during dry season to keep surface runoff from field during rainy season.

Construction Materials: Sand and gravel plentiful along river beds. Coral rock from fringing reefs available locally (see Construction Materials Sheet for locations). Possibly some limestone suitable for crushed rock aggregate in hills east of southernmost part of the lowlands; extent and quality not known.

Clearing and Grubbing: Probably none necessary. Most vegetation is cogon grass or sugarcane that can be cleared by burning.

Water Supply: Plentiful ground water easily developed from shallow dug wells or from drilled wells. Surface water polluted but suitable for construction; little or none available during dry season; subdrains, side collection channels and pumping may be needed.

SITES IN AREA IIa

Site 5. Caguray

Emergency landing field, probably suitable for runways to accommodate fighters and light bombers with ample space for dispersal. Open to south and west; clearance apparently adequate over low hills north and east. Could be readily expanded.

Location and Accessibility: South side of Caguray River in southern Mindoro. Road construction probably easy to Mangarin site and to wharf facilities at Caminawit Point on the west side of Mangarin Bay.

Topography and Grading: Flat lowlands; probably little grading necessary.

Foundation and Drainage: Clay loams and clays poor foundation, but probably hard and firm during dry season and suitable for landing mat. For use during wet season construction of base course and surface necessary. Water table high and drainage poor.

Construction Materials: Probably some sand and gravel banks along Caguray River. Sandy beach at Santa Terese, 3 1/2 miles south. May be thin layers of limestone usable for crushed rock in hills 5 to 10 miles east.

Clearing and Grubbing: Little necessary.

Water Supply: Caguray River probably perennial; water polluted but suitable for construction. Plentiful supplies from shallow dug wells and from drilled wells.

Site 6. Mangarin (Waterous)

In 1940 this was an all-weather emergency field with two level strips, one, 3,270 feet by 150 feet oriented north-south and the other, 1,980 feet by 150 feet oriented northeast. Both runways could probably be extended at least 2,000 feet. A still longer runway could be constructed in a northwest-southeast direction. Glide clearance should be good in most directions, although hills to the north and northeast may make approaches hazardous from that direction.

Location and Accessibility: Situated on lowlands east of Mangarin Bay on the southwest coast of Mindoro. Wharf at Caminawit Point on the northwest side of Mangarin Bay might have to be extended before being used, as harbor is sanded by currents from the northwest. During the dry season transportation would be easy from the wharf to the field, but a road would probably have to be constructed for use during the wet season.

Topography and Grading: Flat land; little grading necessary except to fill shallow gullies.

Foundation and Drainage: Foundation fair to good; good on sandy gravel in parts of existing strip. Water table high, but surface drainage fairly good. Landing mat laid directly on the hard, firm ground during the dry season satisfactory, but for use during the rainy season a base course of coarse aggregate should be constructed and surfaced.

Construction Materials: Sand and gravel probably available from Caguray River, 2 1/2 miles southeast; smaller quantities along streams west of site. Limestone suitable for crushing to use as aggregate for base course surfacing and for concrete occurs in hills 5 to 10 miles east and north of site.

Clearing and Grubbing: Little necessary for long runway to northwest; more for northeast and north runways; trees probably cleared by dozer.

Water Supply: Plentiful from shallow dug wells or from drilled wells. Little or no surface water during dry season. Well on site equipped with windmill and small storage tank mounted in windmill tower.

Site 7. Tamarao Airfield

Emergency landing field (view taken 1934), reported as an all-weather strip, 4,920 feet by 465 feet. The possible area is probably at least 8,000 feet northeast-southwest by 2,000 feet.

Location and Accessibility: North of San Jose, southwestern part of Mindoro, on terrace along southeast side of Bugsanga River. Road construction easy to San Jose and to railroad to wharf at Caminawit Point on Mangarin Bay.

Topography and Grading: Cogon grass covered terrace with very gentle slope to southwest; slope angle probably not too great for longitudinal grade of runway. The glide angle over the high mountains to the northeast is approximately 20 to 1 but the approach from the southwest, which would be into the wind most of the time, is open. There are also hills and mountains on the southeast and across the river on the northwest. Probably ample space for dispersal area on terrace but no concealment. Two small hills in center of terrace are obstacles, but clearance and landing areas should be ample around them. Moderate grading to smooth minor irregularities; probably best to haul fill from outside strip rather than disturb level areas adjoining small gullies in terrace.

Foundation and Drainage: Gravelly sand good foundation with good bearing ratio; good drainage. Landing mat laid on burned cogon grass satisfactory during dry season. For rainy season, base course needed; gravel aggregate plentiful along river bed; base course can be laid directly on mat of burned roots of cogon grass.

Construction Materials: Good supplies of sand and gravel along river by site; will probably require screening and crushing for use as concrete aggregate. Some limestone in the hills 6 miles to south may be usable as crushed rock.

Clearing and Grubbing: Probably none required.

Water Supply: Little or no surface water during dry season; river floods during rainy season but probably does not get over terrace; surface water not potable. Plentiful ground water easily developed from shallow dug wells and from drilled wells.

Site 8. Barahan

Emergency landing strip on beach (view taken 1935), site probably too small for development of airdrome. Runway restricted to north-south orientation by shore and adjacent stream.

Location and Accessibility: On beach south of town of Barahan between small river and sea. No harbor facilities; supplies probably could be landed on the beach.

Topography and Grading: Almost flat beach strip. Little grading necessary.

Foundation and Drainage: Packed sand good foundation; surface drainage good but water table fairly high.

Construction Materials: Nearest gravel probably 2 miles south along bed of Amnay River or 4 miles north along Pola River; haul from Amnay River would require crossing small river just east of strip.

Clearing and Grubbing: Small bushes easily cleared.

Water Supply: Shallow dug wells in beach usable but water probably brackish; best source from shallow dug wells or from drilled wells farther inland.

Site 9. Mamburao

Small private landing field (view dated 1938). Not suitable for enlargement to accommodate combat planes.

Location and Accessibility: On small point west of town of Mamburao. Accessible by road.

Topography and Grading: Flat coastal area with shallow, water-filled depressions which require filling.

Foundation and Drainage: Foundation fair, may be good locally where sandy; probably hard and firm during dry season and usable with landing mat. Base course and surface necessary if runway to be used during rainy season. Drainage difficult; water table nearly at surface; may require elevation of subgrade for all-weather installation.

Construction Materials: Gravel and sand probably obtainable from Sinambalan River, 1 mile east. Bank run consisting of mud, sand, rock dredged from coral reef flats off point bonds rapidly and makes good base course. Probably coral beach sand suitable for use in cement.

Clearing and Grubbing: Little needed.

Water Supply: Shallow dug wells give fair supply; these and drilled wells would be better located farther inland.

AREA IIb. WESTERN ROLLING HILLS

General: Conditions fairly good, if large enough level areas can be found. Careful ground reconnaissance necessary, as topographic details cannot be obtained from available maps.

Location and Accessibility: Between coastal lowlands and rough hills and mountains of western Mindoro. No roads, but movement easy during dry season; some trail building probably necessary across valleys and gullies. Equipment probably can be landed on beaches.

Topography and Grading: Rolling country with terrace-like hills, some of which may have large enough flat tops for sites. Some grading required to fill small gullies.

Foundation and Drainage: Clay loams with gravel lenses fair to good foundation; good compaction at optimum moisture content; landing mat directly on soil probably satisfactory during dry season. Thin base course with hard surface needed for runways during rainy season. Drainage good, although may require control of some seepage water.

Construction Materials: Sand and gravel available along river beds; coarse gravel along large rivers may require crushing for aggregate for base course and concrete. Possibly some hard sandstone and conglomerate, suitable for base course or concrete aggregate, in rough hills and mountains around inner margins of areas.

Clearing and Grubbing: Mainly cogon grass areas which can be cleared by burning.

Water Supply: Plentiful from shallow dug wells and from drilled wells. Surface water polluted, but suitable for construction; little or none available during dry season.

SITE IN AREA IIb

Site 10. San Jose (southwest Mindoro)

Existing field (view taken 1939) had two level strips, 2,970 feet by 660 feet oriented north-south and 2,520 feet by 660 feet oriented east-west; all-weather. Located on terrace which limits length of runways; extension not practical. Possible, though doubtful, that a similar area large enough might be found in the same general region.

Location and Accessibility: West of San Jose, southwestern Mindoro, in rolling hill country with hilltops of about same altitude. Easily accessible from San Jose; in 1941 there was a railroad from San Jose to the wharf at Caminawit Point on Mangarin Bay and to San Agustin.

Topography and Grading: Rolling hill country with hills of about equal altitude; existing field on flat top of terrace-like area. Some grading might be required to fill small gullies; extension of present field impractical, because too much fill would be required in large valleys.

Foundation and Drainage: Compaction at optimum moisture content would produce good subgrade; bearing ratio good. Drainage good; might require some control of seepage water during wet season.

Construction Materials: Bed of Bugsanga River, 3 miles northwest, good source of sand and gravel; would require screening and perhaps crushing for use as concrete aggregate.

Clearing and Grubbing: Little required. Mostly cogon grass which can be burned.

Water Supply: Plentiful surface water during wet season; can be used for construction work but is polluted. No surface water during dry season. Plentiful ground water easily developed from shallow dug wells and from drilled wells.

AREA III. COASTAL LOWLANDS ON THE LUBANG ISLANDS

General: The Lubang Islands, Lubang, Ambil, and Golo, are northwest of the island of Mindoro. Areas of possible airdrome sites are limited to coastal lowlands on Lubang and Golo. Only one site (11) is suitable for construction of bomber field. The following general discussion applies to the lowland areas; specific sites are discussed briefly with respect to area, topographic hazards, general suitability.

Location and Accessibility: Coastal flats on Lubang and Golo Islands. Only road is on Lubang Island, connecting towns of Tilig, Lubang, and Tagbac; third-class. Road between Tilig and Looc reported under construction in 1941. Most of Lubang and Golo fringed by coral reefs, broken by short stretches of beach as at Tilig, Looc. No wharf facilities.

Topography and Grading: Flat rice land with altitude below 100 feet. Probably little grading necessary except to fill shallow gullies and ditches.

Foundation and Drainage: Clay loam and clay, probably overlying uplifted coral reef. Poor foundation in wet season; dry and firm during dry season (December through April), satisfactory beneath landing mat. Drainage generally poor, pumping or elevation of subgrade, surfacing necessary for wet season use. Ditches needed to canalize surface water. Dikes probably necessary to keep outside water off sites.

Construction Materials: Coral reefs fringing most of islands best material available; dredging should be relatively easy. Timber generally available in nearby hills.

(continued)

MINDORO (P.I.)

SUITABILITY FOR AIRDROMES

Reliability: Fair

AREA III. COASTAL LOWLANDS ON THE LUBANG ISLANDS (continued)

Clearing and Grubbing: Little necessary.
Water Supply: Little if any surface water except during wet season. Adequate supplies generally obtainable from shallow dug wells or drilled wells back from coast, at base of foothills.

SITES IN AREA III

Site 11 (Lubang Island)

Northwest end of Lubang Island, dimensions of site approximately 5 by 5 miles. Rough hills on southeast limit clearance in that direction, but all other approaches clear, except for few trees to southwest. Topographically suitable for bomber field. Ample space for dispersal; some trees for concealment, particularly in southwest section.

Site 12 (Lubang Island)

East side of Lubang Island. Dimensions approximately 8,000 by 5,000 feet. Possibly suitable as site for emergency field. Hills on northwest, and south make approaches hazardous. Road reported under construction in 1941, connecting towns of Tilig and Looc and crossing coastal margin of site.

Site 13 (Lubang Island)

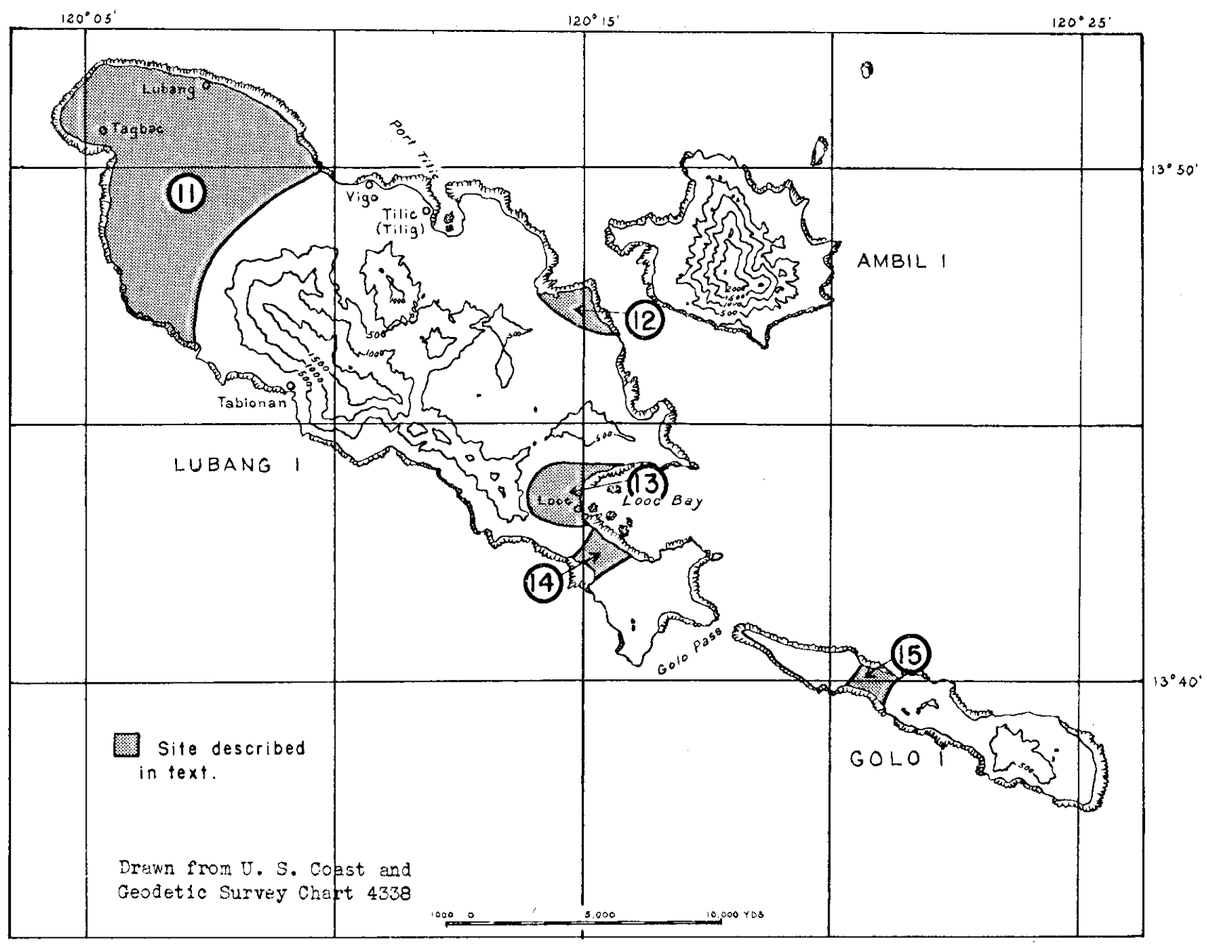
Southeast coast of Lubang Island, near town of Looc. Approximate area, 7,000 by 4,500 feet. Open to east and partly open to south, restricted by high hills on north and west. Road reported under construction in 1941, connecting Tilig and Looc. Suitable only for emergency field.

