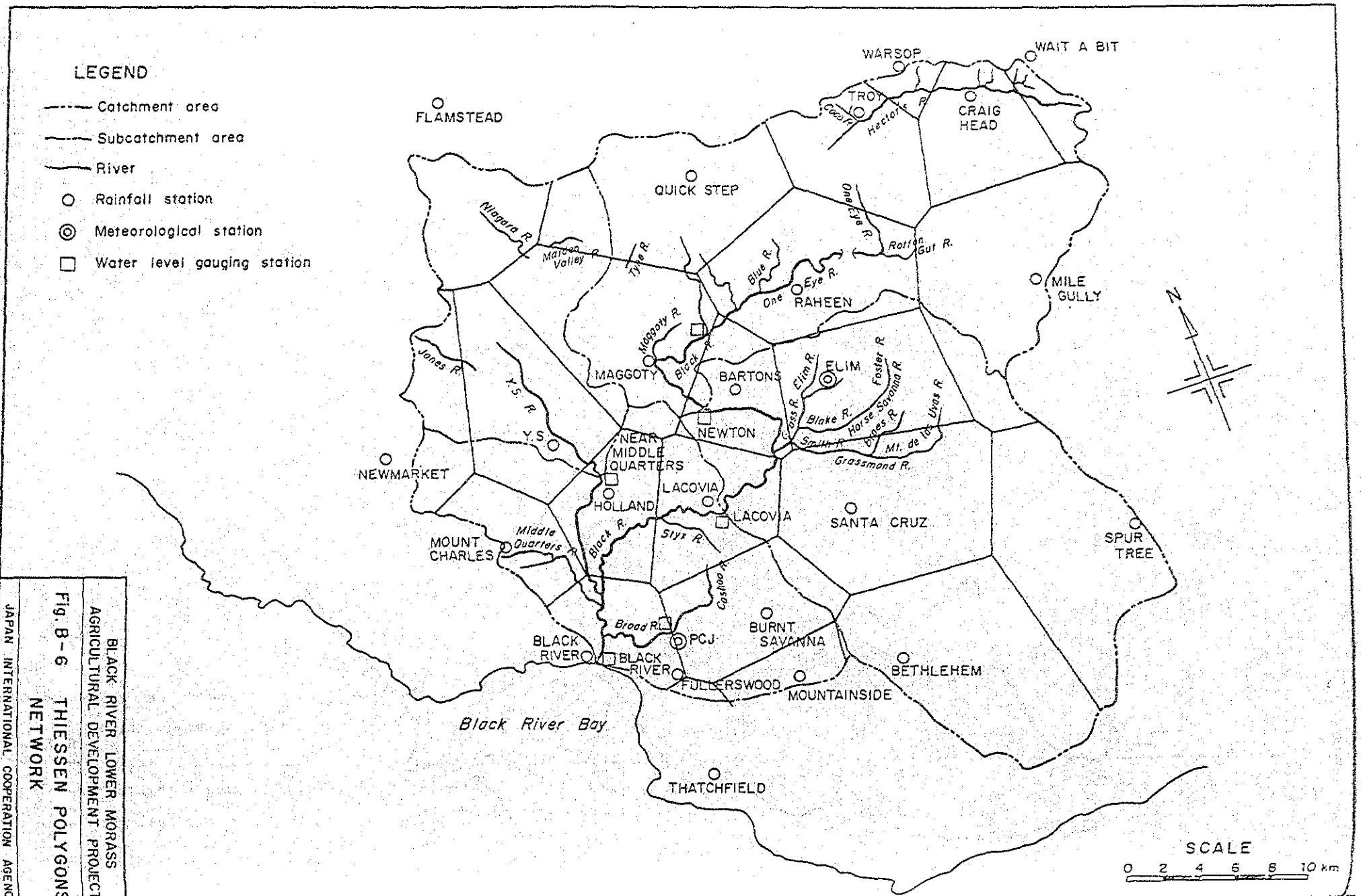
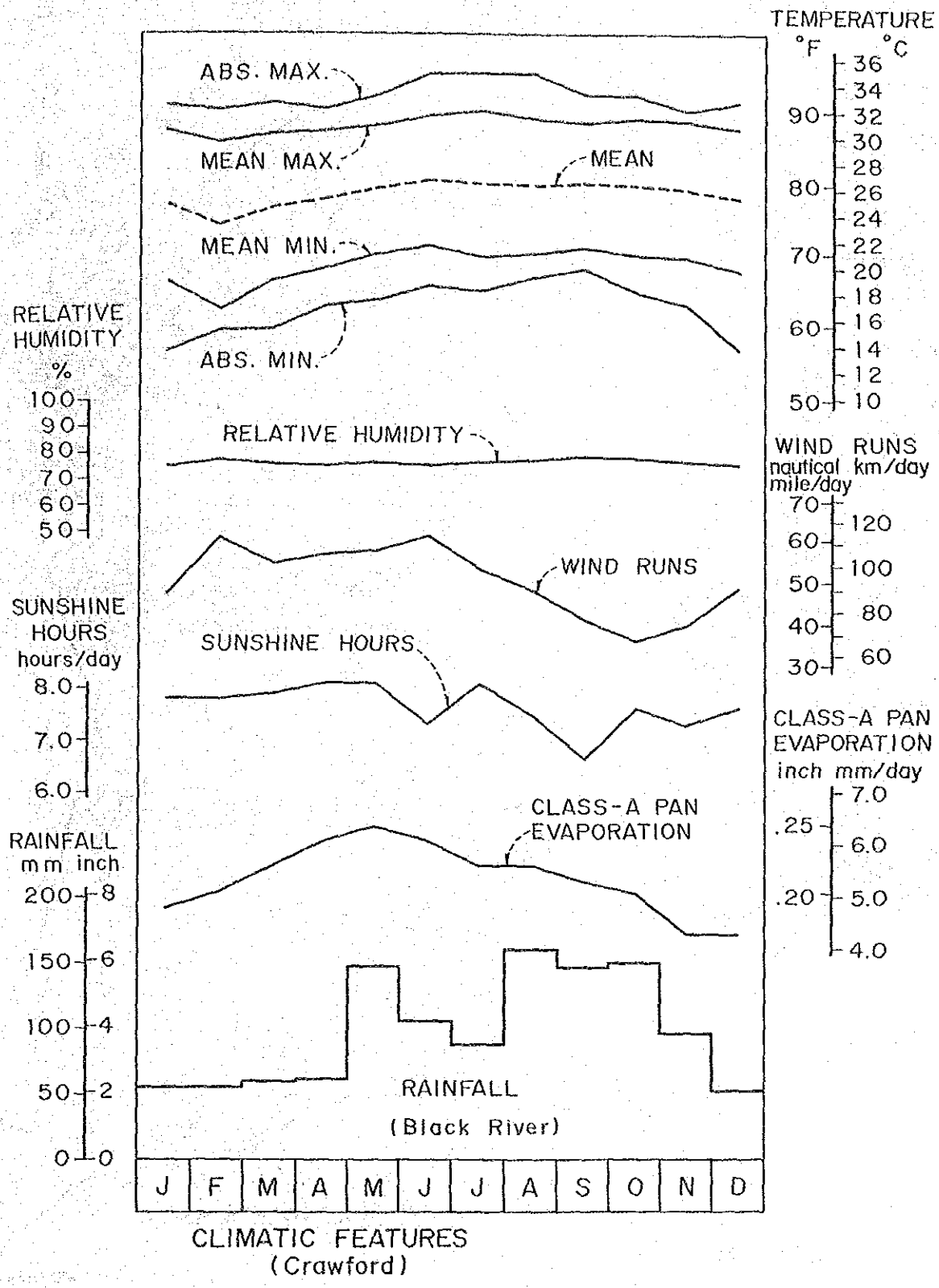


BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

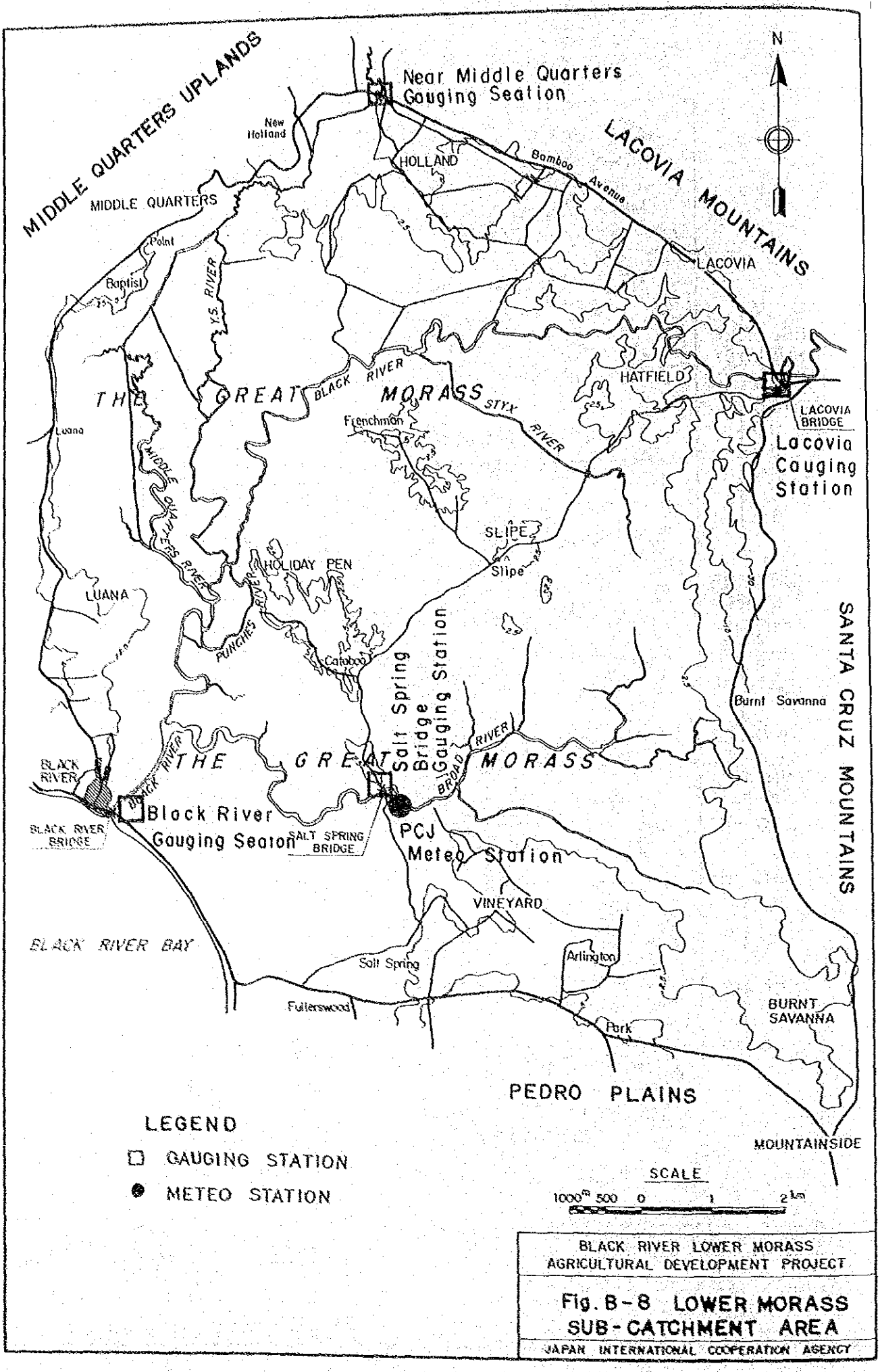
Fig. B-6 THIESSEN POLYGONS NETWORK

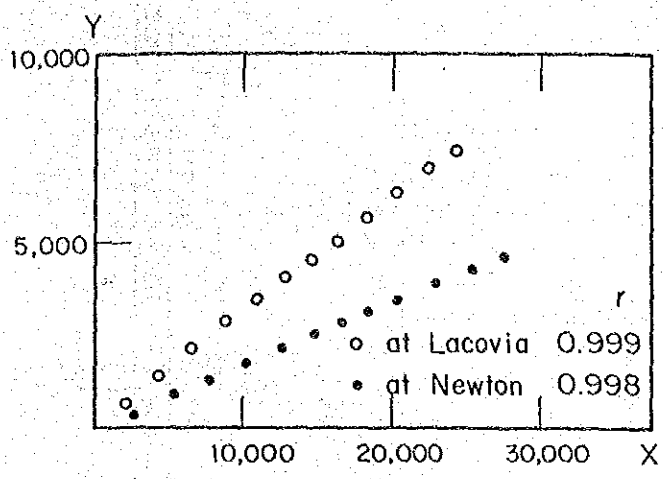
JAPAN INTERNATIONAL COOPERATION AGENCY



CLIMATIC FEATURES
(Crawford)

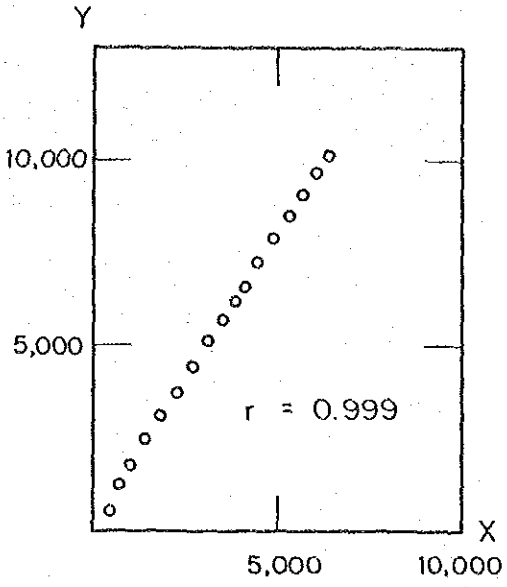
BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT
Fig. B-7 CLIMATIC FEATURES (at Crawford)
JAPAN INTERNATIONAL COOPERATION AGENCY


MIDDLE QUARTERS UPLANDS
Near Middle Quarters Gauging Seation
New Holland
HOLLAND
Bamboo Avenue
LACOVIA MOUNTAINS
N
MIDDLE QUARTERS
Point
Baptist
Y.S. RIVER
LACOVIA
THE GREAT BLACK RIVER MORASS
STYX RIVER
HATFIELD
LACOVIA BRIDGE
Lacovia Gauging Station
Luana
Frenchman
MIDDLE QUARTERS RIVER
SLIPE
Slipe
HOLIDAY PEN
LUANA
PUNCHES
Catoboo
Salt Spring Bridge Gauging Station
SANTA CRUZ MOUNTAINS
Burnt Savanna
BROAD RIVER
BLACK RIVER
THE GREAT MORASS
BLACK RIVER
Block River Gauging Seaon
BLACK RIVER BRIDGE
SALT SPRING BRIDGE
PCJ Meteo Station
VINEYARD
BLACK RIVER BAY
Salt Spring
Arlington
Fullerswood
BURNT SAVANNA
Park
PEDRO PLAINS
MOUNTAINSIDE
LEGEND
GAUGING STATION
METEO STATION
SCALE
1000m 500 0 1 2 km
BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT
Fig. B-8 LOWER MORASS SUB-CATCHMENT AREA
JAPAN INTERNATIONAL COOPERATION AGENCY



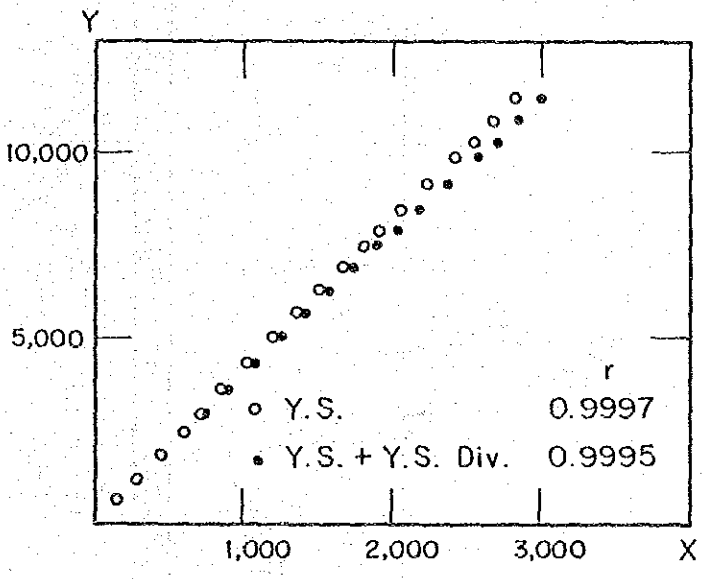
Y : Discharge ($10^6 m^3$)

X : Basin Rainfall (mm)



Y : at Lacovia ($10^6 m^3$)

X : at Newton ($10^6 m^3$)



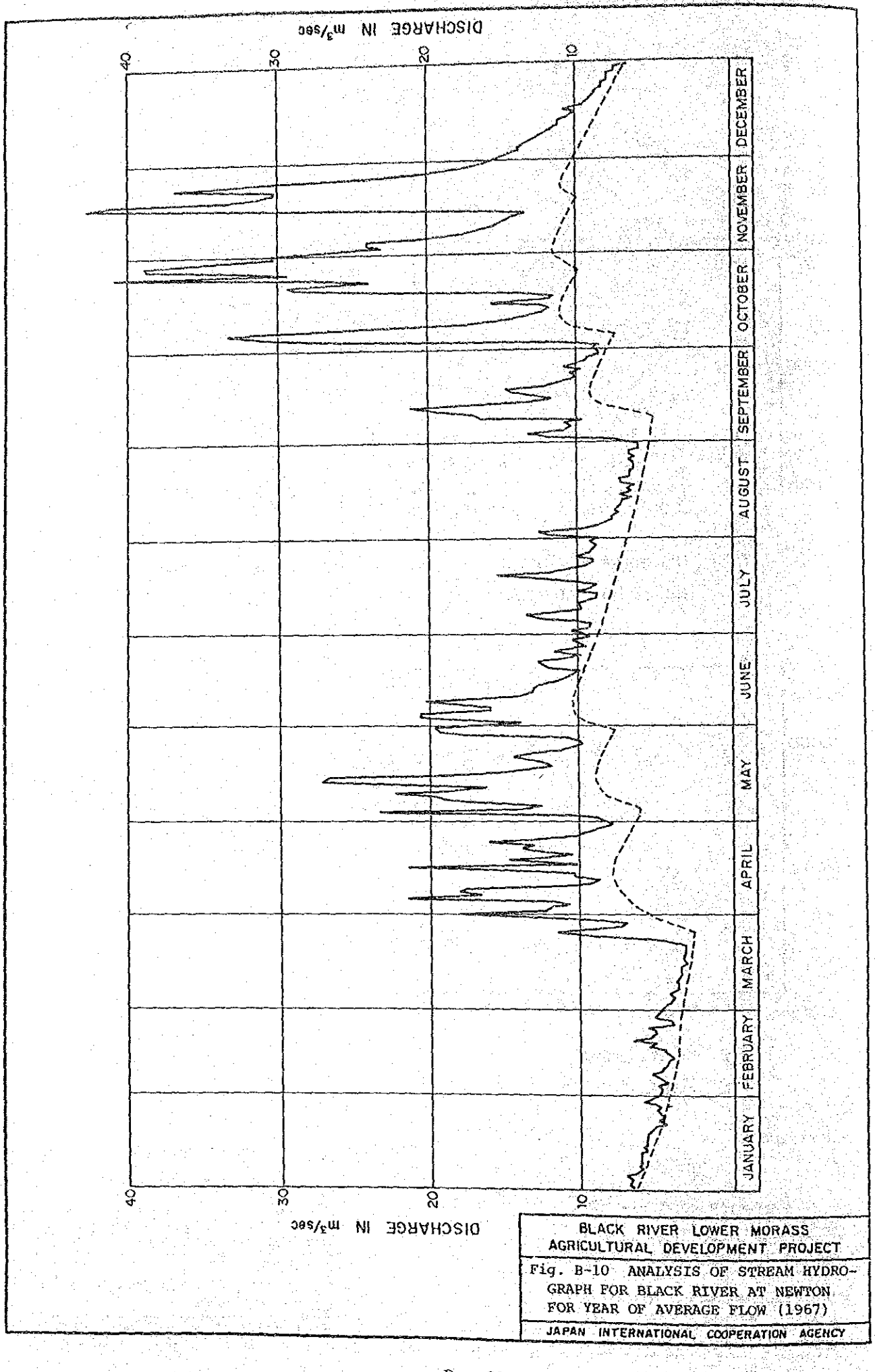
Y : at Lacovia

X : at Y.S.

BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-9
DOUBLE MASS CURVE ANALYSES OF
DISCHARGE RECORD

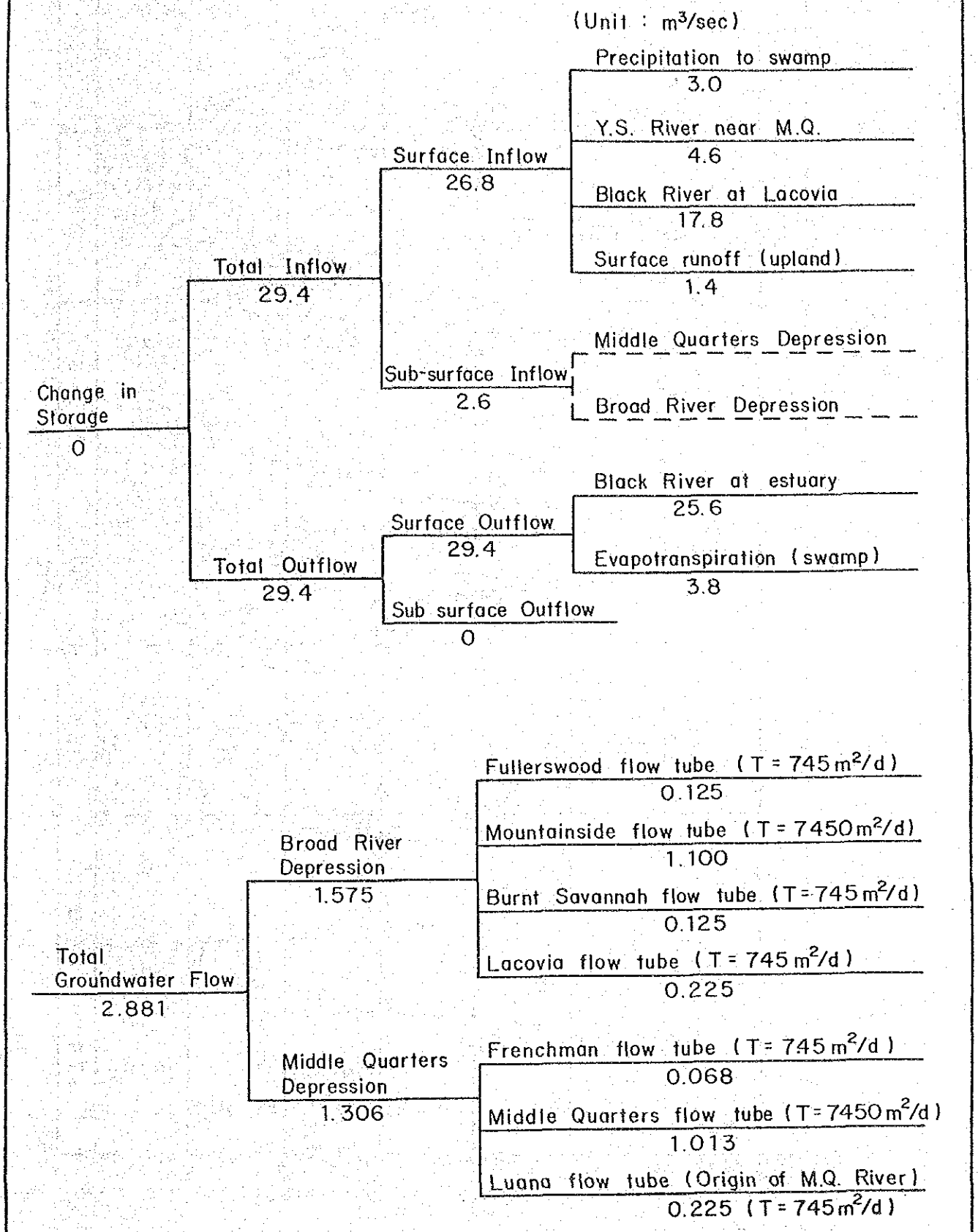
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-10 ANALYSIS OF STREAM HYDROGRAPH FOR BLACK RIVER AT NEWTON FOR YEAR OF AVERAGE FLOW (1967)

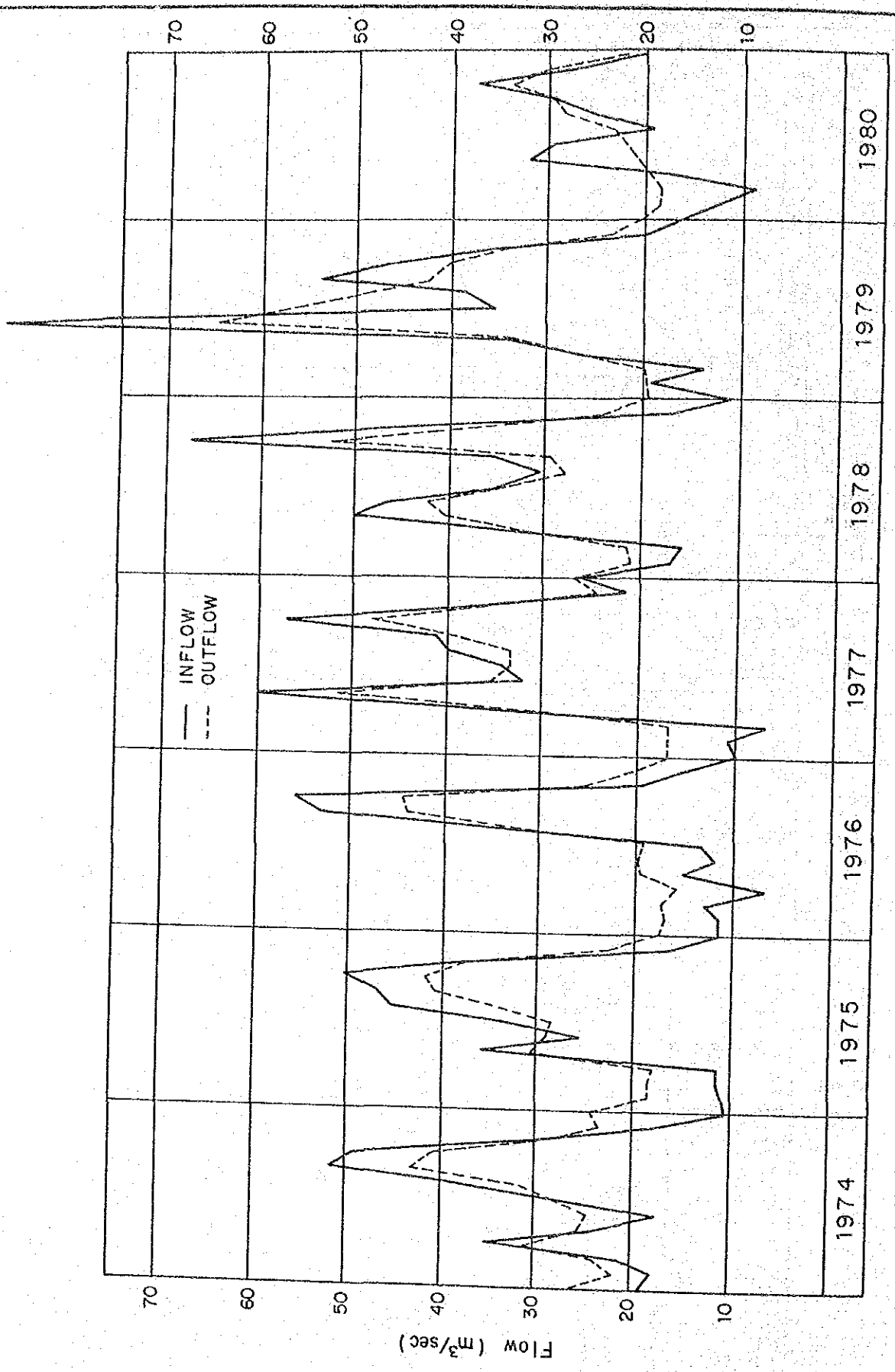
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-11
WATER BALANCE DIAGRAM FOR LOWER MORASS

