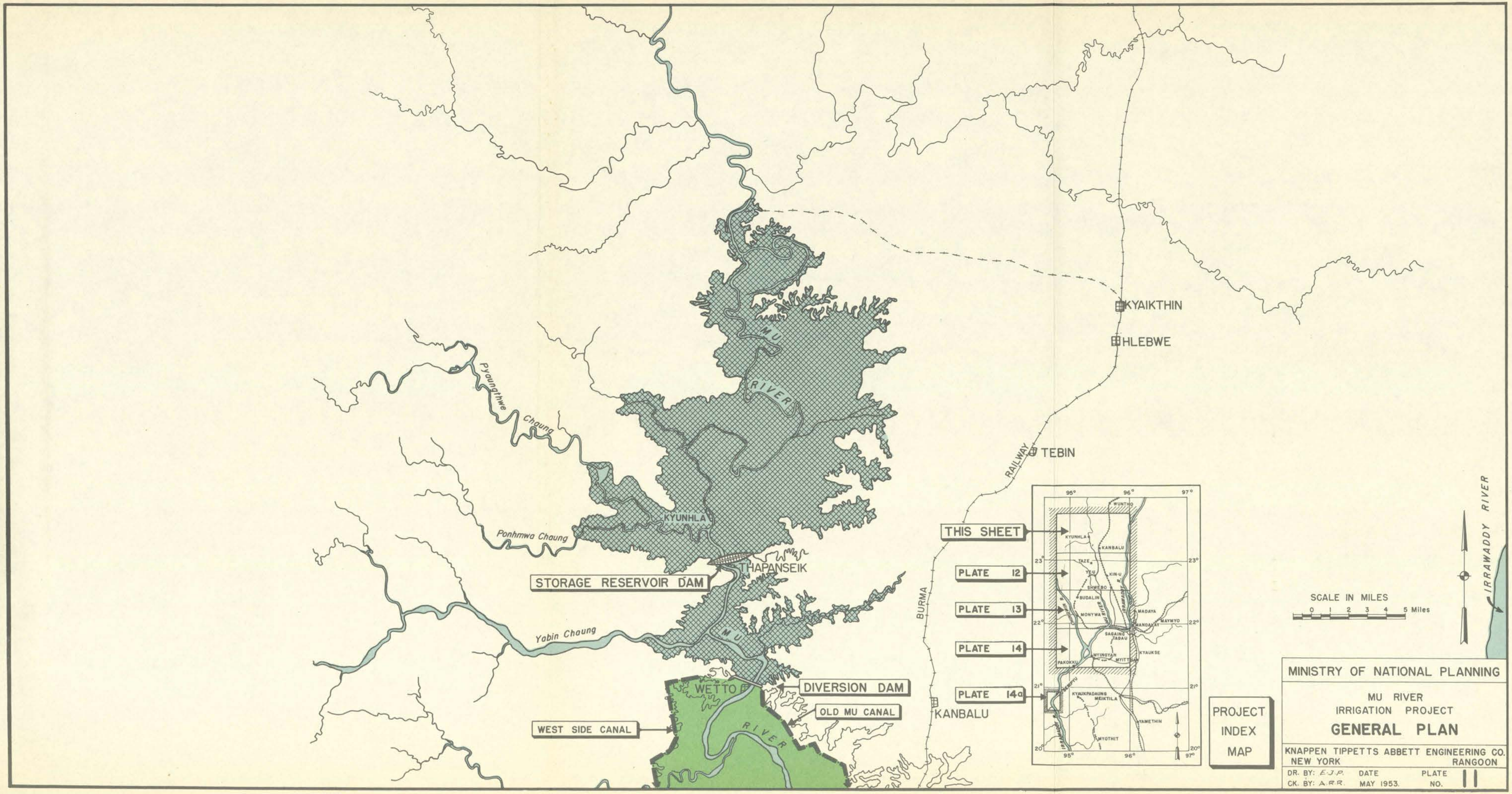
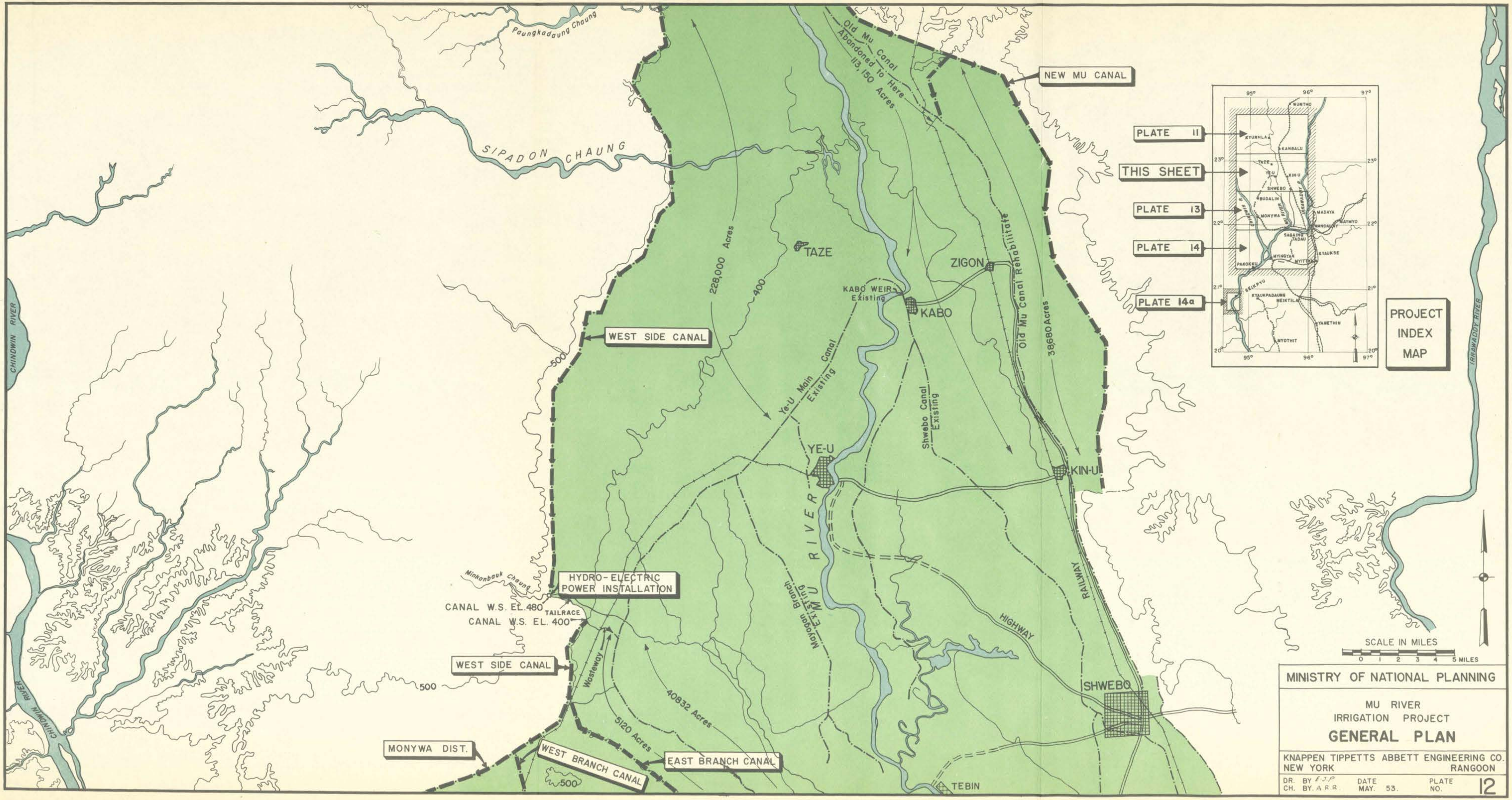
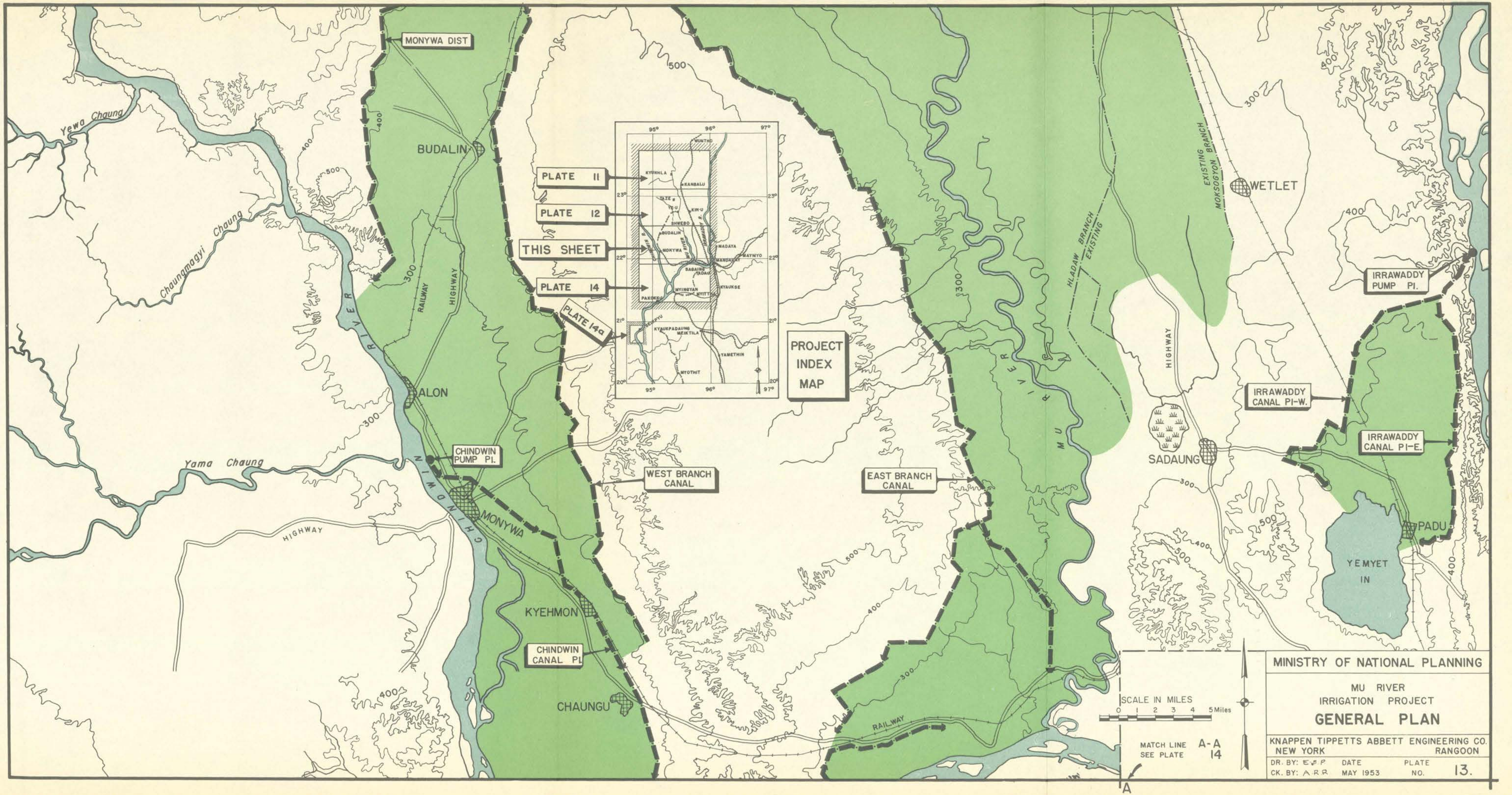
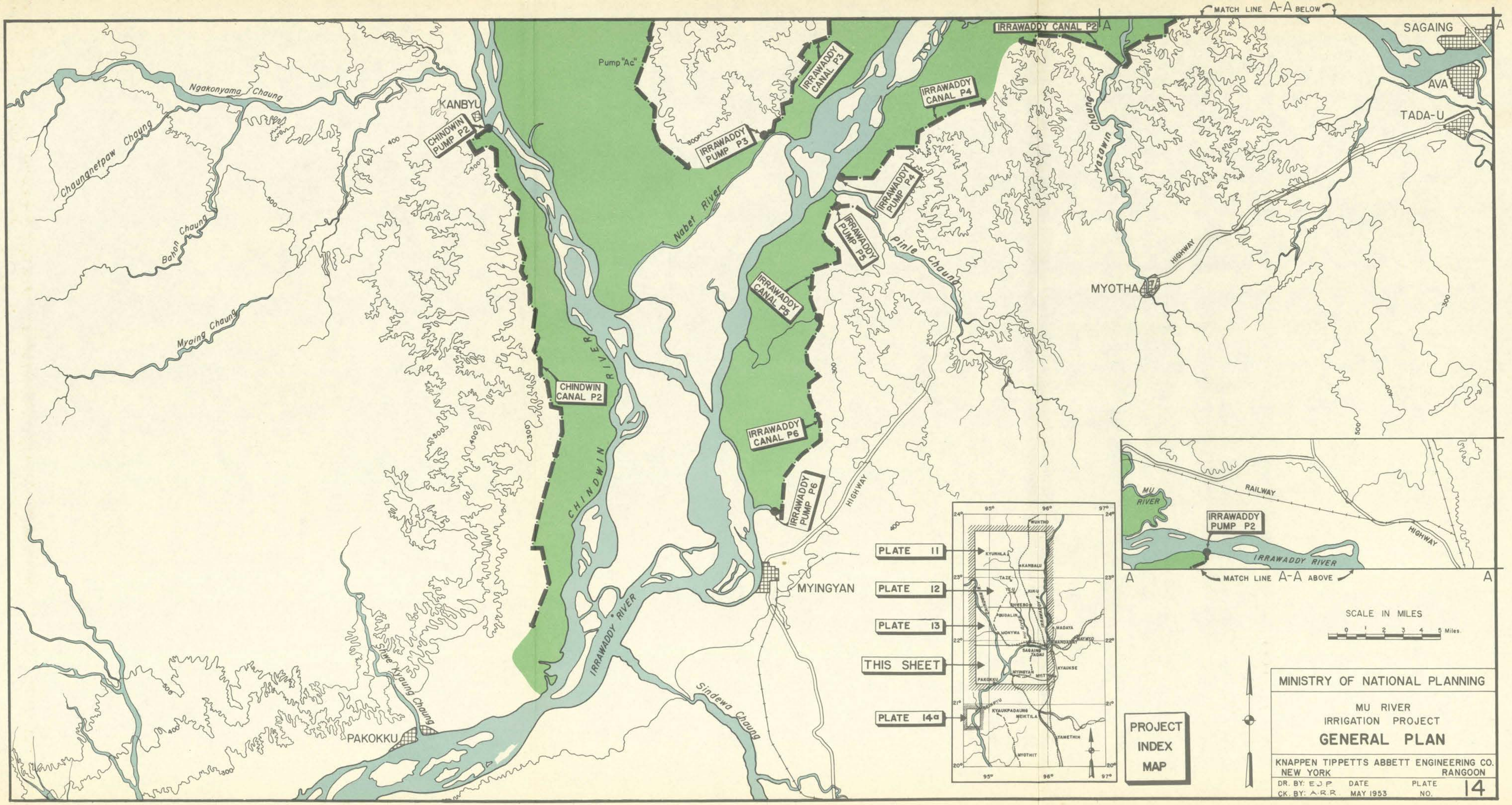

KYAIKTHIN
HLEBWE
TEBIN
RAILWAY
BURMA
KANBALU
MU RIVER
Pyaungthwe Chaung
Ponhmwa Chaung
KYUNHLA
THAPANSEIK
STORAGE RESERVOIR DAM