Site 14 (Lubang Island)

Near southeast end of Lubang Island. Approximate dimensions, 5,000 by 3,500 feet. Clear approaches for northeast runway, which is also best direction because of winds. Possibly suitable for fighter field.

Site 15 (Golo Island)

On Golo Island, southeast of Lubang. Approximate dimensions, 4,500 by 3,000 feet. Open on south and southwest, but has 186-foot hill in center of open area along north margin of site. Could probably be developed as emergency landing field for fighters.



Area III. Coastal Lowlands on the Lubang Islands

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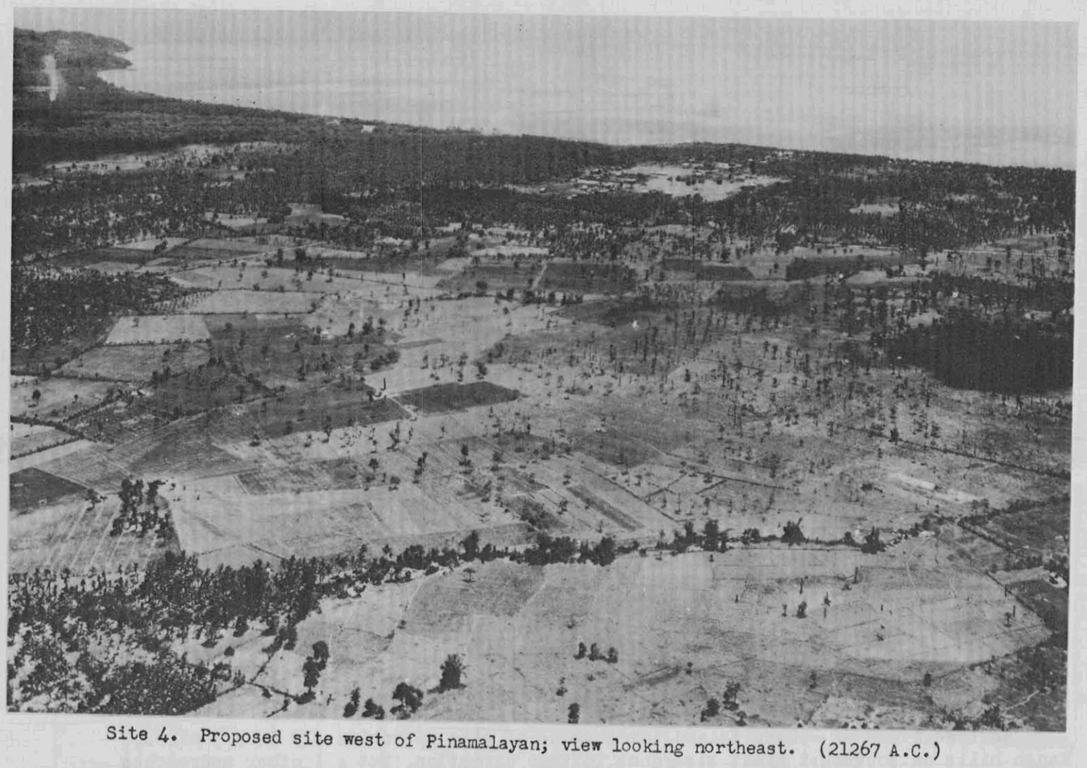
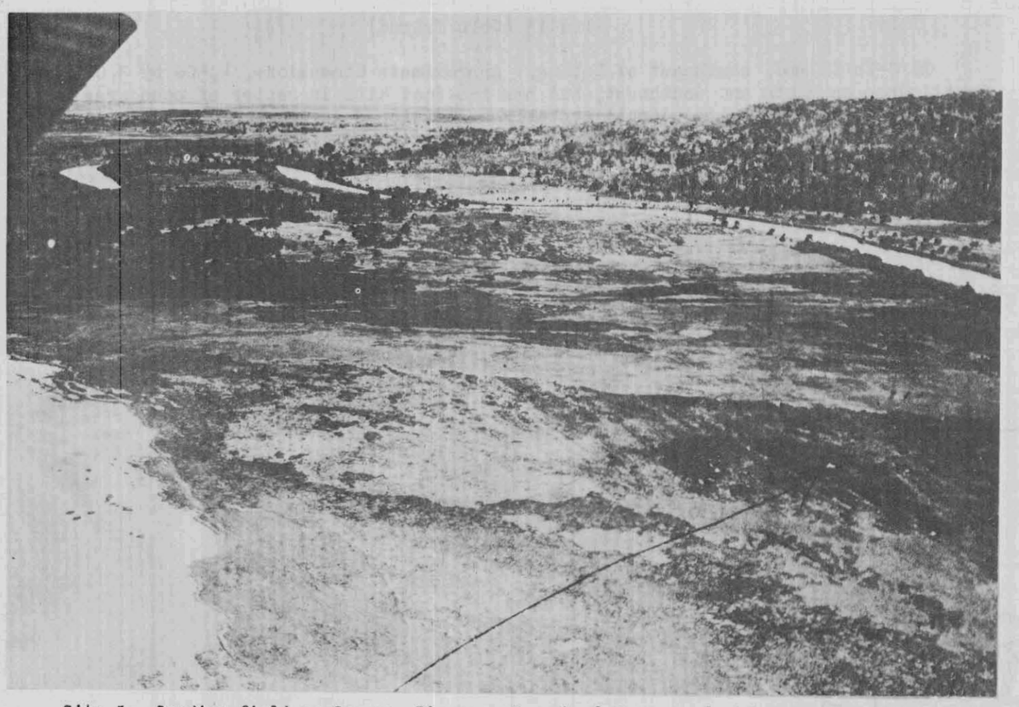
Site 1. Calapan landing field; view looking northwest. (21270 A.C.)



Site 4. Proposed site west of Pinamalayan; view looking northeast. (21267 A.C.)

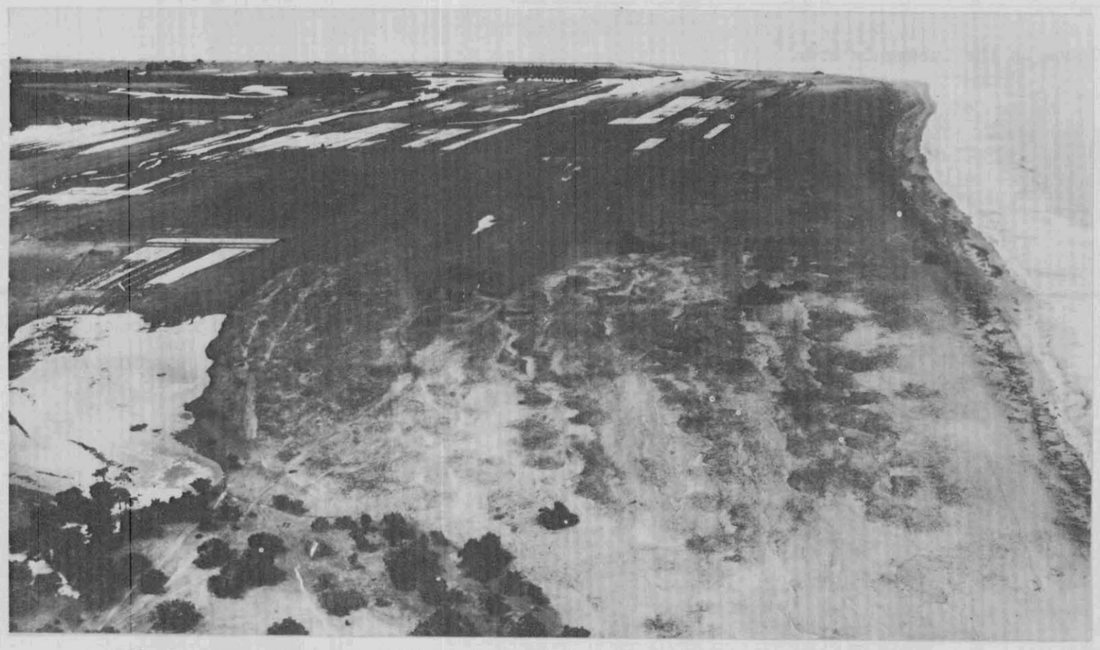


Site 5. Landing field on Caguray River northeast of Caguray; looking north-northeast. (MID S30-603A, vol. II, p. 62)

Site 6. Mangarin (Waterous) field, east and north of Mangarin Bay; looking north. (ONI 320-254) See also Terrain View 11.

Site 7. Tamarao field; looking east. River terrace on east side of Bugsanga River. (MIS 1648.262 - 1648.262A)

Site 8. Landing strip south of Barahan; looking north. (21271 A.C.)



Site 9. Landing field on point west of Mamburao; looking southeast. (21266 A.C.)

For Sites 2 and 3 see Terrain Views 2 and 4.

Site 10. Landing field east of San Jose; looking south-southeast. (CFL 1657525) See also Terrain View 10.

ROAD CONSTRUCTION AND MAINTENANCE

MINDORO (P.I.)

CAUTION—UNEDITED EDITION

Noted errors: Lumintao River may extend north of Mt. Sinclair. The river (no name) shown running south of Iriron should probably run along the northeast side of the ridge and empty just south of Dongon Pt. The Magasaungtubig River should turn northward west of Pinagsabangan and join the river immediately northwest of the Baluagan River. The south fork of the Magasaungtubig River between Pinagsabangan and San Jose is the Pinagsabangan River and the Butos (Butas) River should empty into it about midway between Pinagsabangan and San Jose.

CONTOUR AND FORM LINE INTERVAL 500 FEET

CONTOUR AND FORM LINE INTERVAL 200 FEET

LEGEND

Railroad, Less than 3'6" gauge

Mangrove

Swamp

Reef

Road, surfaced, all weather

Road, partially surfaced, generally all weather

Track, trail

Road under construction, 1941

Compiled by U. S. Geological Survey from following sources: Solid contours from U.S.C. & G.S. field sheets Nos. 3139, 3198, 3200, 3201, 3334, 3335, 3336, 3369, 3745, 3746, 3747, 3748, 3749, 3818, 3862, 3863, mostly 1:20,000.
Dashed form lines sketched from C. & G.S. of Philippines No. 10, 1:200,000 and A.M.S. S401, 1:500,000, Sheet 51–4, except Bagagay Point area for which U.S.C. & G.S. field sheets were used.

10 8 6 4 2 0 10 20 Miles

10 8 6 4 2 0 10 20 30 Kilometers

10000 0 10000 20000 30000 Yards

Reliability: Fair

EXPLANATION

NUMBERS AND HEAVY LINES DESIGNATE MAP UNITS DESCRIBED IN TEXT. LETTERS AND LIGHTER LINES REFER TO GROUND TYPES:

A — Swamps. Thick clay and silty clay, saturated and highly plastic.

B — Alluvial clay and clay loam of coastal plains. Impervious; plastic and sticky when wet; high water table.

C — Silt and sand of stream channels and natural levees; sands and gravels of beach ridges. Good natural drainage, low plasticity.

D — Thick clay loam in hills and lower mountains. Impervious and sticky when wet.

E — Thin clay and clay loam on limestones of hills and lower mountains. Many outcrops. Moderately plastic; impervious, particularly when puddled.

F — Thick clay loam of rough high mountains. Moderately to very plastic; impervious, particularly when puddled.

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

MINDORO (P.I.)

ROAD CONSTRUCTION AND MAINTENANCE

Reliability: Fair

INTRODUCTION

Mindoro is one of the least developed of the Philippine Islands and the pre-war road-construction program consisted of the addition of only a few kilometers of highway a year. A first-class road, graded and surfaced with asphalt or water-bound macadam connects Calapan with Bongabong across the eastern coastal plain and extends branches to a few nearby towns. First-class roads in the Philippines have permanent culverts and bridges, or ferries capable of carrying 2-ton trucks; are constantly maintained, and are passable at all times. Since the Japanese occupation, roads may have deteriorated greatly. The few second-class roads on the northeast coast are probably partially surfaced. There is a narrow-gauge railway at the San Jose sugar estate in southwest Mindoro, but elsewhere in the island foot trails or sea routes are the only means of communication.

Except along natural levees of streams and low beach ridges along the coast, the trafficability of the soils is extremely poor. In the rainy season unsurfaced roads become completely impassable for wheeled vehicles and extremely difficult for foot travel. On slopes, gullies develop rapidly, and slides are common. Banks and cuts may be protected by planting rapidly growing cogon grass, and by covering with bundles of grass when first dug. Streams rise rapidly with heavy rains, becoming unfordable, and boulders and driftwood moved by the currents are hazards to temporary structures. Wooden bridges deteriorate rapidly under tropical conditions.

Sand and gravel for road construction may be obtained from beaches and from many of the streams of the coastal plain, but hauls of several miles may be necessary between the larger streams away from the coast. Sound bedrock for crushed aggregate is difficult to obtain except in limestone area of southern Mindoro and in stream channels in hill and mountain country.

MAP AREA 1

Existing Roads: Two-way graded and surfaced road from Calapan to Bongabong, with branches northeastward to wharf on west side of Calapan Point, to Naujan, and to Pola; short extensions westward toward Baco and San Teodoro. Permanent culverts and concrete or timber bridges across most streams. Second-class road, graded but unsurfaced extends to San Teodoro. Sand-clay surfaced road along coast from Calapan Point to Naujan and San Jose has satisfactory all-weather surface for light traffic as far south as Silonay.

Topography, Alignment, and Grades: Low flat coastal plain, 4-12 miles wide, rising gently to elevations of 100 to 200 feet at border of rough foothills on west; broken by rough hill country in peninsula at Mt Dumali, east of Lake Naujan and ridge 500 to 600 feet high extending about 6 miles south from Calapan Point. Roads generally have straight alignments, long radius curves, slight grades, no cuts or fills. Chief obstacles to road construction are numerous streams, and swamps along coast.