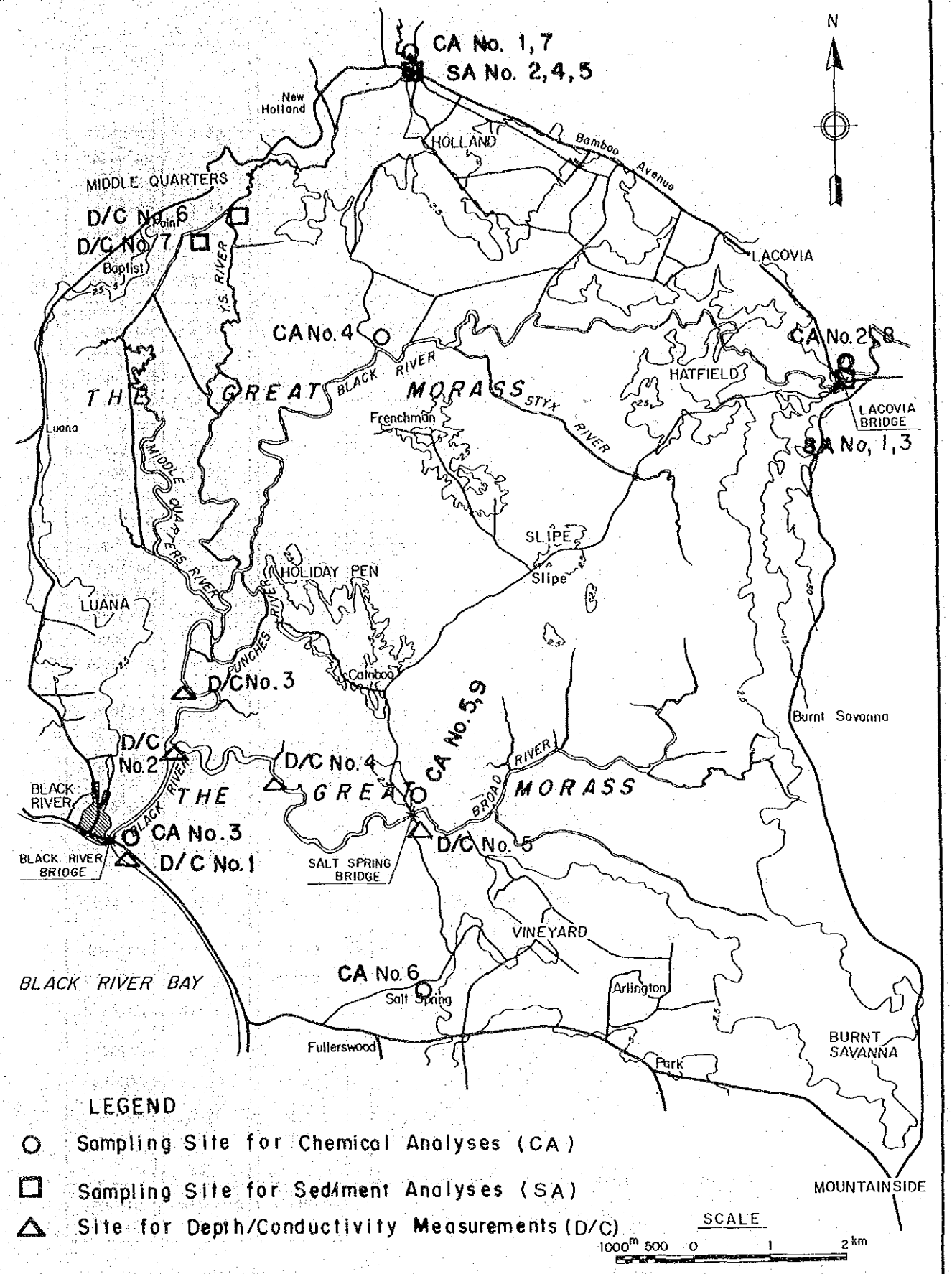
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-12
WATER INFLOW AND OUTFLOW FOR
THE BLACK RIVER LOWER MORASS

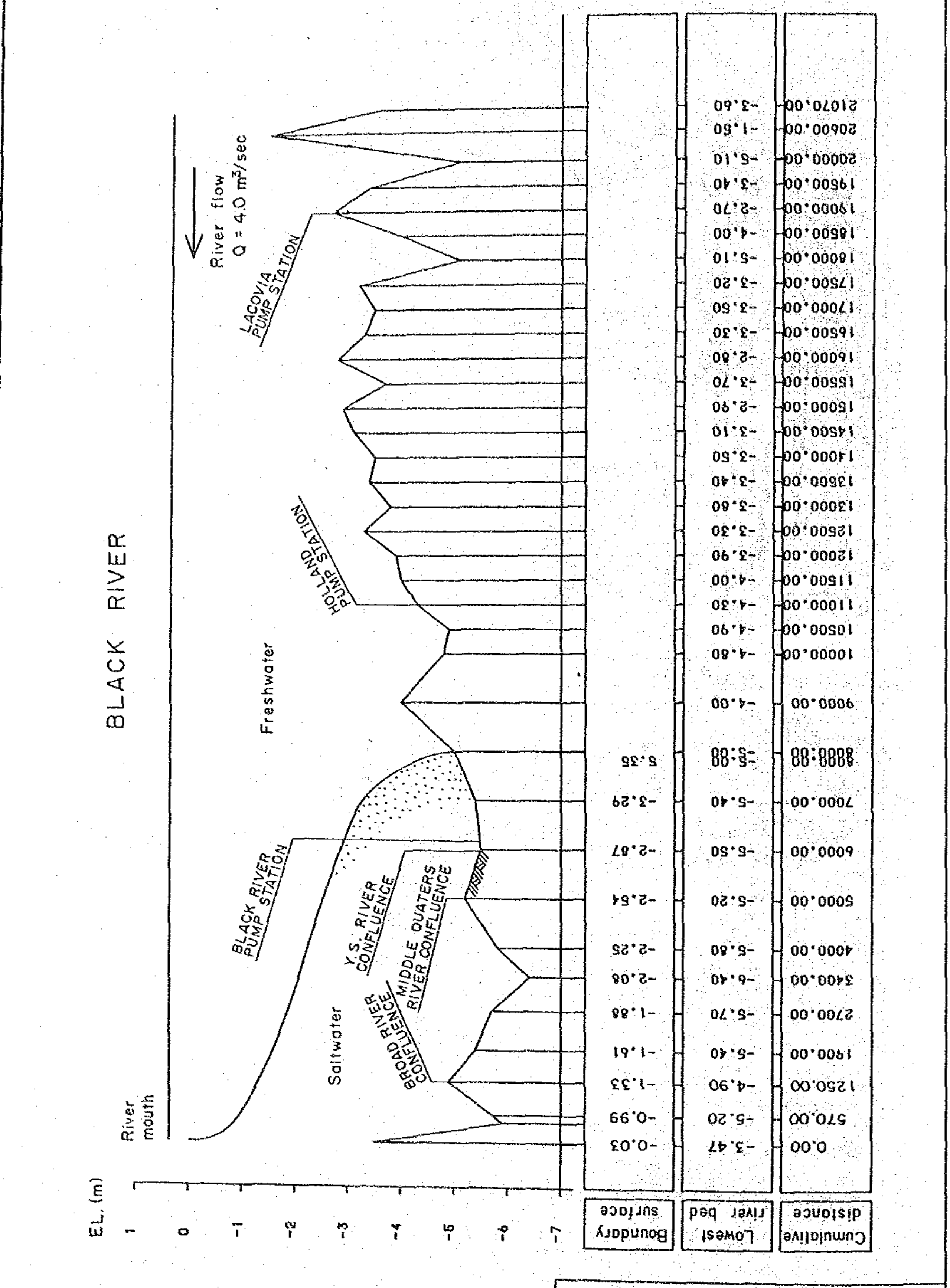
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-13 LOCATION OF WATER SAMPLING SITES AND DEPTH / CONDUCTIVITY MEASUREMENTS

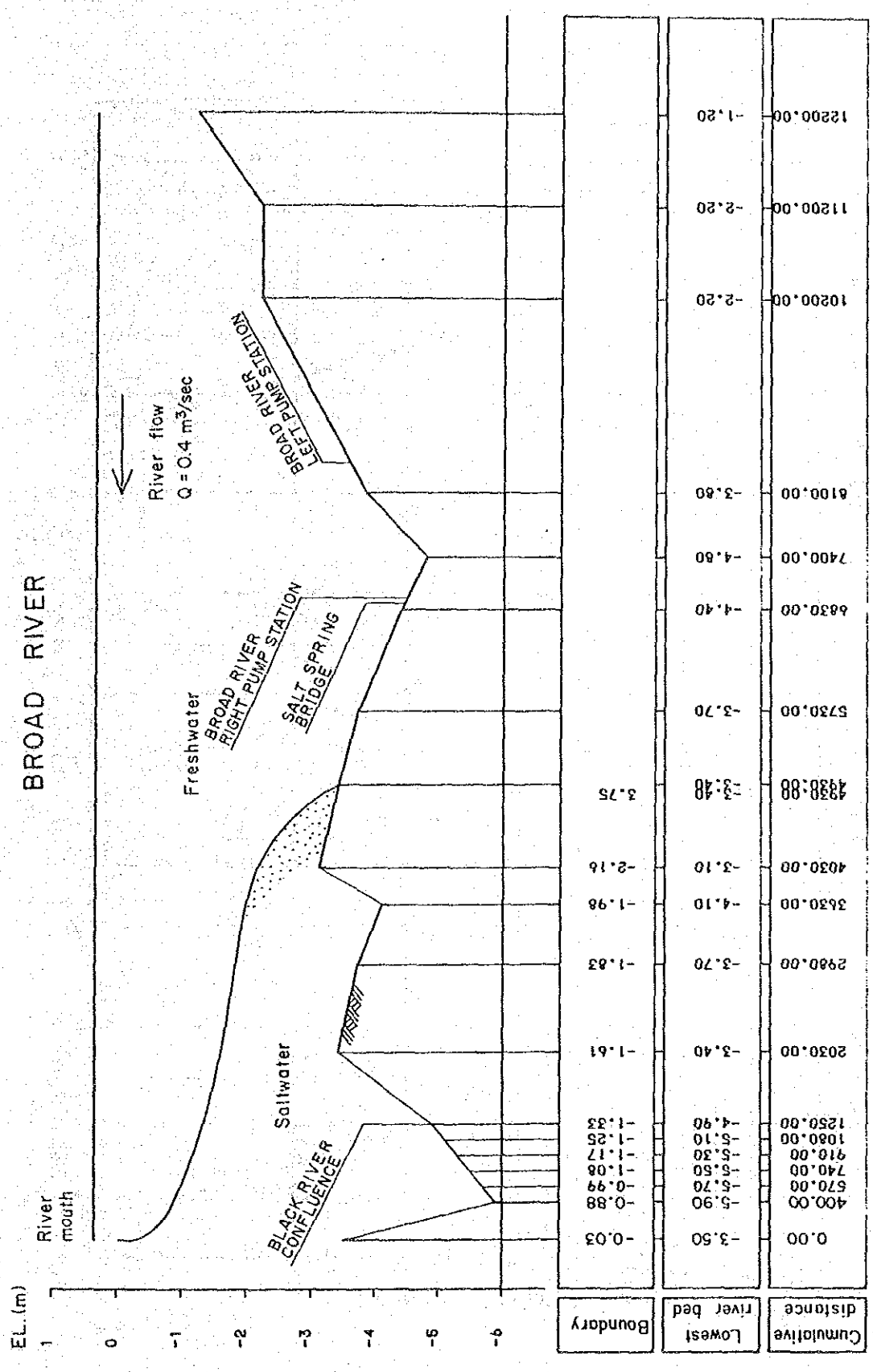
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-14 (1/2)
SALTWATER INTRUSION