Yabin Chaung
MU RIVER
WETTO
DIVERSION DAM
OLD MU CANAL
WEST SIDE CANAL
RIVER
THIS SHEET
PLATE 12
PLATE 13
PLATE 14
PLATE 14a
95° 96° 97°
23° 22° 21° 20°
WUNTHO
KYUNHLA
KANBALU
TAZE
YEU
KIN-U
SHWEBO
BUDALIN
MONYWA
MADAYA
MANDALAY
MAYMYO
SAGAING
TADAU
MYINGYAN
MYITTHA
KYAUKSE
PAKOKKU
KYAUKPADAUNG
MEIKTILA
YAMETHIN
MYOTHIT
IRRAWADDY R.
PROJECT INDEX MAP
SCALE IN MILES
0 1 2 3 4 5 Miles
IRRAWADDY RIVER
MINISTRY OF NATIONAL PLANNING
MU RIVER
IRRIGATION PROJECT
GENERAL PLAN
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
DR. BY: E.J.P.
CK. BY: A.R.R.
DATE MAY 1953
PLATE NO. 11



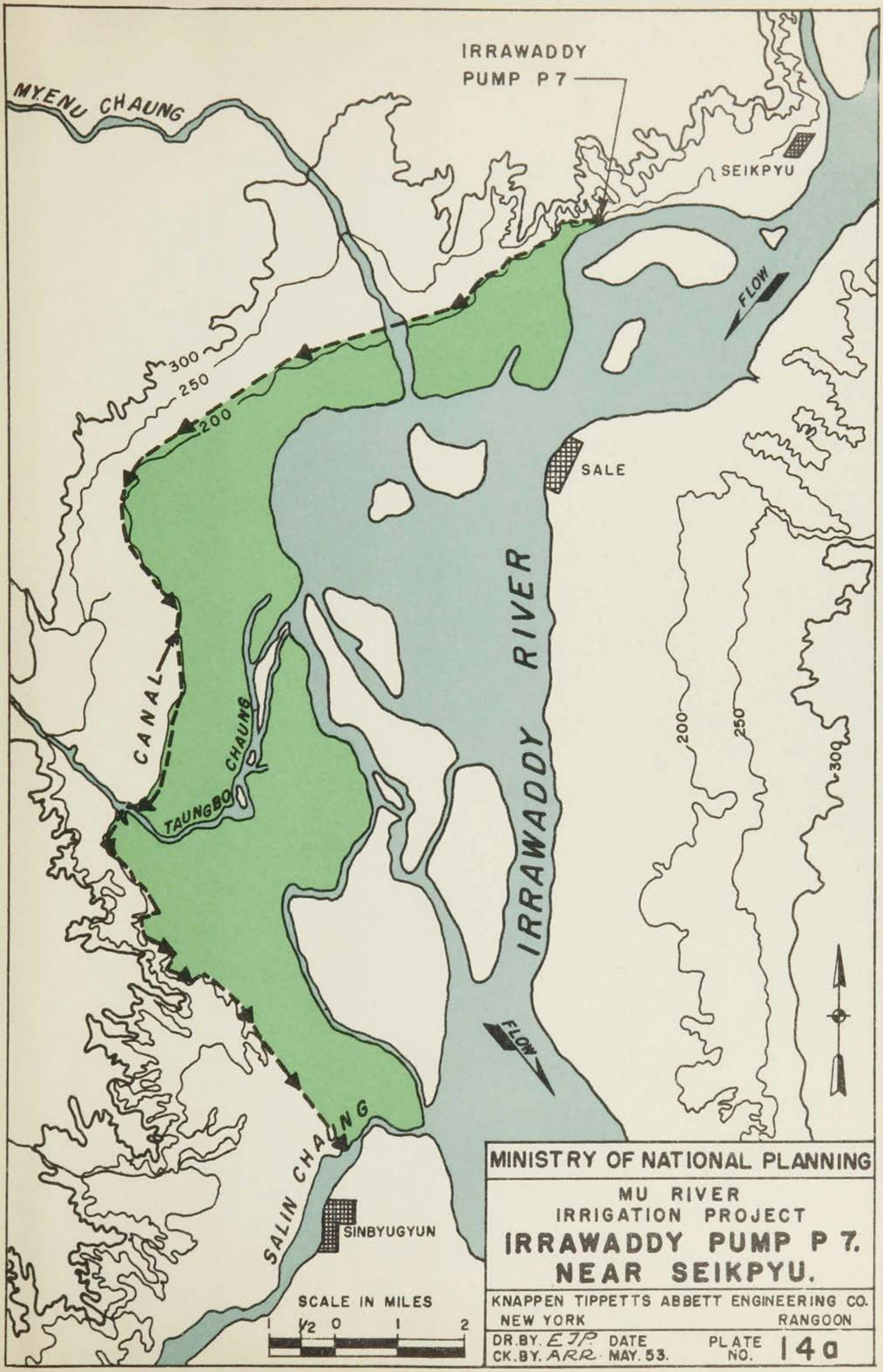
Paungkadaung Chaung
SIPADON CHAUNG
CHINDWIN RIVER
Old Mu Canal
Abandoned to Here
113,150 Acres
NEW MU CANAL
228,000 Acres
400
500
TAZE
ZIGON
KABO WEIR
Existing
KABO
Old Mu Canal Rehabilitate
38680 Acres
WEST SIDE CANAL
Ye-U Main Canal
Existing
Shwebo Canal
Existing
YE-U
KIN-U
MU RIVER
Mayagan Branch
Existing
Minkonbauk Chaung
HYDRO-ELECTRIC
POWER INSTALLATION
CANAL W.S. EL. 480
TAILRACE
CANAL W.S. EL. 400
WEST SIDE CANAL
Wasteway
40832 Acres
5120 Acres
HIGHWAY
RAILWAY
SHWEBO
MONYWA DIST.
WEST BRANCH CANAL
EAST BRANCH CANAL
TEBIN
PLATE 11
THIS SHEET
PLATE 13
PLATE 14
PLATE 14a
PROJECT
INDEX
MAP
IRRAWADDY RIVER
SCALE IN MILES
0 1 2 3 4 5 MILES
MINISTRY OF NATIONAL PLANNING
MU RIVER
IRRIGATION PROJECT
GENERAL PLAN
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
DR. BY E.J.P.
CH. BY. A.R.R.
DATE
MAY. 53.
PLATE
NO.