Subgrade: Soils between main streams are plastic clays and clay loams; trafficability even for carts extremely poor when wet. Subgrades require good compaction at optimum moisture content and application of thick base course before surfacing. Natural levees along banks of larger streams are a few feet above interstream areas, have silty and sandy loams providing fair to good trafficability. Clays in swamps unsuitable for road subgrades without thick fill.

Stream Crossings: Numerous streams a few feet to 100 yards wide; banks typically steep, 2 to 20 feet high. Larger streams unfordable for 1-2 miles back from coast. Streams are subject to rapid rise after heavy rains, endangering fixed or pontoon bridges and making ferry operation hazardous.

Clearing and Drainage: Coastal area is cultivated; coconut palms are set wide apart near shore and in strips along streams; ground easily cleared by bulldozer. Some fruit trees may require cutting. Inland border of area covered with heavy primary forest which requires cutting and blasting, grubbing with tractors.

Lower parts of coastal plain have impervious poorly drained soils and high water table. Roads should be ditched and subgrade built up to give adequate drainage. Soil drainage good on natural levees along streams; subject to flood after heavy rains. Good drainage on low beach ridge along coast.

Construction Materials: Sand and gravel abundant in many stream channels and in pockets along banks. Beach gravel, well rounded and sorted, needs addition of clay for stabilized surfacing material. Small quantities of coral may be available along coast. Hard rock for crushed aggregate can be obtained from quarry on ridge east of Calapan, probably from hills east and northeast of Lake Naujan and around Mt Dumali. Timber for bridges and piling available in swamps along coast and from heavy forests on inland side of coastal plain, on hills east of Lake Naujan, and around Mt Dumali. Coconut palms along coast and stream banks suitable for corduroy, posts, and cribbing.

MAP AREA 2

Existing Roads: A few dirt tracks around Pandurucan sugar mill and wharves. Native trails unsuitable for motor transport.

Topography, Alignment, and Grades: Discontinuous low flat coastal plain reaching a maximum width of about 8 miles. Inner part of plain rises to elevations of 100 to 300 feet, has flat terrace areas, broken by small stream valleys. Roads can be layed out with many long tangents, long radius curves, some cut and fill in clays and gravels of dissected terraces. Grades flat or very gentle in most of area; grades less than 5% required across edges of terraces.

Subgrade: Soils on lowlands between streams are clays and clay loams; trafficability extremely poor during rainy season, fair in dry. Terrace soils somewhat less plastic, have better supporting value. Careful moisture control is essential during compaction, application of base course necessary before surfacing. Sandy loams of natural levees and sands and gravels of dry stream channels have fair to good trafficability but may be locally bouldery; provide good road routes at right angles to coast. Sandy and gravelly beaches have best subgrade for routes parallel to coast. Swamp soils unsuitable for roads without thick fill of riprap or course aggregate.

Stream Crossings: Streams and rivers subject to great seasonal variation. Lumintao, Bugsanga, and probably one other large river have flat sandy and gravelly channels up to ½ mile wide, filled with swift shallow water after heavy rains; criss-crossed with narrow shallow streams in dry season. Upper reaches are narrower and have many boulders 1 to 3 feet in diameter. Caguray, Amnay, Sinambalan, and other rivers have widths up to 300 feet at mouths; banks are clay and gravel, up to 30 feet in height in inland areas, lower near coast in dry season. Most streams fordable above mouths; require ponton bridges or ferries operated against swift currents. Approaches for fords and bridges easily dug in banks by hand tools or bulldozers.

Clearing and Drainage: Coastal plain and wide river valleys cultivated or covered with tall grasses and scattered light timber of secondary forest. Easily cleared with hand tools or bulldozers.

Soil drainage good on beaches, natural levees, and river channels; poor in clays of interstream areas. Rise of water table in rainy season will saturate road foundations: roads must be ditched and subgrade built up to provide adequate drainage. Rivers subject to flash floods, at times overflowing natural levees.

Construction Materials: Sand and gravel abundant in most stream channels and in low stream terraces along upper courses of rivers. Some coral and beach sand and gravel available on coast. Boulders for riprap and bridge abutments in upper courses of larger streams; hard rock for crushed aggregate generally not available. Limestone quarried on hill east of Sta. Teresa and probably available in hills east of Caguray River. Timber for piling and bridges in scattered coastal swamps; scarce elsewhere. Coconut palms and casuarina on coast and along sandy stream channels suitable for corduroy, posts, and cribbing.

MAP AREA 3

Existing Roads: No roads except for 8 miles of unsurfaced road along north coast of Lubang Island. Native trails, unsuitable for motor transport, along coasts, and possibly across island through mountain passes north (elevation 2,000 ft) of Mt Baco. In mountains trails grow over rapidly with vegetation and are difficult to follow. Road construction on trail from Mamburao (west coast) to Abra de Ilog (north coast) is reported (1941) but it is doubtful whether any work has actually been done. Trail crosses ridge approximately 2,000 feet in elevation.

Topography, Alignment, and Grades: Rugged hills and mountains with NNW trend rise to elevations of over 8,000 feet in central part of range; cut by steep-walled valleys containing swift streams. Rough hill country around Mt Dumali and east of Lake Naujan. Small areas of coastal plain around Mansalay, Soguicay, Bulalacao, and Paluan Bays, at Abra de Ilog on north coast, and on northwest end of Lubang Island. Road construction will involve many sharp turns and switchbacks, few straight alignments, steep grades, and many side hill cuts, in part in hard rock requiring blasting.

Subgrade: Soils are clays, clay loams, and loams; from a few to many feet thick over hard rock. Soils generally stonier and thinner in limestone area in southern part of island. Trafficability good when dry, fair to poor in wet weather. Much seepage and sliding in excavations and fills. Subgrade requires careful compaction at optimum moisture content and application of base course before surfacing.

Stream Crossings: Streams swift and bouldery, subject to rises of 20 to 30 feet in a few hours. Steep banks, in many places of hard rock, prohibit fording by vehicles, make fording by foot troops difficult even at low water stage. Roads along valley walls must turn sharply to cross bridges. Pile driving generally difficult as many streams and banks have rock exposed or under thin cover.

Clearing and Drainage: Heavy primary forest in central high range from Cape Calavite to near Mansalay Bay, extends down to northern coast and onto eastern coastal plain; cutting, blasting, and grubbing with power equipment required. The lower part of the western slope and the southern end of the range have much grassland interspersed with patches of pine forest and larger areas of both primary and secondary forest. Clearing in grasslands and secondary forest can be done with hand tools or bulldozers.

Control of heavy runoff and seepage is necessary to prevent washing out of roads and sliding of excavations.

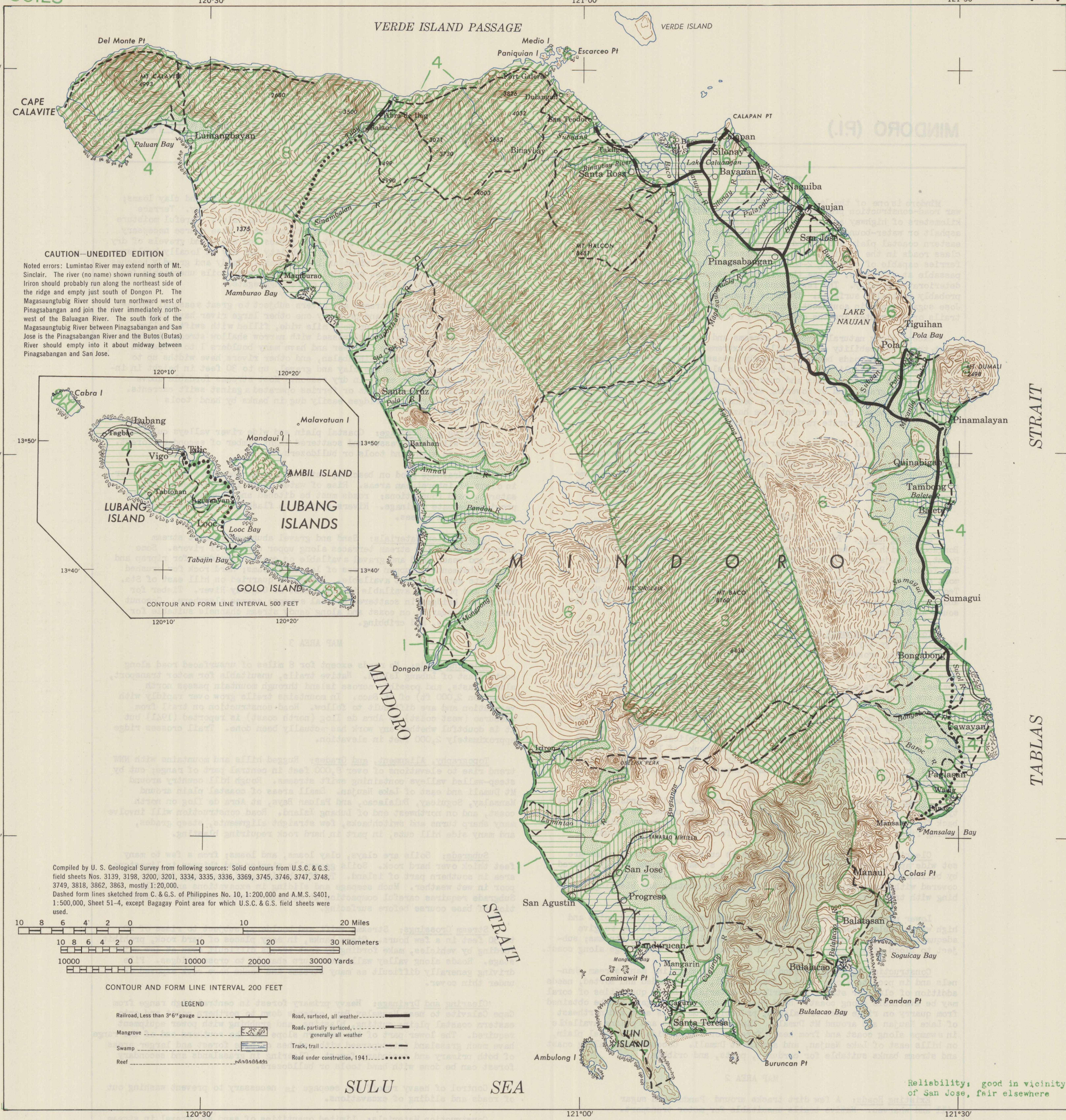
Construction Materials: Limited quantities of sand and gravel in stream beds; boulders available for riprap and crushing. Hard rock chiefly along streams except in southern end of island where hard limestone is covered by thin soil, crop out on hills. Other than limestone, rocks of area are hard micaceous, platy and layered rocks in higher part of range, shales and sandstone on flanks; generally fair to poor for base course and surfacing. Some granitic rocks and marble may occur in high central part of range. Much timber for heavy construction in high mountains and on eastern slope of range. Timber scattered in grasslands on western slope.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.

[redacted]

SOILS

MINDORO (P.I.)



120°30′
121°00′
121°30′
13°30′
13°00′
12°30′
VERDE ISLAND PASSAGE
VERDE ISLAND
Medio I
Paniquian I
Escarceo Pt
Del Monte Pt
MT CALAVITE 4993
CAPE CALAVITE
Paluan Bay
Lumangbayan
Port Galera
Dulangan
Abra de Ilog
Balao
San Teodoro
Subaang
Binaybay
Takligan
Binaybay River
Santa Rosa
Baco
Lake Caluangan
CALAPAN PT
Calapan
Silonay
Bayanan
Naguiba
Naujan
San Jose
Pinagsabangan
LAKE NAUJAN
Tiguihan
Pola Bay
Pola
MT. DUMALI 2498
Pinamalayan
Quinabigan
Tambong
Balete
Sumagui
Bongabong
Cawayan
Paglasan
Wasig
Panag
Mansalay
Mansalay Bay
Manaul
Colasi Pt
Balatasan
Soguicay Bay
Bulalacao
Bulalacao Bay
Pandan Pt
Buruncan Pt
STRAIT
TABLAS
MT. HALCON 8481
Sinambalan R
Mamburao
Mamburao Bay
Paluan
Sta Cruz R
Santa Cruz
Pola R
Barahan
Amnay
Pandan R
Mongpong R
Dongon Pt
MINDORO
MT. SINCLAIR
MT. BACO 8160
6430
Aglubang R
Iriron
OBELISK PEAK
Bugsanga R
Lumintao
TAMARAO AIRFIELD
San Jose
Progreso
San Agustin
Pandurucan
Mangarin Bay
Mangarin
Caminawit Pt
Caguray
Santa Teresa
ILIN ISLAND
Ambulong I
MINDORO STRAIT
SULU SEA
CAUTION—UNEDITED EDITION
Noted errors: Lumintao River may extend north of Mt. Sinclair. The river (no name) shown running south of Iriron should probably run along the northeast side of the ridge and empty just south of Dongon Pt. The Magasaungtubig River should turn northward west of Pinagsabangan and join the river immediately northwest of the Baluagan River. The south fork of the Magasaungtubig River between Pinagsabangan and San Jose is the Pinagsabangan River and the Butos (Butas) River should empty into it about midway between Pinagsabangan and San Jose.
120°10′
120°20′
13°50′
13°40′
Cabra I
Lubang
Tagbac
Malavatuan I
Mandaui I
Vigo
Tilic
AMBIL ISLAND
Tabionan
Agcawayan
LUBANG ISLAND
LUBANG ISLANDS
Looc
Looc Bay
Tabajin Bay
GOLO ISLAND
CONTOUR AND FORM LINE INTERVAL 500 FEET
Compiled by U. S. Geological Survey from following sources: Solid contours from U.S.C. & G.S. field sheets Nos. 3139, 3198, 3200, 3201, 3334, 3335, 3336, 3369, 3745, 3746, 3747, 3748, 3749, 3818, 3862, 3863, mostly 1:20,000. Dashed form lines sketched from C. & G.S. of Philippines No. 10, 1:200,000 and A.M.S. S401, 1:500,000, Sheet 51-4, except Bagagay Point area for which U.S.C. & G.S. field sheets were used.
10 8 6 4 2 0 10 20 Miles
10 8 6 4 2 0 10 20 30 Kilometers
10000 0 10000 20000 30000 Yards
CONTOUR AND FORM LINE INTERVAL 200 FEET
LEGEND
Railroad, Less than 3′6″ gauge
Mangrove
Swamp
Reef
Road, surfaced, all weather
Road, partially surfaced, generally all weather
Track, trail
Road under construction, 1941
Reliability: good in vicinity of San Jose, fair elsewhere

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

EXPLANATION

Symbol	Description
1	SAND AND GRAVEL. Alluvial, well drained.
2	CLAY AND SILTY CLAY. Mostly saline, alluvial, waterlogged.
3	FINE SANDY LOAM AND SILT LOAM. Alluvial, well drained.
4	CLAY LOAM AND CLAY. Alluvial, poorly drained.
5	CLAY LOAM AND GRAVELLY CLAY LOAM. Alluvial, well drained.
6	CLAY LOAM AND STONY LOAM. Residual, well drained.
7	CLAY LOAM AND CLAY. Residual, well drained.
8	STONY CLAY LOAM. Residual, well drained.