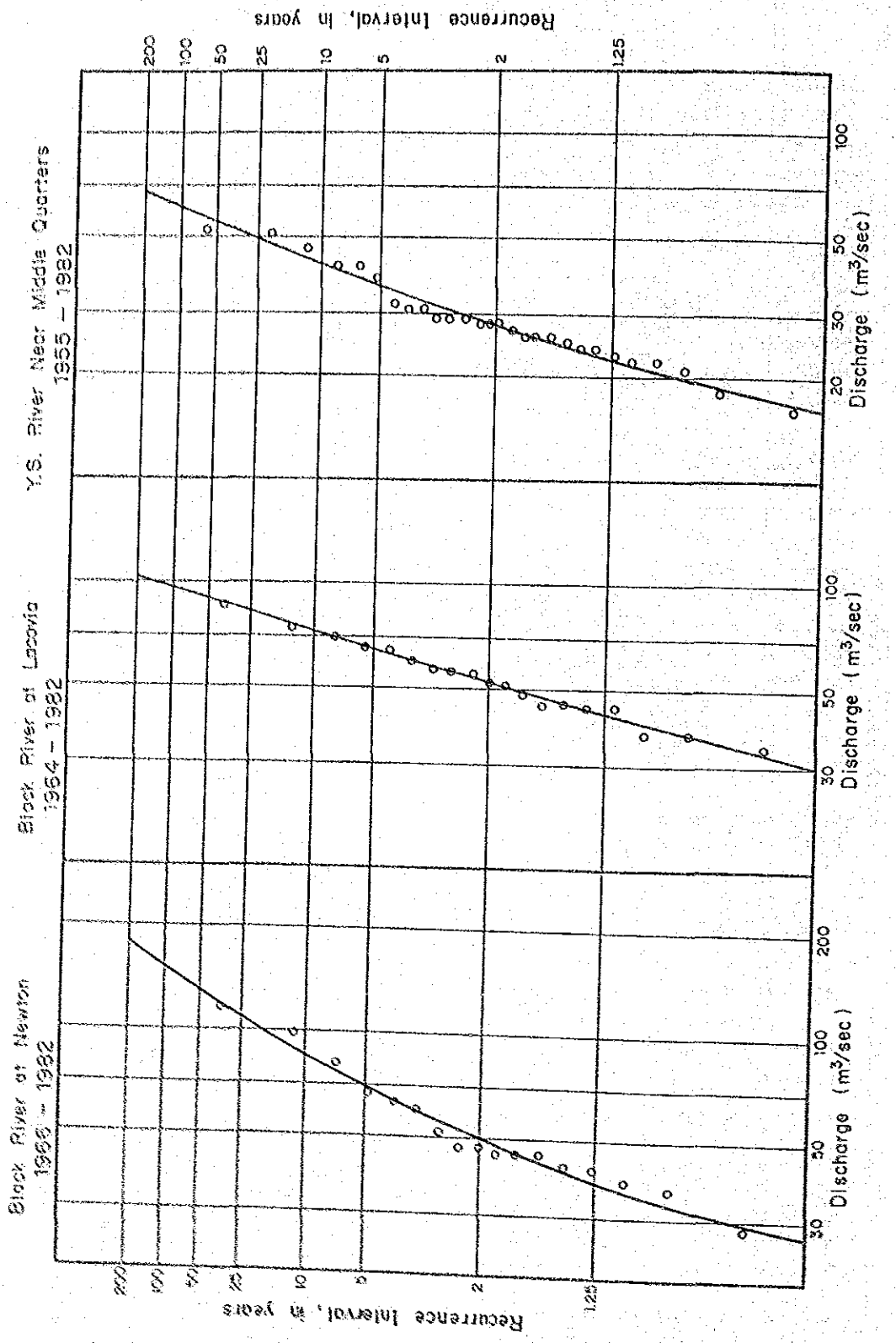
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-14 (2/2)
SALTWATER INTRUSION

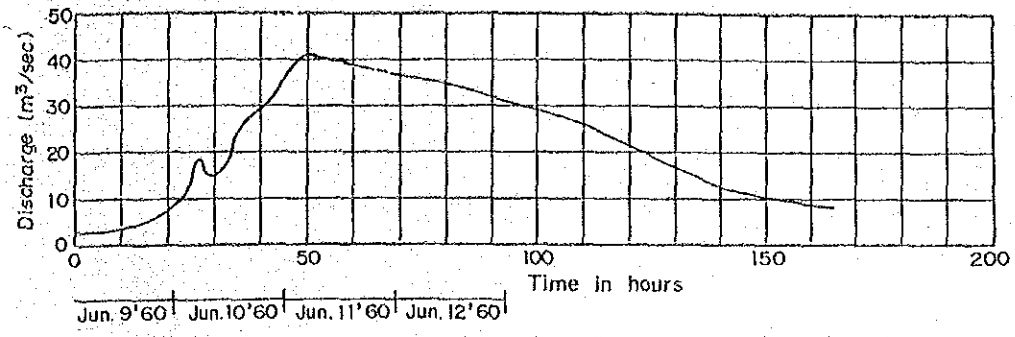
JAPAN INTERNATIONAL COOPERATION AGENCY

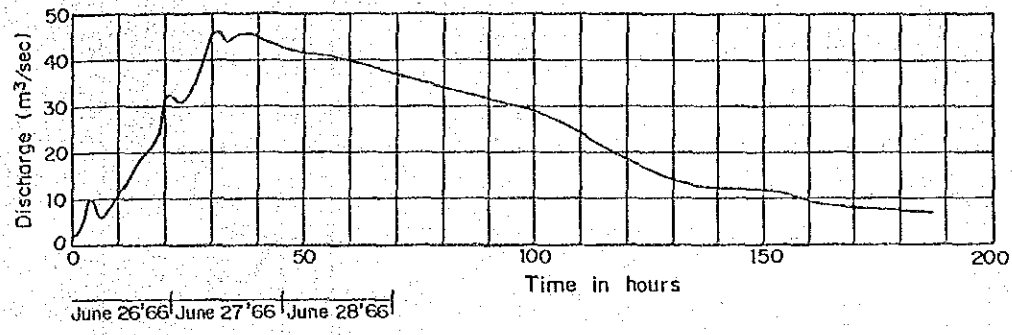


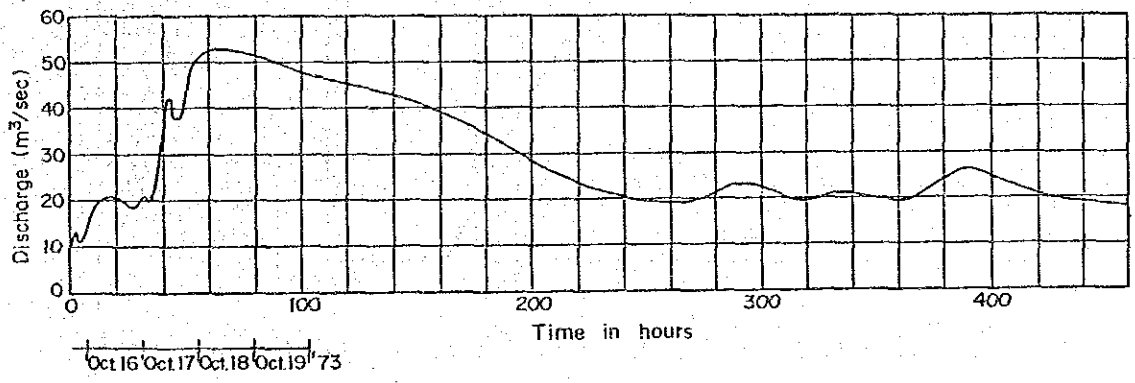
BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

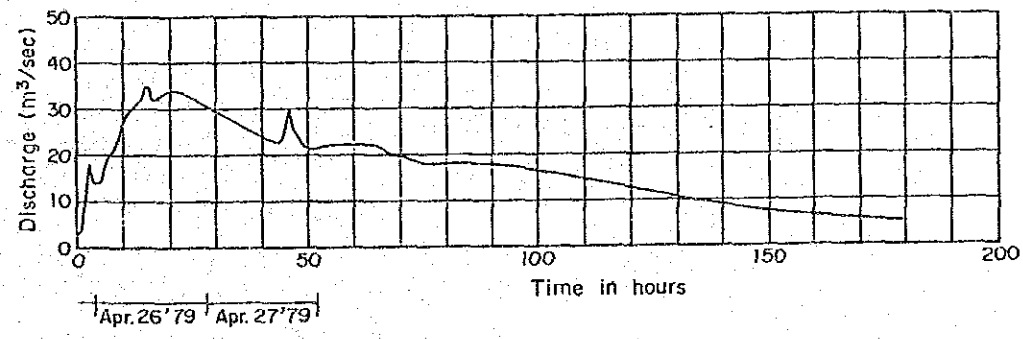
Fig. B-15
FLOOD FREQUENCY IN LOG
PEARSON III DISTRIBUTION