[redacted]

MINDORO (P.I.)

SOILS

Map Unit	1. Sand and gravel; alluvial; well drained.	2. Clay and silty clay; mostly saline; alluvial; waterlogged.	3[b]. Fine sandy loam and silt loam; alluvial; well drained.	4. Clay loam and clay; alluvial; poorly drained.	5. Clay loam and gravelly clay loam; alluvial; well drained.	6. Clay loam and stony loam; residual; well drained.	7. Clay loam and clay; residual; well drained.	8. Stony clay loam; residual; well drained.
	Reliability: Fair							
Engineering Group Symbol[a]	SW,GP,SP	CH,OH	SF,ML	CH,CL	CL,GF	CL (stony)	CL,CH	CL (stony), CH
P.R.A. Class[a]	A-3	A-7	A-2, A-4, A-6	A-7, A-6	A-4, A-6, A-2	A-4, A-6 (stony)	A-6, A-7	A-4, A-6 (stony), A-7
Depth in feet	10 and deeper	6 to 10	1 to 3 and deeper	1 to 2	10 to 20	1 and much deeper	1 to 3 and deeper	Commonly shallow
Texture and Color	Sand, pale; gravel, varicolored	Clay and silty clay, dark gray to dark bluish gray	Fine sandy loam and silt loam; light grayish brown	Clay loam and clay, dark brownish gray	Clay loam and gravelly clay loam, brown or reddish brown. Lenses of gravel common	Clay loam and stony loam; light brown. Rock rubble present	Clay loam and clay; brown, reddish, or black	Stony clay loam; brown to yellowish brown. Rock rubble present
Drainage Conditions	Well drained; water table not far below surface	Waterlogged; covered by salt water at high tide	Well drained	Poorly drained, water table near surface; waterlogged in rice fields during rice-growing season	Excellent surface drainage high run-off	Very good surface drainage. Internal drainage fair	Well drained	Excellent drainage. Run-off may be excessive
Consistency	Devoid of structure; loose	Highly plastic; hard when dry, harder when salts removed by leaching	Friable or plastic; loose or compact; dusty when dry	Plastic; hard when dry	Moderately plastic; easily puddled; may be dusty when dry	Moderately plastic; fairly granular; not resistant to puddling. Fairly stable when dry	Moderately plastic; fairly granular; not resistant to puddling; stable when dry	Moderately or very plastic; may be fairly resistant to puddling; stable when dry
Underlying Materials	Gravel-sand mixtures; shattered rock; hard rock	Gravel with fines	Commonly clay loam underlain by sorted deposits of varied texture	Light yellowish brown clay, many feet deep	Gravel-clay mixtures. Clean gravel may be found	Hard or soft sandstone, shale, and similar rocks	Chiefly limestone and coral rock, commonly hard	Hard or weathered rock
Topography	Steeply sloping beach ridges 6 to 12 feet above high water	Tidal swamps	Slightly raised natural levees subject to overflow from stream channels	Low flat depressions back of natural levees of streams and beach ridges	Elevated dissected coastal plains at 10 to 200 feet altitude	Mountains and hills; moderately steep slopes	Mountains and hills; flat to moderately sloping; irregular	Rugged mountains; commonly steep slopes
Vegetation	Commonly bare; grass and brush on multiple ridges near Pandurucan	Mangrove forest	Tropical high forest; sugarcane, coconuts, and fruit trees in cleared areas	Tropical high forest; brush and grass in extensive deforested areas; lowland rice	Tropical high forest, brush and grass in extensive deforested areas	Tropical high forest; brush and grass in deforested areas	Tropical rain forest partly replaced by coconut palms	Tropical rain forest; grass in deforested areas
Permeability	Very high	Medium	Medium	Low to very low	Low	Medium to low	Medium to low	Medium to high
Cohesion in Dry State	Very low to none	Medium	Low to medium	High	Medium	Medium	Medium to high	Low to high
Expansion and Shrinkage	None	Medium	Low	Medium to high	Low	Low	Medium	Medium to low
Suitability for Mechanical Stabilization	Well suited. Ample binder common in adjacent areas. Moisture control not essential during compaction	Not suited	Readily stabilized at optimum moisture content	Difficult to stabilize; careful moisture control essential during compaction. Maintenance of drainage is of prime importance	Compaction to very high density may be required. Close moisture control essential during compaction. Run-off drainage must be provided	Suited for compaction at optimum moisture content. Run-off drainage must be provided	Difficult to stabilize, unless enough aggregate of good quality is added	Satisfactory compaction is possible where topographic conditions permit operations. Run-off drainage must be provided
Value as Subgrade and Base Course	Excellent, except where water table is too near surface	None	Fair to good	Low to very low; high water table is common	Fair to good; control of seepage water may be required	Fair for stony soils; control of seepage water is commonly required. Subject to slides	Fair	Poor to good, depending on topography; control of seepage water is required, subject to slides
Suitability for Stabilization with Portland Cement and Bitumen	Well suited. Gravel needs addition of sand and binder	Not suited	Commonly not suited	Not suited	Not suited	Not suited	Not suited	Not suited
Bearing Ratio at Optimum Compaction	Medium to very high	Low	Medium to fairly high	Low to medium	Medium to low	Medium	Medium to low	High to low

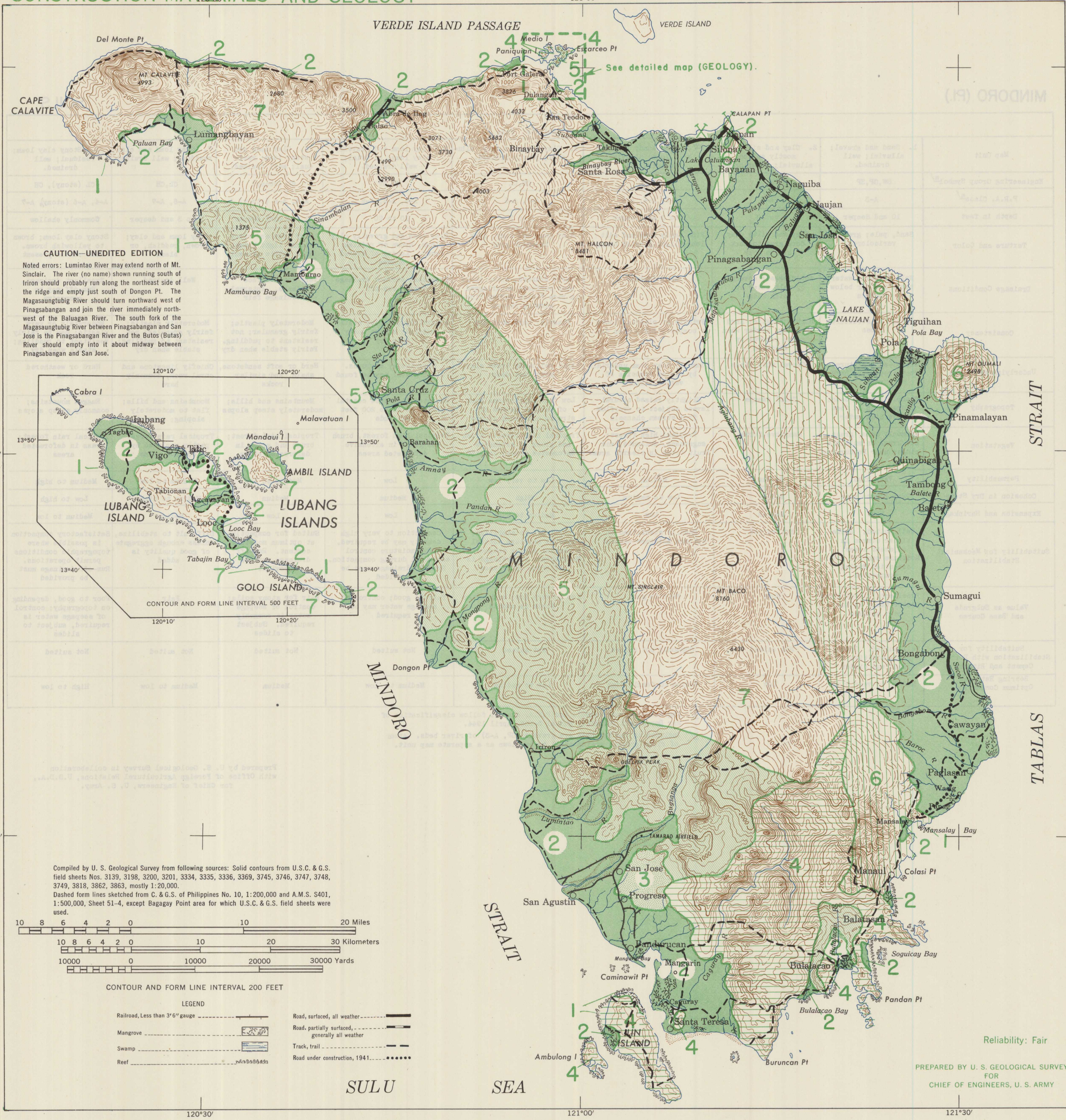
a/ Engineering group symbols and P.R.A. classes follow classification of War Department Technical Manual 5-255, April 1944.

b/ Included in the Map Unit are gravels (GP, A-3) of river beds. Areas of river gravels aretoo small to be shown as a separate map unit.

Prepared by U. S. Geological Survey in collaboration with Office of Foreign Agricultural Relations, U.S.D.A., for Chief of Engineers, U. S. Army.

CONSTRUCTION MATERIALS AND GEOLOGY

MINDORO (P.I.)


VERDE ISLAND PASSAGE
VERDE ISLAND
See detailed map (GEOLOGY).
Del Monte Pt
CAPE CALAVITE
MT CALAVITE 4993
Paluan Bay
Lumangbayan
Abra de Ilog
Medio I
Paniquian I
Escarceo Pt
Port Galera
Dulangan
San Teodoro
Binaybay
Santa Rosa
CALAPAN PT
Calapan
Silonay
Lake Caluangan
Bayanan
Naguiba
Naujan
San Jose
Pinagsabangan
LAKE NAUJAN
Tiguihan
Pola Bay
Pola
MT DUMALI 2498
Pinamalayan
Quinabigan
Tambong
Balete
Sumagui
Bongabong
Cawayan
Paglasan
Mansalay
Mansalay Bay
Manaul
Colasi Pt
Balatasan
Soguicay Bay
Bulalacao
Bulalacao Bay
Pandan Pt
Buruncan Pt
Santa Teresa
Caguray
Mangarin
Mangarin Bay
Caminawit Pt
ILIN ISLAND
Ambulong I
Bondurucan
Progreso
San Jose
San Agustin
TAMARAO AIRFIELD
OBELISK PEAK
Iriron
Dongon Pt
MT SINCLAIR
MT BACO 8160
MT HALCON 8481
M I N D O R O
Mamburao
Mamburao Bay
Santa Cruz
Barahan
STRAIT
TABLAS
MINDORO
STRAIT
SULU
SEA
13°30′
13°00′
12°30′
120°30′
121°00′
121°30′
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Cabra I
Lubang
Tagbac
Vigo
Tilic
Tabionan
Agcawayan
Looc
Looc Bay
Tabajin Bay
Mandaui I
Malavatuan I
AMBIL ISLAND
LUBANG ISLAND
LUBANG ISLANDS
GOLO ISLAND
CONTOUR AND FORM LINE INTERVAL 500 FEET
Compiled by U. S. Geological Survey from following sources: Solid contours from U.S.C. & G.S. field sheets Nos. 3139, 3198, 3200, 3201, 3334, 3335, 3336, 3369, 3745, 3746, 3747, 3748, 3749, 3818, 3862, 3863, mostly 1:20,000.
Dashed form lines sketched from C. & G.S. of Philippines No. 10, 1:200,000 and A.M.S. S401, 1:500,000, Sheet 51-4, except Bagagay Point area for which U.S.C. & G.S. field sheets were used.
20 Miles
30 Kilometers
30000 Yards
CONTOUR AND FORM LINE INTERVAL 200 FEET
LEGEND
Railroad, Less than 3′6″ gauge
Mangrove
Swamp
Reef
Road, surfaced, all weather
Road, partially surfaced, generally all weather
Track, trail
Road under construction, 1941
Reliability: Fair
PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

EXPLANATION

1	Fringing Coral Reefs. Coral limestone, interbedded sand, gravel, blocks, and calcareous clay, chiefly composed of coral remains. Reefs partly exposed at low tide. Recent.
2	Alluvium. Sand, gravel, and boulders in stream channels, silt and clay with weathered gravel lenses in interstream areas. Sand and gravel beaches. No bedrock. Recent.
3	Terrace deposits. Clay with sand and gravel lenses. No bedrock. Pleistocene.
4	Limestone. Massive thick-to thin-bedded limestone, some interbedded siltstone, sandstone, shale, minor conglomerate. Some raised coral reef limestone may be included. Thin soil. Oligocene to Miocene.
5	Shale and Sandstone. Soft shale and soft crumbly sandstone; minor limestone, minor coal beds. Thick soil. May be Eocene to Upper Miocene.
6	Mudstone, sandstone, and conglomerate. Hard, Well-cemented calcareous rocks. Moderately thick soil. Mesozoic.
7	Thin-layered and platy micaceous rocks (gneiss and schist), slate, marble, chert, soft green rock (serpentine), trap rock (gabbro), and granitic rocks. Thick soil and weathered rock. Pre-Mesozoic.
X	Known quarry.

MINDORO (P.I.)