JAPAN INTERNATIONAL COOPERATION AGENCY





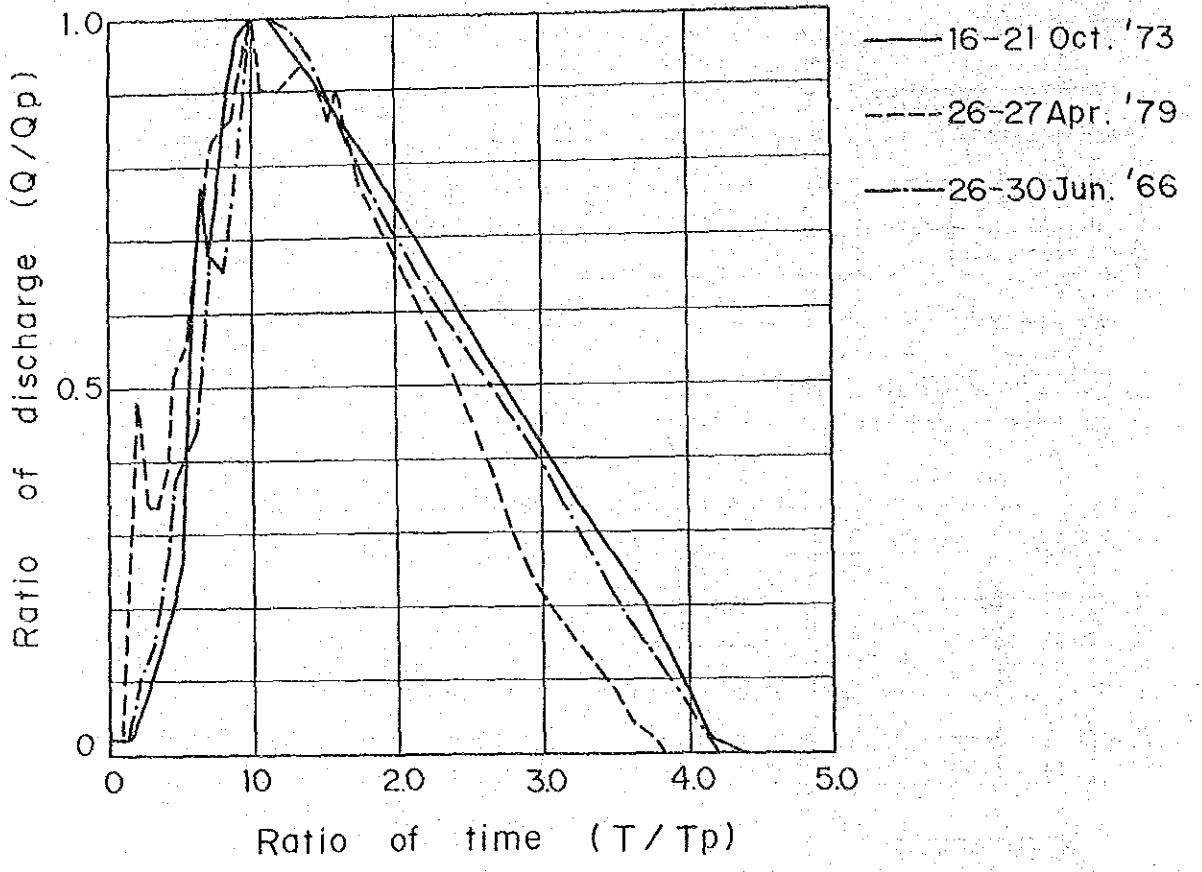




BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-16
REPRESENTATIVE MAJOR FLOOD
HYDROGRAPHS ON THE Y.S. RIVER

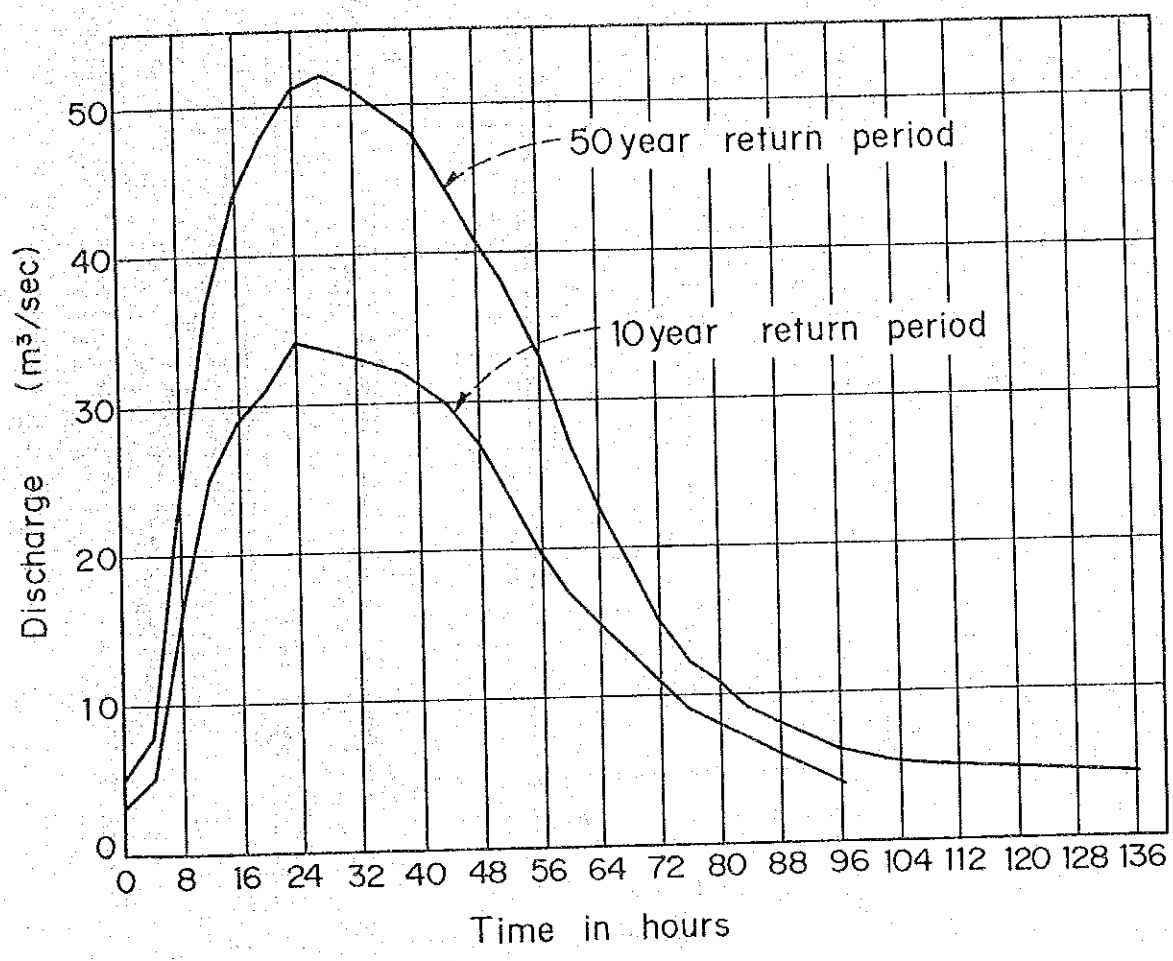
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-17
DIMENSIONLESS FLOOD HYDROGRAPHS
ON THE Y.S. RIVER

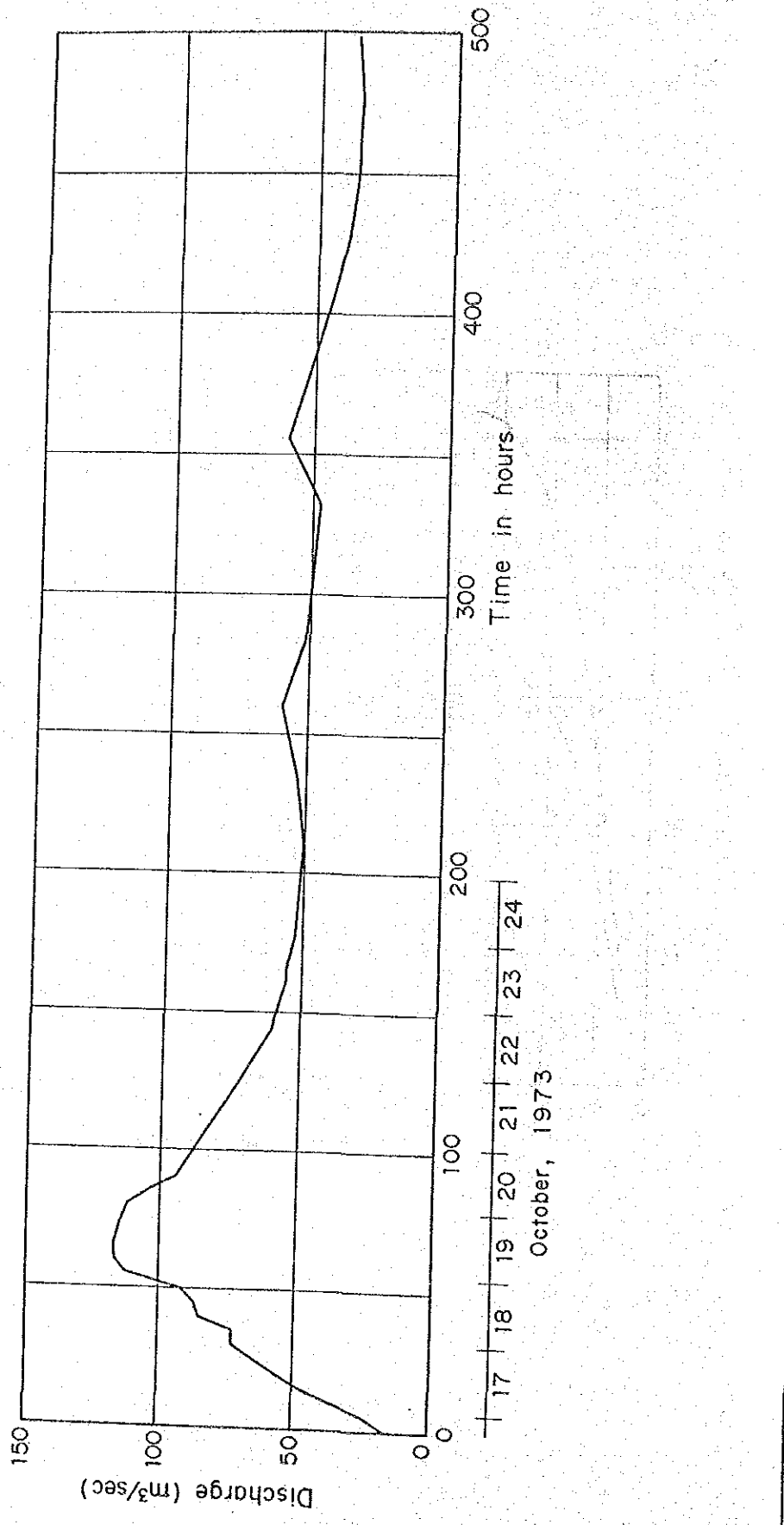
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-18
PROBABLE FLOOD HYDROGRAPH ON
THE Y.S. RIVER