CONSTRUCTION MATERIALS

Reliability: Fair

INTRODUCTION

In the coastal plain areas sound bedrock is deeply covered with alluvium and the only construction materials available are sand and gravel, readily obtained from stream and river channels; from numerous places in river banks; and from terraces along the main river. Dredging may be necessary during wet season. Terrace deposits and lenses of gravel in interstream areas are weathered and more or less disintegrated; recent stream deposits are sound. Coral can be obtained from fringing reefs and beaches along parts of the coast. Limestone, with shallow overburden and many outcrops, is abundant in hills and low mountains in southern Mindoro. Sound bedrock in hilly and mountainous country throughout much of the island to north is overlain by soil and disintegrated rock 10 to 100 feet thick, is usually exposed only in stream bottoms. Mountain streams contain at least some poorly sorted boulders and gravel almost everywhere.

The approximate locations of 3 quarries are shown on the map, but the source of most materials used for road, wharf, and other construction in recent years is not known. Limestone, marble, and coral sand; suitable for lime is fairly abundant. At hill east of Sta. Teresa, SW Mindoro, limestone is quarried and burned locally for lime for sugar manufacture at the San Jose mill.

Large timber for heavy construction abundant in high mountains and extends down to inner edge of eastern coastal plain. Scarce on most of most coastal plains and on west flank of central range. Mangrove for bridge construction and pilings scattered through tidal swamps. Coconut and casuarina suitable for cribs, posts, and corduroy on sandy portions of coastal plains.

Wood suitable for fuel is abundant in the mountainous interior but is scarce in cultivated areas along east and west coasts and in a broad belt of grassland in the hills bordering the western coastal plain. For details see Vegetation Sheet.

Four minable coal beds, average thickness 4 feet, have been prospected north of Bulalacao: sub-bituminous, low ash, volatiles 40%, carbon 37%, moisture 17%, sulfur 3%, Btu. value 11,000. The beds are folded and broken. A small amount might be stripped, but any amount more than a few tons would have to come from underground workings.

Map Unit	Type of Material	Quarrying Problems	Foundation Characteristics	Aggregate for Surfacing and Base Course	Aggregate for Concrete and Riprap	Timber (See Vegetation Sheet)
1	Fringing reefs, 100 yards to 1 mile wide, partly exposed at low tide, around outlying islands and along parts of west and southeast coasts. Soft to hard limestone large blocks, fragments, shells, sand, and limy mud on shoreward side of reef flats; blocks and fragments generally somewhat porous. Exposed surface may be harder than underlying rock; weathering produces a case-hardening effect. Coral sand and shingle on beaches, with some mud from other sources; may be cemented into slabby "beach rock".	Covered at high tide, partly exposed at low tide. Reef flats best handled by drag line from beach. Where bare at low water can be worked by hand tools with some blasting, or by dozer. Beach deposits readily worked by hand tools or dozer.	Reefs covered at high water; piles can sometimes be driven through thin layers of reef rock; where reef is thickly layered or well-consolidated penetration may be very difficult even with blasting of pile locations. Coral beach sand and shingle cement readily, have good bearing strength if not mixed with much mud from other sources.	Loose coralline material dredged from reef flat bonds rapidly as surfacing; makes good base course. Sprinkling with sea water in areas of low rainfall, mixture with non-limy mud in areas of heavy rainfall speeds bonding. Poorly-graded coral sand needs fines, coralline or clay , to promote bonding.	Nodular coral broken by waves, either on reef flat or along beaches makes good aggregate. Coral sand between high and low water on beaches near reefs may be only source of sand free of clay in many areas.	None
2 and 3	Bed Rock: Mantled. Stream Deposits: Stream channels a few yards to a half-mile wide, floored with intermixed boulders, gravel, and sand (View 3). Interstream areas and terraces bordering valleys of Lumintao and Bugsanga Rivers in SW Mindoro (View 7) have well-graded sand and gravel layers and lenses interbedded with clay. Some mica present in finer-grained deposits. Lenses in interstream areas are weathered, boulders and gravel generally rotten. Beaches: Beaches from a few feet to more than 100 feet wide of poorly graded sand and gravel; above high water, material is better graded.	Overburden: Little or none in stream channels and low terraces. Soils in interstream areas may be 10 to 20 feet thick; gravel layers at various depths. Bed rock deeply buried throughout most of coastal plain. Equipment: Sand and gravel and rare outcrops of limestone can be worked by hand tools or dozer.	Low interstream areas have clay soils, high water table; poor foundations. Higher areas satisfactory, locally may need control of seepage in excavations. Support for excavations necessary both in lowland and higher areas in rainy season.	Sand and gravel from stream channels and terraces excellent for base course; need screening of larger sizes for surfacing.	Coarse gravel and boulders of stream channels and in lenses on low terraces are good source. Small outcrops of bedrock on NW coastal plain badly weathered, will make poor aggregate.	Mangrove timber for piling and bridge construction scattered through tidal swamps; coconut palms and casuarina of beaches, sandy valley floors, and natural levees, suitable for posts, cribs, and corduroy. Large timber for heavy construction in primary forest on foothills side of eastern coastal plain.
4	Bedrock: Limestone, massive to thin bedded, with some interlayered sandstone, siltstone, shale, and minor conglomerate. Limestone at Port Galera and on Ilin, Ambulong, and Lubang Islands is softer, more porous than elsewhere. Stream Deposits: Well-graded gravel and boulders, dominantly of hard limestone, some intermixed mud and sand, in stream beds in steep-walled narrow valleys. Terraces with lenses of gravel may occur along Caguray River.	Overburden: Generally stony soils from 1 to several feet thick; many outcrops on hills and at breaks of slope; cliffs along coast. Equipment: Large boulders of stream deposits may require blasting. Limestone must be blasted.	Massive limestone makes good foundations, generally well-drained, locally cavernous. Thin-bedded limestone around Soguicay and Bulalacao Bays folded, interlayered with shale, silt, and sandstone; will slide along shale partings on steep slopes and in excavations when wet; seepage along some sandstone layers. Stream deposits subject to frequent flooding except for possible terraces on Caguray River.	Limestone and boulder and gravel deposits excellent source.	Limestone excellent for concrete aggregate; shale and sandstone layers must be excluded. Limestone and small quantity of stream boulders suitable for riprap.	Mangrove in small swamps along coast. Timber for heavy construction on Ilin Island, north of Buruncan Point, and on east shore of Bulalacao Bay. A few coconut palms in cultivated areas.
5	Bedrock: Shale and sandstone, generally soft and crumbly, some interlayered limestone. Marly and sandy shale at Port Galera (N Coast). Coal beds and associated clay and minor sandstone around Bulalacao Bay. Stream Deposits: Well-graded silt, sand, and gravel, some boulders, in narrow streams in steep-walled valleys.	Overburden: Soil and deeply weathered rock 20 to 50 feet thick in flat and gently sloping areas. Few outcrops except in steep-walled valleys. Equipment: Bulldozers or power shovels; some blasting may be necessary in deep excavations.	Stream deposits frequently flooded. Seepage common and landslides frequent in folded shale and sandstone; difficult to maintain walls of excavations. Sea cliffs along western coast probably not well-suited for gun emplacements.	Sand and gravel in limited quantities from stream channels adequate for base course ; poor for surfacing. Bedrock sandstone and shale crumble readily; high in clay; unsatisfactory for either base course or surfacing.	Stream depsoits contain limited quantities of gravel for concrete aggregate, and boulders for riprap; Bulalacao River channel may have limestone gravel suitable for concrete aggregate. Stream deposits and most bedrock contain much clay; unsatisfactory for concrete.	Large areas without good timber for construction. A few patches of primary forest with good timber for light and heavy construction.
6	Bedrock: Hard calcareous mudstone and sandstone; conglomerate near coast in southeast Mindoro, at Mt. Dumali, and east of Lake Naujan. Stream Deposits: Well-graded gravel and boulders, some silt and sand in steep-walled valleys.	Overburden: Soil and weathered rock 10 to 30 feet deep; some outcrops at breaks of slope and in steep valleys. Equipment: Stream gravel may be handled with dozers; some blasting of large boulders necessary. Bed rock requires blasting.	Stream deposits frequently flooded. Bedrock gives fair to good foundation strength; seepage along some sandstone layers.	Sand and gravel in limited quantities from stream channels; adequate for base course, poor for surfacing. Bedrock mudstone and sandstone poor to fair for base course; poor for surfacing due to high clay content and rapid disintegration. Conglomerate can be crushed for fair base course and surfacing aggregate.	Stream gravel, hard sandstone and conglomerate will make fair riprap. Bedrock quarried near Calapan for wharf construction. Both stream deposits and bedrock poor for concrete aggregate because of high clay content. Crushed conglomerate may be suitable for concrete.	Much timber for light and heavy construction in primary forest. Coconut palms locally in cultivated area around Mansalay Bay suitable for corduroy and cribbing.
7	Bedrock: Wide variety of rock types: platy micaceous rock (schist), thin-layered granite-like rock (gneiss), slate, fine-grained marble, chert, granitic rocks, and soft green rock (serpentine). Details of distribution not known, except in Port Galera area (see inset map on Geology text). Stream Deposits: Well-graded sand and gravel intermixed with boulders, some of giant size, in steep-sided narrow valleys; sand generally micaceous. Quartz sand and gravel on SE end of Lubang Island; intermittently worked gold placers south of Port Galera.	Overburden: Soil and weathered rock, 10 to 100 feet thick; exposures chiefly in stream bottoms, rare on ridges and slopes. Equipment: Stream sand and gravel can be handled with bulldozers with blasting of large boulders. Bedrock will require heavy blasting.	Stream deposits swept along frequently by flash floods. Platy rocks, micaceous rocks, and soft green rocks are subject to slides in wet weather; less abundant granite and marble make good foundation.	Sand and gravel in limited quantities fair to good for base course and surfacing, contains mica. Granite and marble satisfactory after crushing and screening. Other rocks unsatisfactory.	Crushed and screened boulders, gravel, and marble of bedrock satisfactory for concrete aggregate or riprap. Other rocks unsatisfactory for aggregate, fair to poor for riprap.	Plentiful timber for all construction except in dwarfed forests at high altitudes.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.

MINDORO (P.I.) — SEE CONSTRUCTION MATERIALS MAP — GEOLOGY

Reliability: Poor to Fair.

INTRODUCTION

Little is known of the detailed geology of Mindoro. Information has been taken from a brief description by the National Development Company Petroleum Survey of Southeastern Mindoro, descriptions of reconnaissance of the coal deposits near Bulalacao (Burritt, de Villa), and forestry bulletins and reports of exploration in northeastern Mindoro. The geology of the Lubang Islands, of the Binaybay River gold placers, and references to oil seeps in southwestern Mindoro are found in reports of the Mineral Resources of the Philippine Islands. The only detailed geologic map available is that of the Port Galera area (see inset map by Teves).

GENERAL STATEMENT

Mindoro consists of a mountainous core of basement schist and gneiss intruded by igneous rocks ranging from granite to peridotite; flanked by folded Mesozoic shale, sandstone, and conglomerate; in turn overlain by folded Tertiary limestone and coal-bearing sandstone and shale. Along the east and southwest coasts many rivers have spread a nearly continuous alluvial apron 3 to 12 miles wide. On the southeast, west and north coasts mountain ridges extend to the sea, restricting the alluvium to crescentic and triangular areas between the spurs. Recent coral reefs surround the Lubang and Ilin Island groups, and occur in the Bulalacao and Soguicay Bay region in southeast Mindoro, and at a number of places along the west coast. In some places old reefs have been upraised, so that they now blanket older rocks at heights as great as several hundred feet above sea level.

GEOLOGIC HISTORY

Extensive pre-Jurassaic metamorphism has obscured the early history of Mindoro. In Jurassic time the present island was the northern margin of a geosyncline extending from western Borneo and Palawan. Thick marine sandstone and shale accumulated, at least as far north as Mt Dumali (central east coast). In late Mesozoic time the area was uplifted, the rocks folded in a NE trend, and eroded. By Oligocene time at least the margins of the present island were again depressed; massive limestone, sandstone, and shale were laid down over wide areas of the beveled basement and Mesozoic rocks, in addition, coal-bearing clay and sand accumulated in southeast Mindoro. The details of Oligocene-Miocene history are uncertain; it is certain only that several gentle orogenies with NNW folding interrupted sedimentation. Since late Miocene time vertical movements have taken place, with uplift dominating, causing erosion of the Tertiary rocks, uplift of marine plains and fringing coral reefs, and deposition of thick alluvial blankets on the bordering lowlands.

DESCRIPTION OF ROCK UNITS

FRINGING CORAL REEFS (MAP UNIT 1)

General: Coral limestone, some interbedded sand, gravel, and calcareous clay; chiefly composed of coral remains. Limestone generally hard, but usually porous and cellular; may locally grade to soft calcareous clay. Extremely variable in texture, cementation, and hardness, within short distances. Coral sand and shingle on beaches, with some mud from other sources; may be cemented into slabby "beach rock". Exposed surface may be harder than underlying rock; weathering produces a case-hardening effect. Fringing reefs, 100 yards to a mile wide, partly exposed at low tide, around outlying islands and along parts of west and southwest coast

RECENT ALLUVIUM (MAP UNIT 2)

General: Interlayered clay and silt, some sand, gravel and boulders. Chief constituents of larger sizes are probably quartz, feldspar, rock fragments, some mica. Deposits are thick, lenticular, and poorly sorted because of rapid deposition by shifting torrential streams. Large valleys may be bordered with terraces 10 to 50 feet high of sand, gravel, and boulders (View 8). On coastal plains the rivers have wide channels with 6 to 12-foot natural levees. Adjacent interstream areas are thickly mantled with clay deposited at flood stage. In rainless periods stream levels are very low, channels floored with intermixed boulders, gravel, and sand (Views 3 & 9). Temporary sand bars may form between times of heavy rain and most streams have sand bars at mouths. Beaches and beach ridges sandy and gravelly. Soil cover varies from none in dry stream beds to 10 to 15 feet in most permanent interstream areas.

East Coast Alluvial Plain: From Takligan, 8 miles west of Calapan on NE coast, to Mansalay Bay on SE coast, an alluvial apron 3 to 12 miles wide formed by coalescing deltas of the many streams draining the central mountains rises to low rolling country (200 feet maximum elevation) back from coast. Low natural levees border the streams of the coastal lowland. On north coast near Port Galera, Dulangan, and on the Binaybay River, unsorted coarse gravels, boulders, and sands in steep mountain streams (alluvial areas too small to show on map). Low beach ridge of sand and gravel is backed by mangrove swamp in many places. Black mud occurs on west shore of Lake Naujan, and in adjacent valley of Subaan River.

Southwest Coast Alluvial Plain: Made of the deltas of Caguray, Bugsanga, and Lumintao Rivers. These river valleys have sandy and gravelly flood plains; natural levees near coast, and 10 to 20-foot terraces farther inland. Alluvial fans probably occur where rivers pass from mountains to lowlands. South channel of Lumintao around island 6 miles in from coast is probably abandoned, gravel filled. Gravel and sand on north spit at mouth of Mangarin Bay. Coastal flats pass into low gently rolling hills inland; elevation of 100 to 150 feet.

Central West Coast Alluvial Plains: Little is known of character or extent of alluvium. Probably similar to southwest coast alluvial plain. A beach ridge along coast, in many places paralleled by rivers on landward side.

North, Northwest, and South Coasts: Mountain ridges project to sea, restricting alluvium to triangular and crescentic areas between spurs (see inset map of Port Galera region). Material probably coarser than that of broad plains.

Lubang Islands: Beaches of quartzose sand, quartz gravel and boulders occur on shores of Looc and Tabajin Bays and in vicinity of Agcauayan. Sand is clean between low and high water levels, mixed with clay and mica between high water and hills.

PLEISTOCENE TERRACE DEPOSITS (MAP UNIT 3)

General: Boulder and gravel lenses in clay matrix; similar to Recent alluvial deposits, but more deeply weathered. Chief rock types of coarser material are probably granite, gneiss, and schist. Terraces occur as low, flat-topped hills to 200 feet in elevation, cut by many steep-walled ravines. Differential uplift and faulting have probably destroyed the original accordance of summits in most places. Soil cover 1 or 2 feet on slopes, 4 to 10 feet on tops of flat hills. Probably uplifted coral reefs locally, but no information available (See Tertiary Limestone).

San Jose-Progreso Area, near Bugsanga River, Southwest Mindoro: Low, flat-topped hills, moderately dissected. At least one area, about 3,000' by 500 to 1,000 feet, remains undissected.

East Coast: No information available. Foothill belt, 1 to 3 miles wide, bordering coastal plain alluvium, may contain flat-topped terrace remnants with elevations to 200 feet. (Not mapped).

TERTIARY LIMESTONE (MAP UNIT 4)

General: Massive and thin-bedded limestone, calcareous pebble beds, sandstone, blue-gray siltstone, shale, and minor coarse conglomerate. Thickness is extremely variable, may total 2,000 feet. Beds folded with general NNW trend and dips up to 50°, probably faulted at least locally; unconformities and overlaps within the formation are common. Age is Oligocene to Miocene. Rough, knobby hills, with outcrops on breaks in slope; coast usually cliffed. Caves present in the massive limestone. Some Pleistocene coralline limestone may be included.

Southern Mindoro: Massive white Pocanil limestone, 700 to 1,000 feet thick occupies a large area in the southern end of the island. It is underlain by 1,500 feet of Tertiary coal measures (see Tertiary Clastics). Ilin and Ambulong Islands and hill east of Sta. Teresa are known to be limestone which may be either Pocanil or upraised coral reefs. The Bulalacao formation, occupying the peninsula between Soguicay and Bulalacao Bays and the point south of Mansalay Bay is a thin-bedded limestone with associated calcareous pebble beds, sandstone, blue-gray siltstone, shale, and occasional coarse conglomerate, totaling 1,500 to 2,000 feet in thickness. It is not certain whether the Bulalacao formation over-or underlies the Pocanil formation. Both formations are folded with a NNW trend.

Northern Mindoro and Lubang Island: (See inset map). Medio and Paniquian Islands and south shore of Escarceo Point near Port Galera are chiefly of coralline limestone of late Tertiary or Pleistocene age. White marly siltstone and limestone crops out in road cuts south and west of Lake Naujan. Much of the alluvium of the northeast coastal plain may be underlain by similar rocks. Similar limestone reported on NW Lubang Island.

TERTIARY CLASTIC ROCKS (MAP UNIT 5)

General: Several thousand feet of sandstone, shale, clay, some limestone, and locally some coal. Age may be Eocene to upper Miocene. Beds are folded with general NNW trend. Faults are probably numerous. Usually rough hill country, softer beds may form low hills and open valleys.

Southeast Mindoro: Bluish-gray, green, and yellow clays, sandstone, and conglomerate, some sand and marl, intercalated with 4 minable seams of coal; lie unconformably on Mesozoic sandstone and shale: are overlain by Tertiary limestone. Total thickness is approximately 1,500 feet. Details of the distribution of coal measures and Pocanil limestone are unknown. Beds folded in a NNW trend, with limbs dipping 30° to 70°. Age is Oligocene or Miocene. Irregular, rolling hills, with infrequent outcrops, chiefly along streams and on steeper hillslopes.

Port Galera, Northern Mindoro: Approximately 1,000 feet of gray fine-grained, red and yellow coarse-grained, tuffaceous and marly shales, with a basal conglomerate containing pebbles of quartz, marble, schist, and serpentine, occurs on the peninsula (See inset map). Beds are fairly well compacted, gently folded, faulted, and lie unconformably on the Basement Complex. Age is probably Miocene. Topography is flat or gently rolling, probably representing a recently uplifted and moderately dissected marine plain.

Southwest Mindoro: Oil seeps from Miocene shale and sandstone are reported somewhere to north of Mangarin Bay on tributaries of the Bugsanga River, and in hills to northeast of bay, beyond alluvial plain.

MESOZOIC CLASTICS (MAP UNIT 6)

General: 5,000 to 10,000 feet of hard calcareous mudstone, calcareous or siliceous carbonaceous sandstone, some conglomerate. Beds are folded, with north or northeast trend, probably faulted in many places. Deeply dissected into rough hills and mountains; outcrops occur along streams; on breaks of slope of steep hills.

Southeastern Mindoro: Several thousand feet of hard calcareous mudstone and calcareous or siliceous carbonaceous sandstone is exposed near Mansalay Bay in an east-dipping NNE striking monocline. At the point just northeast of Manaul, limestone concretions containing cephalopods are present in coarse conglomerate. In area to west of Manaul, shale and sandy shale exposed on hill crests.

Mt Dumali, and Hills East of Lake Naujan, East Central Coast: Mt Dumali is composed of beds similar to those of Mansalay Bay. Hills east of Lake Naujan and those east of Calapan are of conglomerate or agglomerate, and are classified with the Mesozoic, although they may be Tertiary.

BASEMENT COMPLEX (MAP UNIT 7)

General: Highly metamorphosed complex of granite, diorite, gabbro, serpentine, gneiss, schist, chert, slate, marble, all cut by numerous massive quartz veins. Some andesite may also be included. These rocks form the high rugged central range of Mindoro, and continue to the northwest in the Lubang Islands. Soil and disintegrated rock cover are deep except in stream gorges, where fresh bedrock is exposed in the stream bed and canyon walls in many places.

Port Galera, Northern Mindoro: (see inset map) Hornblende mica granite, granodiorite, light brown granite gneiss, lenticular carbonate gneiss, sericite and chlorite schists, fine-grained white-to yellow-gray massive marble, some serpentine. Rocks dissected by ravines with rapids and falls in streams.

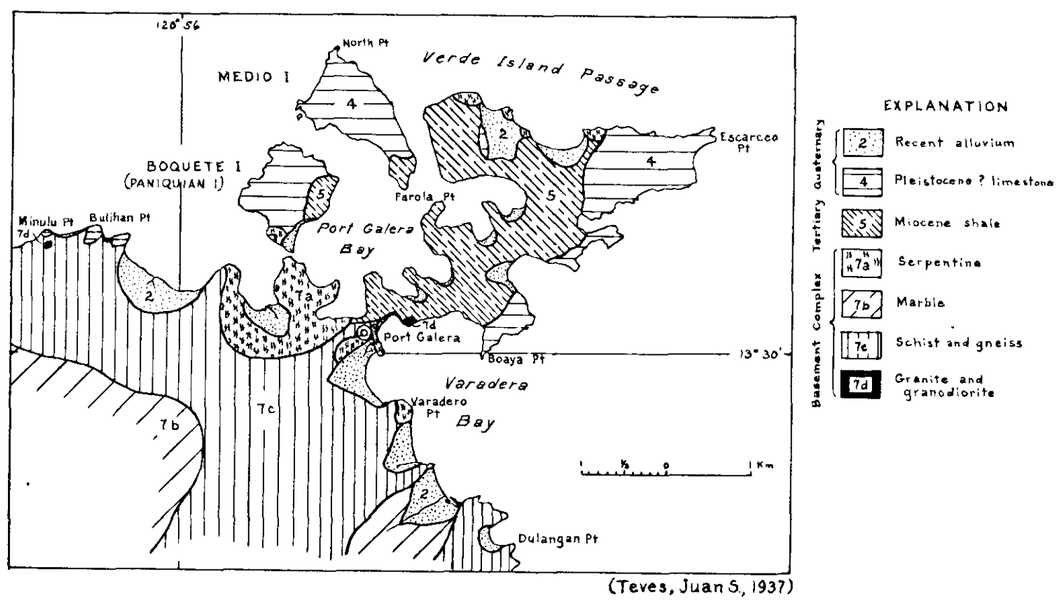
Binaybay, Northeast Mindoro: Schist, gneiss, probably granitic, cut by many quartz veins, form rough, deeply dissected hills.

Mt Halcon, North Central Mindoro: Mt Halcon is a mass of granite, quartz, schist and marble. Possibly some andesite is present. Extremely rough country, with high, narrow ridges and deep canyons which often have bare rock walls.

Lubang Islands, Northwest of Mindoro: Granite, acid schist and gneiss, slate, some cross-cutting serpentine and quartz veins. Granite crops out on narrow isthmus between Looc and Tabajin Bays, Lubang Island; is flanked on north and south by mica schist. Golo Island is chiefly mica schist, with serpentine in central part. Ambil Island is probably mostly serpentine. Rugged, deeply dissected hill country, with outcrops along the coast, and probably in some steep cliffs along streams.

Prepared by U.S. Geological Survey
for Chief of Engineers, U.S. Army.

GEOLOGIC MAP OF PORT GALERA, MINDORO



(Teves, Juan S., 1937)

[redacted]

VEGETATION

MINDORO (P.I.)

CAUTION—UNEDITED EDITION

Noted errors: Lumintao River may extend north of Mt. Sinclair. The river (no name) shown running south of Iriron should probably run along the northeast side of the ridge and empty just south of Dongon Pt. The Magasaungtubig River should turn northward west of Pinagsabangan and join the river immediately northwest of the Baluagan River. The south fork of the Magasaungtubig River between Pinagsabangan and San Jose is the Pinagsabangan River and the Butos (Butas) River should empty into it about midway between Pinagsabangan and San Jose.

VERDE ISLAND PASSAGE

VERDE ISLAND

CAPE CALAVITE

Del Monte Pt

MT. CALAVITE 4993

Paluan Bay

Lumangbayan

Medio I

Paniquian I

Escarceo Pt

Port Galera

Dulangan

San Teodoro

Abra de Ilog

Balao

Tuay

Subaong

Binaybay

Takingan

Binaybay River

Santa Rosa

CALAPAN PT

Calapan

Silonay

Lake Caluangan

Bayanan

Naguiba

Naujan

San Jose

Baluan R

Pulangluna R

Silonay R

Baco R

Naujan R

Sinambalan R

Mamburao

Mamburao Bay

MT. HALCON 8487

Pinagsabangan

Butos R

LAKE NAUJAN

Piguihan

Pola Bay

Pola

MT. DUMALI 2498

Pola R

Sta Cruz R

Pagbahan

Santa Cruz

Barahan

Amnay R

Pandan R

Aglubang R

Magasaungtubig R

Subaan

Pinamalayan

Malampaya Sd

Quinabigan

Tambong

Baleto R

Baleto

Sumagui R

Sumagui

MINDORO STRAIT

MINDORO

MT. SINCLAIR

MT. BACO 8160

Mongpong R

Mongpong

Dongon Pt

Bongabong

Sucol R

Bongabong R

Cawayan

Bordc R

Iriron

OBELISK PEAK

Paglasan

Wasig

Pinamak

Lumintao R

Bugsanga R

TAMARAO AIRFIELD

Mansalay

Mansalay Bay

San Jose

San Agustin

Progreso

Manaul

Colasi Pt

Balatasan

Soguicay Bay

Pandurucan

Mangarin

Caminawit Pt

Cagurdy R

Bulalacao R

Bulalacao

Caruray

Santa Teresa

Bulalacao Bay

Pandan Pt

ILIN ISLAND

Ambulong I

Buruncan Pt

TABLAS STRAIT

SULU SEA

Inset: LUBANG ISLANDS

Cabra I

Lubang

Tagbac

Malavatuan I

Mandaui I

Vigo

Tilic

AMBIL ISLAND

Tabionan

Iggamayan

LUBANG ISLAND

Looc

Looc Bay

Tabajin Bay

GOLO ISLAND

CONTOUR AND FORM LINE INTERVAL 500 FEET

Compiled by U. S. Geological Survey from following sources: Solid contours from U.S.C. & G.S. field sheets Nos. 3139, 3198, 3200, 3201, 3334, 3335, 3336, 3369, 3745, 3746, 3747, 3748, 3749, 3818, 3862, 3863, mostly 1:20,000.
Dashed form lines sketched from C. & G.S. of Philippines No. 10, 1:200,000 and A.M.S. S401, 1:500,000, Sheet 51-4, except Bagagay Point area for which U.S.C. & G.S. field sheets were used.