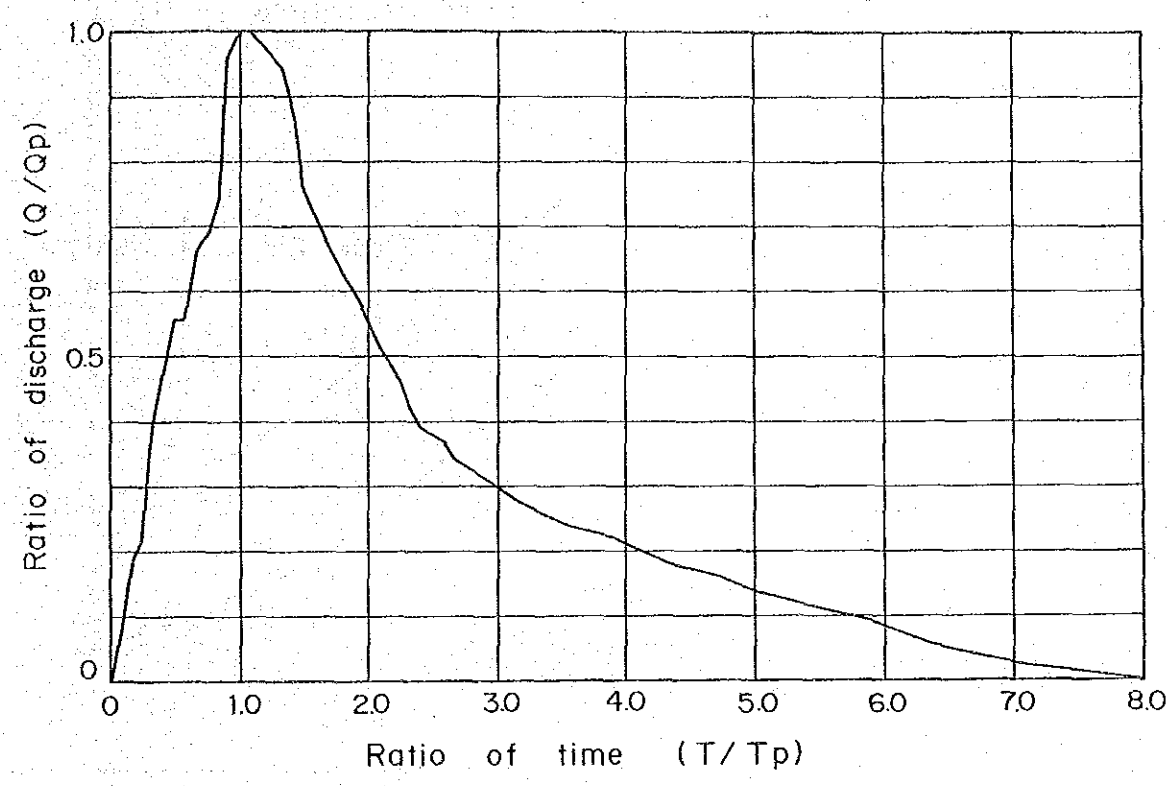
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-19
OCTOBER 1973 FLOOD HYDROGRAPH
ON THE BLACK RIVER

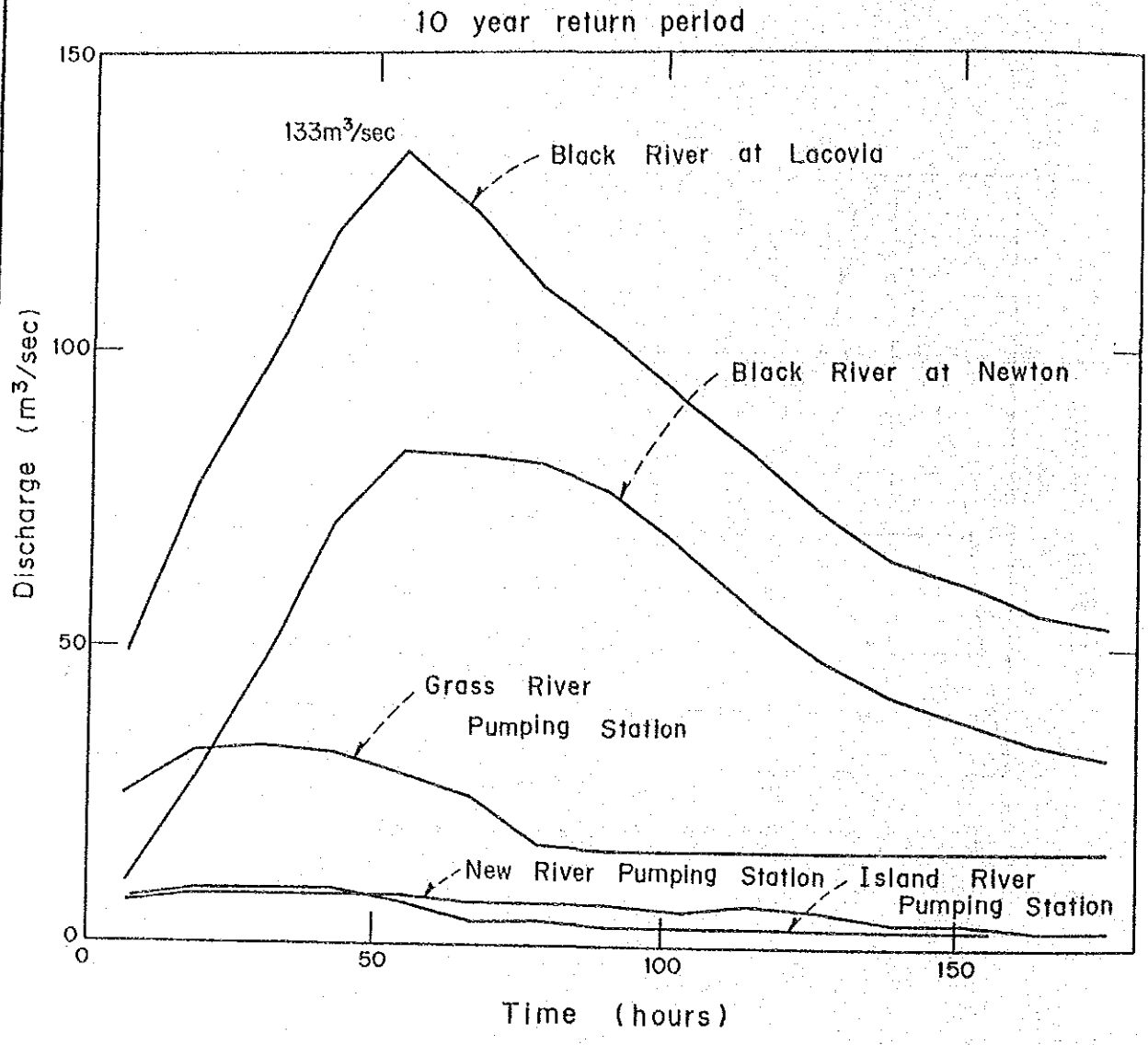
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-20
DIMENSIONLESS FLOOD HYDROGRAPH
ON THE BLACK RIVER