10 8 6 4 2 0 10 20 Miles

10 8 6 4 2 0 10 20 30 Kilometers

10000 0 10000 20000 30000 Yards

CONTOUR AND FORM LINE INTERVAL 200 FEET

LEGEND

- Railroad, Less than 3'6" gauge
- Mangrove
- Swamp
- Reef
- Road, surfaced, all weather
- Road, partially surfaced, generally all weather
- Track, trail
- Road under construction, 1941

Reliability: Fair

EXPLANATION

- Sandy Beach Vegetation
- 2 Mangrove
- 3 Fresh-water Swamp
- 4 Cultivated Land
- 5 Primary Forest
- 6 Secondary Forest
- 7 Grassland
- x x Scattered Groves of Pine in Grassland

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

[redacted] CONFIDENTIAL

Reliability: Good

Map Number, Vegetation Type	Distribution	Description	Movement	Effects on Military Operations: Observation	Effects on Military Operations: Concealment	Clearing and Grubbing	Uses
1 SANDY BEACH VEGETATION	Sandy beaches are commonly formed where plains or rolling terrain comes close to coast, and they alternate with swamps or rocky coast covered with inland vegetation types. Beaches range in width from a few to hundreds of yards; some narrow beaches not shown on map. Terrain inland from the beaches may be hills or lowlands with any type of inland vegetation except fresh-water swamp. Wild beach vegetation commonly pure stands of casuarina (see below) in sandy soils of beaches and some river flood plains, as along Lumintao and Bugsanga Rivers. Elsewhere a mixture of other types of trees and undergrowth, in which pandan (screw pine) may be abundant. However most beaches on Mindoro are cleared, cultivated and settled and resemble type 4.	Casuarina Type: Casuarina resembles a pine; recognizable from considerable distance offshore or from the air. Mature trees are 60 to 100 feet tall and up to 2 feet, rarely 3, in diameter. In most places little undergrowth other than Casuarina seedlings; ground carpeted with fallen twigs. Spacing of trees irregular, but canopy fairly continuous. Mixed Types: Scattered trees of other types commonly have fairly thick, tangled undergrowth of low shrubs, vines, and creepers. The pandan (screw-pine), common on some beaches, is low, scrubby tree with long, broad, spiny-edged leaves; trunks up to 6 inches in diameter. Coconuts: Cultivated coconut palms grow on many beaches, particularly on east coast. (see Cultivated Areas).	Motor Transport: Casuarina forest easily penetrated in most places. Spacing of trees irregular but commonly wide enough for trucks. Traction good on sandy soil of Casuarina beaches; probably not as good on other beaches. In other beach forests thick undergrowth may have to be cleared. Pandanus grows thickly but can be readily cleared; tracked vehicles probably require no clearing. Foot Troops: Easy movement in Casuarina forest; cutting necessary in some mixed types. Spiny leaves of pandan are a nuisance but easily cleared.	Visibility fairly good in Casuarina forests that generally have little undergrowth; may be only a few tens of feet in other forests.	All forest types offer fair to good concealment from aerial observation.	Casuarina trees require cutting or blasting; can be grubbed with dozers. Paths through dense undergrowth readily cleared with bolos.	Casuarina wood, locally called ironwood, is very hard and heavy and somewhat difficult to saw. Makes excellent firewood; wood is suitable for heavy construction; in ground, it will last 6 or 7 years. Trunks up to 2 feet or more in diameter. Other trees on beaches are scrubby and of little value.
2 MANGROVE FORESTS (including Nipa Palms and Mixed Types)	Mangrove forests are formed in the zone which is covered with up to 3 or 4 feet of salt or brackish water at high tide and exposed, or nearly so, at low tide. On Mindoro these conditions are commonly met in tidewater swamps on river deltas, on shores of shallow protected bays, on some small islands and along river banks as far upstream as the water is salty or brackish. All of the swamps are commonly crossed by many tortuous tidal channels of varying width and depth. Nipa palm (see Description column) tolerates fresher water than other swamp forms and is commonly found on the landward margin of swamps; along estuaries and along the lower courses of rivers. However, in places it is mixed with mangrove and locally is found even in the seaward edge of swamps. Nipa palms are cultivated in small areas south of Baco and on a large tract on east side of Baruyan River, south of Caluangan Lake.	Mangrove Forests: Include several species of trees, many fairly large. Some are 80 to 100 feet high and 2 feet or more in diameter, but generally are smaller. Trees form dense stands with nearly closed overhead canopy and little undergrowth. Various kinds of air roots extend upward to high-water level; these may be straight, vertical stick-like roots standing close together, or may form dense tangles of curved roots (convex upward and outward from trunk). Nipa Palms: Have creeping stems that send up clumps of pale green leaves 8 to 15 feet high; generally in close pure stands without undergrowth; in places mixed with mangrove and other kinds of trees; not distinguished from mangrove on map. Mixed Types: Interior of swamp may contain tabau trees, rarely up to 2 feet in diameter usually scattered. Straight slender langaray trees, 6 to 8 inches (rarely 16 inches) in diameter, form pure stands in many places. Large trees known as dungon-late are scattered along landward edge of swamp; in other places transition to dry-land types is abrupt.	Motor Transport: Barrier areas. Even where vegetation is cleared, movement is prevented by soggy, muddy ground that is inundated at high tide. In transition zone at landward edge of swamps, movement is severely limited but in places possible. Foot Troops: Going is difficult. At high tide, movement is practically impossible; at low tide a man may sink knee deep in soft mud at outer edge of swamp; farther inland, soil may contain some sand and give somewhat better footing. Tangles of air roots cover much of ground; commonly encrusted with sharp-edged shells. Common practice is to clamber on top of clusters of air roots, using tree trunks and branches for handholds. In places at landward edge of swamp, thick tangles of vines and other undergrowth are difficult to penetrate: nipa palms grow thickly and are nearly impassable. Crocodiles are common. Many poisonous snakes; generally slow-moving, rarely cause trouble. Biting flies and mosquitoes commonly numerous. Boats: Travel by small boats is generally easier than by foot. At high tide, landing craft and canoes in places may push through mangrove forest; at low tide only tidal channels navigable. Penetration of nipa forest is possible along open channels; very difficult elsewhere. In general, abundant nipa on a channel bank indicates that deepest water is near bank.	Visibility generally restricted to a few score feet.	Excellent.	Trees must be felled by hand or power saws. Logs and roots, where accessible to land equipment, may be removed by tractor and dozer; elsewhere they may be dragged out by winch and cable on anchored boats. Nipa and tangles of mangrove roots can be cut out with saws and bolos.	Mangrove forest is prime source of firewood. Larger trees have hard, heavy, rather straight-grained wood that is strong enough for houseposts and can be used for temporary construction; in ground wood lasts 5 to 8 years. Firewood is cut by hand and carried out on foot; larger timbers for piling or other heavy construction are dragged out by winch and cable on boats. Slender trunks of langaray trees (6 to 8 inches in diameter) are useful for temporary piling and will last 1 to 5 years in ground. Dungon-late trees have strong, very tough wood suitable for heavy construction; provide one of the few local woods that can withstand repeated shocks; recommended for bridge timbering. Tabau trees, if large enough, can furnish durable wood for piling in salt water. The bark of several species of trees contains much tannin, widely used for staining brown and preserving fish nets, cordage, and cloth. Nipa used chiefly in making thatching, which lasts 5 to 7 years.
3 FRESH-WATER SWAMPS	Local and not very extensive. Grassy swamps border the north, west and south sides of Lake Naujan; buri palm swamps border inland margins of some mangrove and nipa swamps. Principal buri swamp along the lower course of the Bongabon River.	Grassy Swamp: Dense growth of grasses or sedges 8 to 10 feet high. Frequently flooded; some always have standing water. Buri Swamp: Generally occupies belt behind nipa swamp never flooded by tide, but very wet, often has standing fresh water. Not confined to area bordering nipa swamp. Palms grow vertically 60 feet or more. Rarely close enough to form complete canopy, but form dense growth along some streams, especially where streams pass through grassy areas. A few scrubby trees and bushes grow between palms. Grades sharply into inland forest types.	Motor Transport: Generally impassable, but parts of swamps may become dry and firm during extended dry period. Foot Troops: In grassy swamps movement difficult; locally impassable; parts may be passable by trail when dry. Easy to become lost in tall grass. In buri swamps movement generally easy, depending on density of undergrowth. Boats: Small boats can easily traverse flooded areas via natural channels or artificial canoe trails.	Visibility good where grasses and reeds are not too tall. Moderate to poor in buri swamp.	Grasses can conceal troops from ground but not from aerial observation. Troops easily concealed from ground and aerial observation in buri swamps.	Grasses readily cut with bolos and mowers. Buri palms difficult to clear; may require cutting and blasting; use of winches and cables.	For grasses, none. Leaves of buri palms make good thatching.
4 CULTIVATED AREAS	The principal cultivated areas are along the coast on the plains, sandy beaches and some of the lower hills. Small patches of higher mountain land are used only locally. Total of all land in cultivation about 5%. Rice, the principal crop, is grown on the low coastal plains. Sugarcane is grown on the southwest coast, coconuts along the east coast, and hemp (abaca) along the northeast coast. The other important crops are corn, sweet potatoes, cassava, and tobacco.	Rice: Requires standing water during planting, dry ground for harvesting; ground generally has impervious substratum to hold water; fields diked with earth embankments one to a few feet high. Permanent swamps are generally drained before planting rice. Coconut Palms: Grow on sandy beaches and other well-drained soils; generally planted 25 to 30 feet apart in rows equally spaced. Trees generally 30 to 50 feet high, in places 80 feet or more; trunk diameter about 10 inches. Overhead canopy fairly close; little undergrowth in most plantations. Manila Hemp (Abaca): Plants resemble banana plants; form dense growth 12 to 18 feet high. Sugarcane: Grows thickly; height 5 or 6 feet up to 10 feet. Bamboo: Commonly forms thorny, impenetrable clumps 40 to 50 feet and exceptionally 80 feet high; many different varieties. Mango: Large dense-crowned tree 50 to 60 feet across; commonly found near houses. Corn: Generally only 3 or 4 feet high, but may be taller.	Motor Transport: Movement easy in coconut groves where slope and ground permit. Light clearing necessary in Manila hemp (abaca) fields. Wheeled motor transport cannot cross wet rice fields unless dikes are broken and water drained. When fields are dry, ground is firm and easily crossed; quickly becomes muddy during rains; dries slowly. Most other crops will not obstruct movement. Foot Troops: Easy movement except in wet rice land where easiest movement is along dikes.	Visibility restricted in coconut groves; and by scattered trees near villages; poor in hemp plantations; good elsewhere.	Most coconut groves can conceal vehicles and personnel from aerial but not from ground observation. Hemp and taller sugarcane provide fair to good concealment from ground and aerial observation. Fruit trees, especially mangos afford excellent concealment from aerial observation. Other crops offer little concealment.	Coconut palms have shallow roots and are easily pushed over by dozers. Most other cultivated growth readily cleared with bolo knives.	Food crops. Hemp for cordage. Trunks of coconut palms, generally 8 to 12 inches in diameter are useful for making temporary corduroy roads on boggy ground and for making temporary retaining walls.
5 PRIMARY FOREST (including Mossy and Pine Forests)	The Primary Forest which once covered the island is now found over most of the higher hills and lower mountain slopes and on some lowlands. There are two modifications of the principal type which develop under special conditions. Mossy forest grows above the prevailing cloud level, the transition zone ranging from 3,000 feet up. Here the humidity is even higher than in the main forest and for long periods approximates saturation. Pine forest grows on high ground on the west side of the northern half of the central mountain range in areas where the ground is particularly well drained and the humidity comparatively low. While its lower limit in general is 3,000 feet, small open groves are found scattered through the grasslands at lower elevation and occur as low as 200 feet near Santa Cruz. (Not shown on map.)	Primary Forest: Many big trees tower over successively smaller trees. Forest canopy up to 100 or 150 feet high, with some higher trees, shuts out sunlight almost entirely. Spacing irregular but in many places wide enough to permit passage of trucks. Trunk diameters up to 6 feet or more. Many trees are supported by large root buttresses extending 10 to 20 feet up along trunk and flaring out as far as 20 feet or more from base; such root buttresses may be a few inches to a foot thick. Undergrowth may be dense, but in many types of forest it is light. At edge of forest, dense wall of secondary growth is common (See Map Unit 6). Mossy Forest: Generally above 3,000 feet altitude, consist of dwarf trees decreasing in height from about 40 feet at lower altitudes to a few feet on higher mountain tops. Branches form dense growth close to ground; many roots above ground form tangles 3 or 4 feet high. Trees, roots, and ground are covered with spongy, soggy mats and festoons of moss. Pine Forest: Scattered groves of pine trees 60 to 100 feet high; 18 inches to 3 feet in diameter on lowest branches 4 to 6 feet above ground. Trees widely spaced with many open areas covered with tall grass. Soil generally extremely dry and well drained. On ridges and western slopes in north at varying altitudes, mostly over 4,000 feet.	Motor Transport: In many places where slope and ground permit, movement through Primary forest is possible without much clearing. In places, especially at edges of forests, cutting of vines and undergrowth is necessary. Heavy clearing necessary in mossy forest. In pine forests movement easy; generally no clearing necessary. Foot Troops: Movement easy in Primary forest; in places light cutting is necessary. In most well-developed forests, a man following the trails can travel about one mile an hour. Movement difficult in dense growth at edge of forest. In mossy forest, low branches and tangles of exposed roots, largely concealed by mosses, make travel very difficult. Sounds are quickly absorbed and movement makes little noise. Movement easy in pine forest.	In many places in Primary and mossy forests it is impossible to see more than 20 or 30 yards in any direction. Some treetops may be high enough to provide view for lookouts. In pine forests observation somewhat restricted, but many vantage points for lookouts.	In Primary forest dense forest canopy gives perfect concealment from aerial observation. Concealment from ground observation good; larger trunks give good concealment and limited cover from small-arms fire. In pine forests concealment from aerial observation fair; from ground observation poor to fair, depending on the density of the trees and height of grass. In mossy forests concealment from aerial observation is afforded much of the time by low cloud cover, concealment from ground observation fair to very good at all times.	Heavy equipment and blasting required to remove large trees. Undergrowth can generally be removed by hand tools. Much of Primary forest can be burned with some difficulty during drier months, but burning of mossy forest practically impossible owing to dampness.	Forests provide many kinds of good timber for light and heavy construction. Plentiful firewood obtainable from fallen trees.

(continued)

VEGETATION

MINDORO (P.I.)

Reliability: Good

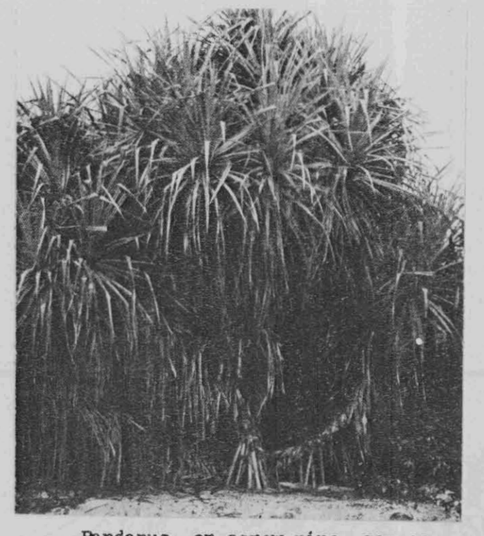
Map Number, Vegetation Type	Distribution	Description	Movement	Effects on Military Operations		Clearing and Grubbing	Uses
				Observation	Concealment		
6 SECONDARY FOREST	Burned over and cleared areas, if left undisturbed, are invaded by quick-growing secondary forest. Secondary forest grows on any terrain except swamps.	Consists of relatively short-lived, mostly soft-wooded trees. Young forests comprised of dense growths of scrubby trees, shrubs, vines, and scattered large partly rotted logs. Such thickets are common at edges of high forests where they form dense tangles of shrubs and climbing growth from ground to tops of trees; and intergrowth of spiny, tough, climbing bamboo in places makes such growths extremely dense and resilient. Repeated burning of secondary forest commonly results in open, park-like areas of scattered medium-sized trees in grassland (savanna). Most cleared hilly areas have moderately dense growths of trees along streams.	Motor Transport: Wheeled vehicles cannot move through dense secondary forest without previous clearing; tracked vehicles can penetrate most younger growths. Easy movement through park-like areas of scattered trees where slope and ground permit. Foot Troops: Slow and difficult movement in dense thickets, especially in thick growths at edge of high forest; much cutting required. Existing trails become choked with vines and creepers if left unused for a few weeks or more.	Visibility only a few yards or feet in denser thickets; tens to hundreds of yards in open park-like areas.	Dense thickets provide excellent concealment for personnel and vehicles; open growths afford limited concealment.	Clearing of dense growths requires much cutting with hand tools, some blasting and grubbing with clearing equipment. Paths for foot troops may be cleared with bolos.	Little value. Wood is soft and of small size; makes fair firewood; some kinds used for light temporary construction.
7 GRASSLAND	Large burned over and abandoned areas known as cogonales are covered with tall harsh cogon grass; its presence generally indicates dry ground. Cogon grows at altitudes from sea level to about 5,000 feet on all types of terrain except swampy ground; other similar grasses may occupy swampy land. Grassland areas in Mindoro are most extensive on the western slopes.	Cogon is a very coarse wild grass, generally 2 to 5 feet high; with sufficient moisture it may grow to 8 feet; forms thick mantle; burns readily when dry and makes quick hot fire; grows back quickly after having been burned off.	Motor Transport: Generally passable to motor traffic where slope and ground permit. Larger permanent streams flowing across cogonales are generally marked by shrubs or trees; small or intermittent streams may be concealed from ground observation by dense grass and are hazards to movement of vehicles or foot troops. In dry months, large grass fires spread swiftly and may be hazardous. Foot Troops: Movement off trails possible but unpleasant owing to density and coarseness of grass, glare and heat, and irritating dust from leaves; trampled grass is slippery on slopes, but grass clumps provide handholds. Quickly tears clothes and cuts hands if gloves are not worn.	Visibility excellent where grass is not too tall.	In a few areas exceptionally tall, cogon grass gives good concealment from ground but not from aerial observation.	In dry months cogon grass may be readily cleared by burning, at other times by mower or by hand.	Young shoots make rather poor forage; older grass is too harsh. Bundles of cogon widely used for temporary thatching and for preventing rain wash on earthern embankments along roads and elsewhere.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.

MINDORO (P.I.)

VEGETATION VIEWS

1 Typical stand of coconut palms along beach, restrict ground observation and provide fairly good concealment from aerial observation; movement easy, clearing light. Trees regularly spaced in well-organized plantations. (Craig, Philippines and Filipinos of Yesterday, Manila, 1934)



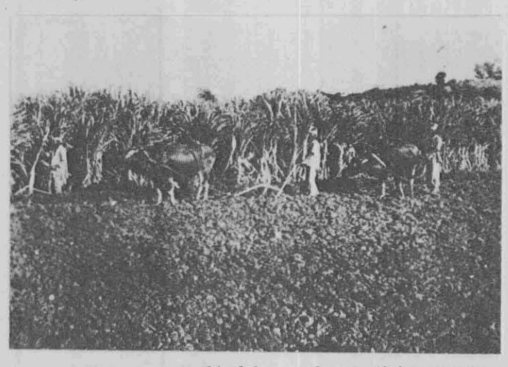
2 Pandanus, or screw pine, common on some beaches; long, broad, spine-edged leaves are nuisance, can be cleared by bolo. (Schimper, A. F., and van Faber, F. C., Pflanzen-geographie, 1935)

3 One type of beach flora; dense forests hamper movement and visibility, provide good concealment. Casuarina beaches are more open. (Whitford, Forests of the Philippines)

4 Casuarina trees, found along some beaches and streams on Mindoro. View does not show typical character; such forests usually open and commonly free of brush; easily penetrated by motor transport and foot troops. Good concealment. Grows in sandy soil. Wood heavy and hard. View along Bongabon River. (Merritt and Whitford, Bull. 6, Bur. Forestry, 1906)

5 Interior view of mangrove swamp at low tide; high water reaches nearly to top of root tangles. Twisted air roots several feet high, in many places encrusted with sharp-edged shells; vertical stick-like roots below. Ground soft, muddy. Excellent concealment; poor visibility. (Whitford, Forests of the Philippines.

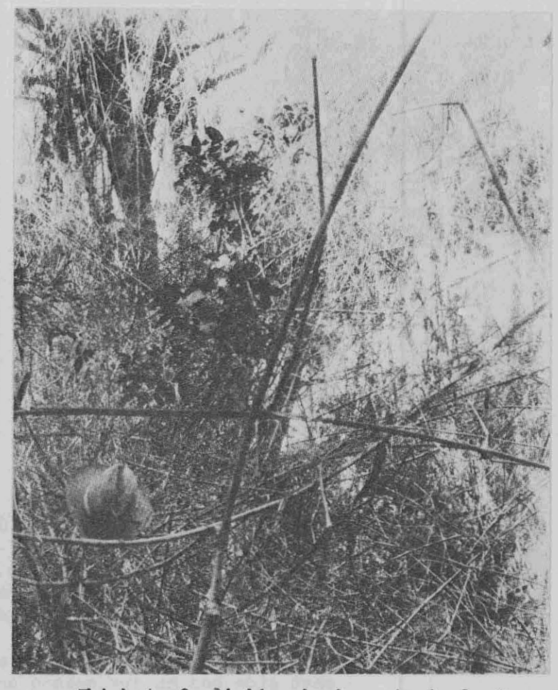
6 Uncultivated nipa swamp. Difficult to penetrate, except in places where small boats can be forced through. (Brown, W. H., and Fischer, A. F., Philippine Mangrove Swamps, Philippine Bur. Forestry, Bull. 17, 1918)



7 Sugarcane fields such as this cover large areas near the streams in southwestern Mindoro. Crops adjacent to fields may be in different stages of growth. (OSS 719905)

8 Hemp, or abaca plants (common in northeast Mindoro). These are unusually tall; average plants are a few feet shorter. Provide excellent concealment; obstruct visibility. Stems soft; plants easily cleared. (Whitford, Forest of the Philippines)

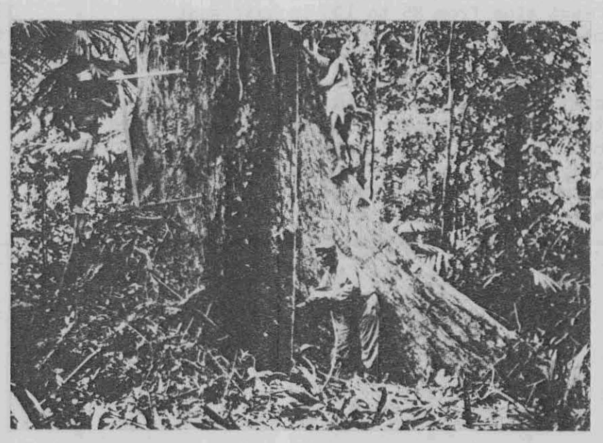
9 Young secondary forest; hampers movement of wheeled vehicles and foot troops; provides good concealment from observation. (Whitford, Forests of the Philippines.



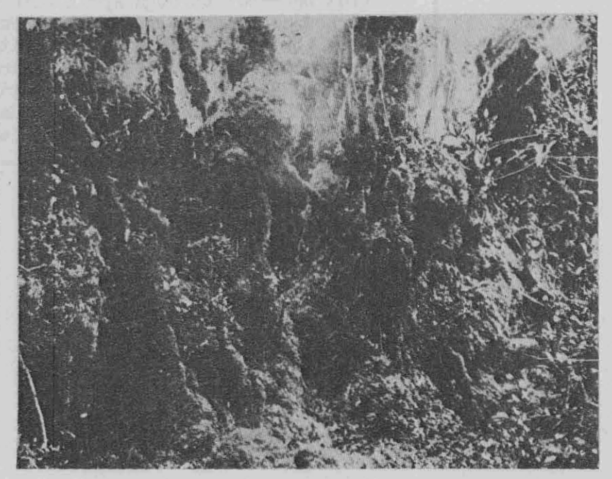
10 Thicket of climbing bamboo, typical of some of the areas of secondary forest and edge of high forest on west side of Mindoro. Nearly impenetrable for foot troops. Hollow stems contain good drinking water. View west of Abra de Ilog. (Merritt and Whitford, Bull. 6, Bur. of Forestry, 1906)

12 Interior view of high forest, showing light undergrowth; canopy here is unusually open. (Whitford, Forests of the Philippines)

11 Typical open pine forest common on higher ridges of western Mindoro. (Whitford, 1911)



13 Base of trunk of large forest tree in primary forest, showing root buttresses. Commonly four or five such buttresses, up to 20 feet in height, 10 feet long at base and a few inches to a foot thick, radiate from trunk; provide limited cover for personnel. (Whitford, Forests of the Philippines)

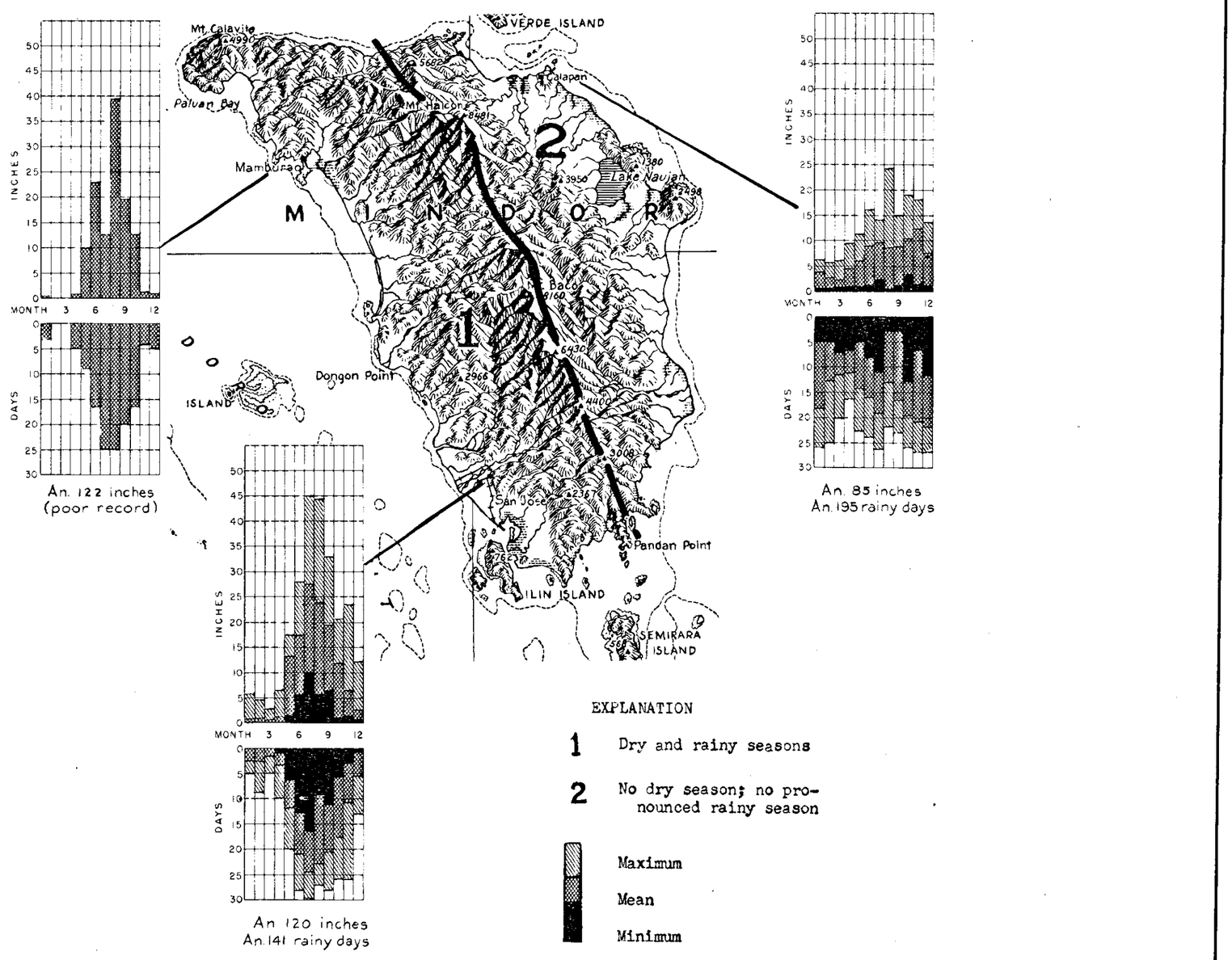


14 Mossy forest. This type of growth may extend as low as 3,000 feet, depending on prevailing cloud level. The tangle of roots and underbrush is covered with mosses which are continually saturated with moisture. (Janis)

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

MINDORO (P.I.)

CLIMATE



CLIMATE

General Statement

Climatic data on Mindoro are limited. Rainfall records were obtained from Observations of rainfall in the Philippines, Philippine Islands Weather Bureau, Manila, 1935.

The climate of the east and west sides of Mindoro differ: the east side has no dry season and no pronounced maximum rain period; the west side has a dry season and marked maximum rain period.

Precipitation

Mean annual rainfall on the east side from 85 to 100 inches; west side 100 to 125 inches. Mean annual number of rainy days on east side 185 to 195; west side 100 to 145. Dry season on west side generally from December through April with less than 3 inches of rain per month. Marked decrease in rainfall on east side from January through April, when the average monthly precipitation is less than 5 inches. Rainy season on west side reaches maximum development during June, July, and August. Rains heavy and torrential, especially on west side, lasting several hours; rainfall in one day may be from 5 to 10 inches. Precipitation generally higher at increased altitudes.

Temperature and Humidity

Temperature generally warm, 75 to 85° F., occasionally as high as 100° F. and as low as 65° F. Humidity high, 70 to 85%.

Storms

Thunder storms frequent during April and May. Typhoons common, generally during period from September through December.

Winds

Generally light (up to 7 mph), except during storms. Steady easterly winds from November through April. Intermittent southwesterly winds from May through October. Calms infrequent.

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for Chief of Engineers, U. S. Army