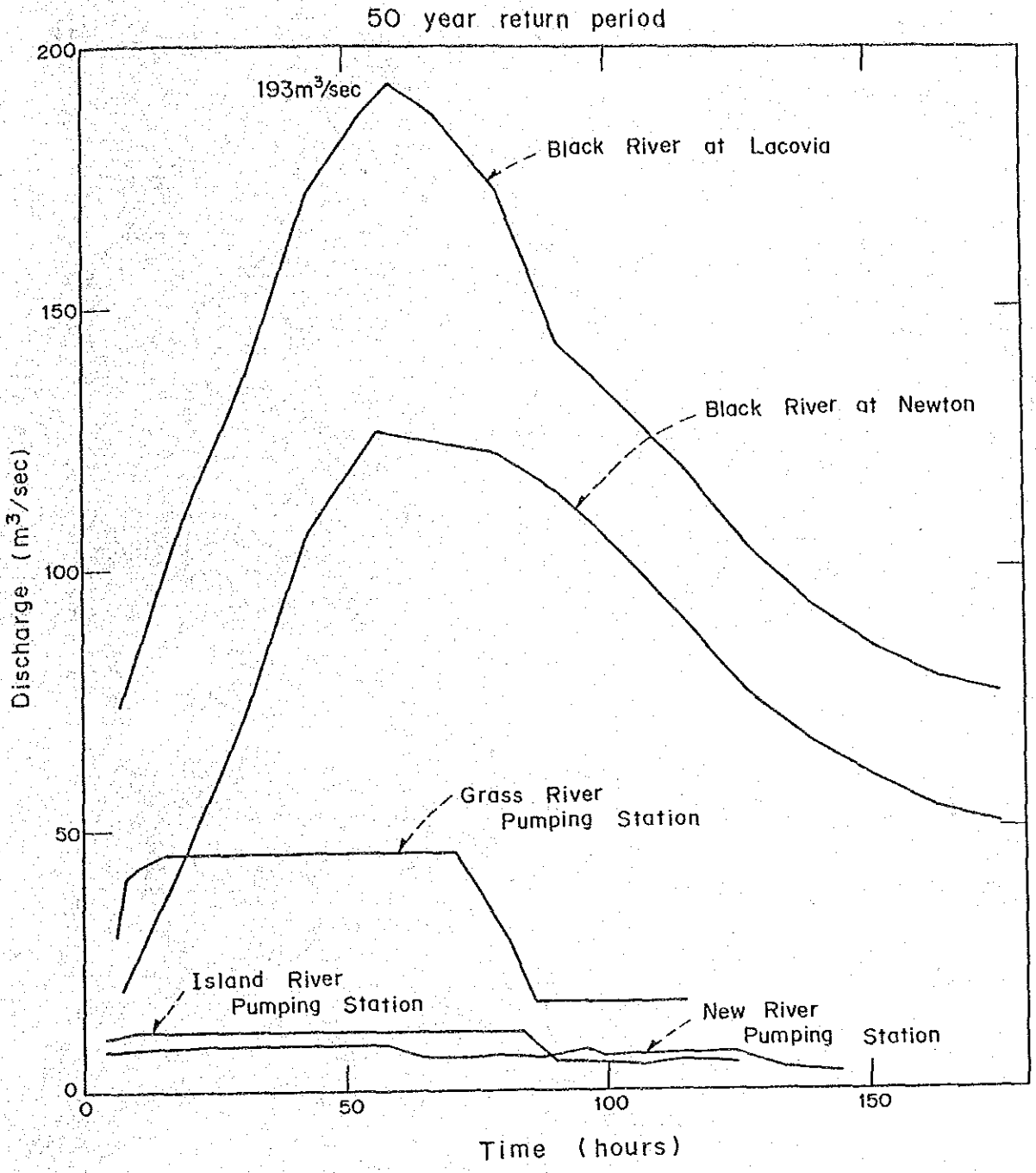
JAPAN INTERNATIONAL COOPERATION AGENCY



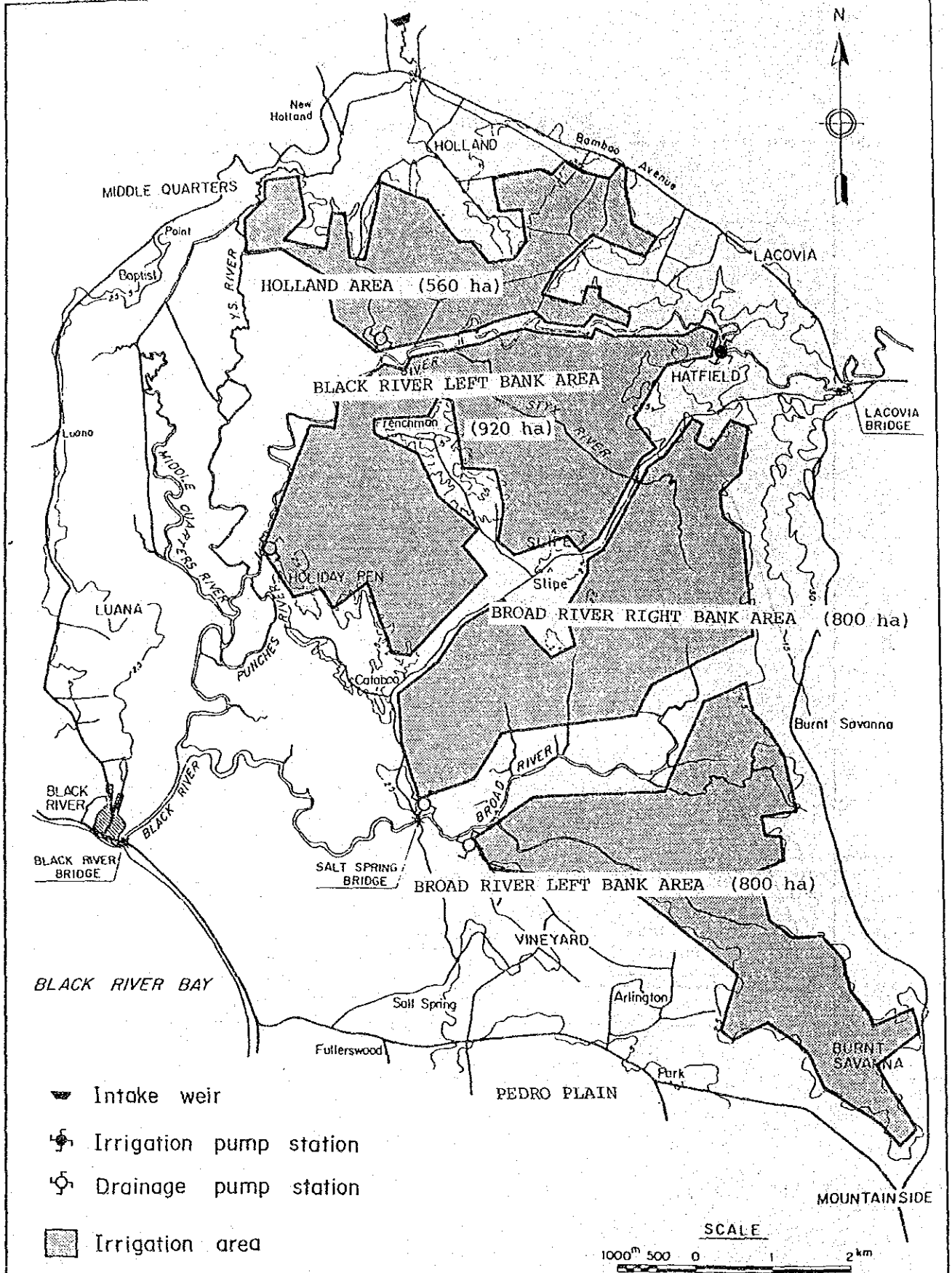
BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-21(1/2)
SYNTHESIZED FLOOD HYDROGRAPH
ON THE BLACK RIVER

JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT
Fig. B-21(2/2) SYNTHESIZED FLOOD HYDROGRAPH ON THE BLACK RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. B-22

IRRIGATION DEVELOPMENT AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX C

GEOLOGY AND HYDROGEOLOGY

ANNEX C

GEOLOGY AND HYDROGEOLOGY

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ANNEX C

GEOLOGY AND HYDROGEOLOGY

1. INTRODUCTION

The geology and hydrogeology investigations were carried out as part of a wider interdisciplinary feasibility level evaluation of the agricultural development potential of the Black River Lower Morass.

These investigations had as their purpose, the evaluation of geological and groundwater conditions in and around the Black River Lower Morass Project Area, with respect to their impact on the potential for agricultural development, in particular irrigation and drainage plans and structures.

The main activities involved in these investigations were as follows:

- The collection and review of existing data;
- Field reconnaissance to identify the geological formations and structure, determine the boundary of the groundwater catchment, and to establish a data network of springs and wells:
- Field collection of groundwater level and select water quality data (temperature, pH and EC) from 5 springs and 20 wells;
- Complete water quality analyses of the discharge from 4 springs and 11 wells;
- Execution of aquifer tests on 2 wells, and
- The analyses and interpretation of all data available, and the preparation of this report.

The Black River Lower Morass Area occupies 115 km^2 (44 sq. miles) of the Black River Basin which has a total area of 1,200 km^2 (462 sq. miles) See Fig. B-1. The Black River Basin is located in the south-west of the island of Jamaica, roughly corresponding to the parish of St. Elizabeth.

2. GEOLOGY

2.1 Previous Investigations

The geology of the Black River Basin has been investigated by Wright, McFarlane and Robinson with the results of their unpublished maps being compiled into a series of geological maps published by the Geological Survey Division (Government of Jamaica). The Basin is covered by Sheets 4, 6, 7, 9, 10 and 12 published at a scale of 1 : 50,000.

Descriptions of the geology of the Black River Basin have also been published by Grontmij (1964) and FAO (1971).

A geological map of the Black River Basin is presented as Fig. C-2

2.2 Stratigraphy

Cretaceous formations form the basement rocks underlying the entire Black River Basin, out-cropping in the north-west and north-east boundary areas of the Basin. These formations are composed of lavas, tuffs, mudstones, sandstones, conglomerates and small limestone lenses.

Basement is overlain unconformably by a Tertiary sequence of limestones in excess of 3,000 m (10,000 ft) thick. The basal 300 m (1,000 ft) of the sequence belongs to the Yellow Limestone Group. It is composed of impure limestones, calcareous mudstones and sandstones which weather to a characteristic yellow-brown colour. The outcrops of Yellow Limestone fringes the Cretaceous Inliers.

The rest of the Tertiary sequence is made of the pure limestone formations of the White Limestone Group, the outcrops of which predominate throughout the Black River Basin. The Group is sub-divided into six formations based on their respective lithologic character and fossil assemblage. In general, the lower 450 m (1,500 ft) of the White Limestone Group has been patchily dolomitised and near completely recrystallised (i.e. the Troy/ Claremont Formation) such that original rock textures and fossils have largely been destroyed. The next 450 m (1,500 ft) is made

of facies equivalents - a deep water sequence essentially of well bedded chalk (the Gibraltar - Bonny Gate Formation) and a shallow water bioclastic sequence with moderate to poor bedding (Swanswich, Somerset and Walderston/Browns Town Formations). The upper 1,500 m (5,000 ft) of the White Limestone Group consists of the Newport Formation, a generally soft, chalky, nodular limestone, in which bedding is indistinct or absent.

Quaternary to Recent Alluviums (mainly clays) occupy the valley floor of the Nassau Valley and rests directly on the White Limestone in the downfaulted depressions of the Upper and Lower Morass. Maximum thicknesses have not yet been determined, but 10 m (33 ft) depth of Alluvium was proved by drilling in the Lower Morass during this project.

Peat deposits overlie the alluviums in the Upper and Lower Morass. Maximum thickness of 12 m (40 ft) have been proved by PCJ (1983) in the Lower Morass.

A summary description of the stratigraphic sequence is presented as Table C-1.

The Lower Morass is a down-faulted limestone depression. The Newport Formation forms the southern, eastern, northern and south-western boundaries of the depression. The down-faulted block is also of Newport Formation, outcropping in the central area of the depression (i.e., upland area of Cataboo and Slipe) as a sandy marly limestone. Clayey alluvial deposits rests on the limestone floor of the depression. Peat deposits occupy the swamp area developed on the alluvium.

2.3 Structure

Cretaceous highs border the north eastern and north-western sections of the Black River Basin. The Tertiary limestone sequence generally thickens down-dip away from these highs towards the south and south west. The limestone formations are folded along a NW - SE axis into broad gentle anticlines and synclines.

This situation is complicated by two dominant sets of faults, one aligned in a NNW - SSE and the other trending in a NE - SW direction. The interception of these sets of faults result in the block faulting which has produced the Upper and Lower Morasses. Maximum displacements of the order of 750 m (2,500 ft) are associated with the NNW -SSE faults i.e., the Santa Cruz and Spur Tree Faults.

The dominant structural features within the Lower Morass are the faults and the resulting block movements which have produced the down-faulted depression of the Lower Morass.