12



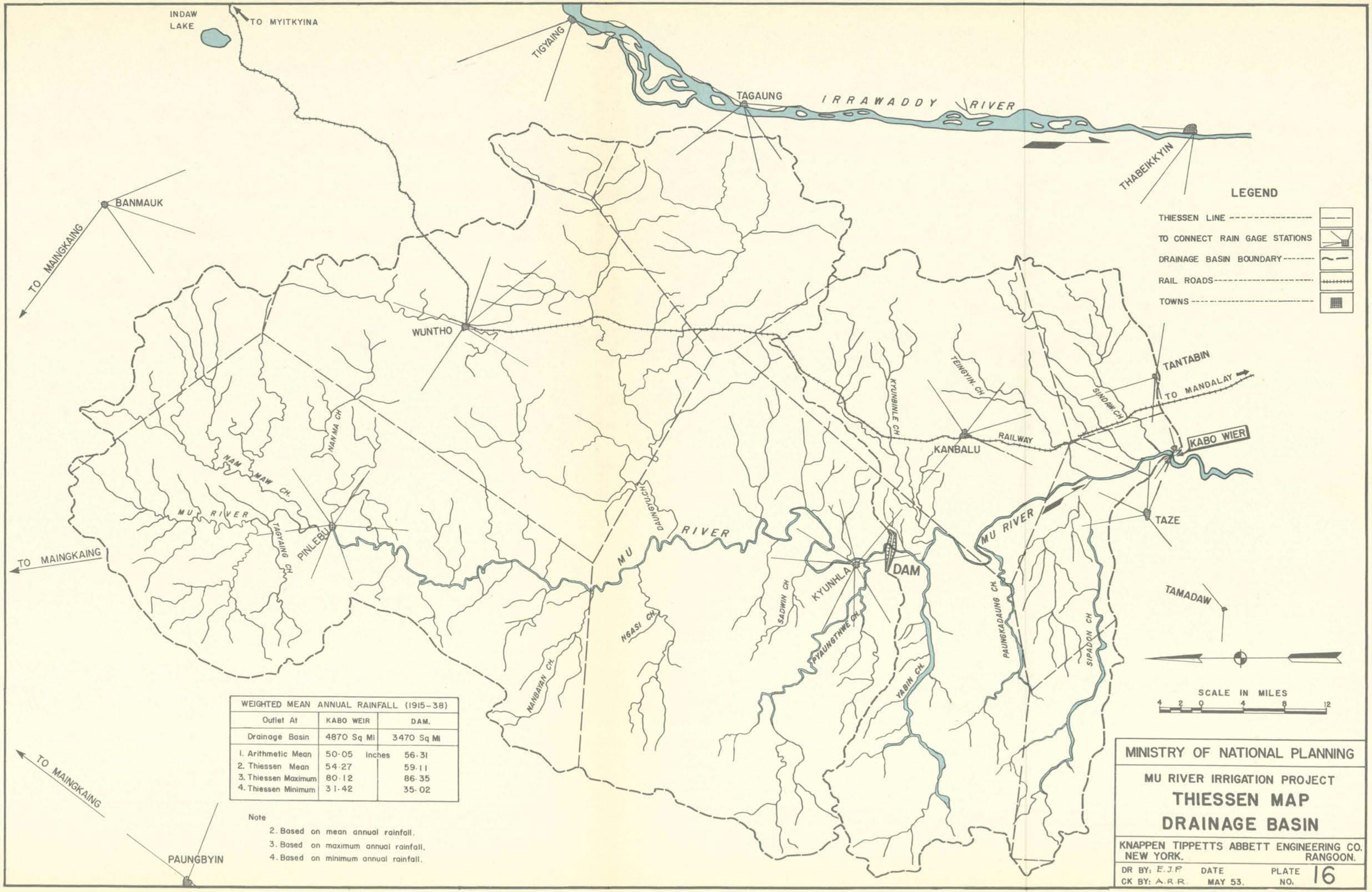
MONYWA DIST
BUDALIN
Yewa Chaung
Chaungmagyi Chaung
Yama Chaung
CHINDWIN RIVER
RAILWAY
HIGHWAY
ALON
CHINDWIN PUMP Pl.
MONYWA
KYEHMON
CHINDWIN CANAL Pl.
CHAUNGU
WEST BRANCH CANAL
PLATE 11
PLATE 12
THIS SHEET
PLATE 14
PLATE 14a
PROJECT INDEX MAP
WUNTHO
KYUNHLA
KANBALU
YE-U
KIN-U
SHWEBO
BUDALIN
MONYWA
MADAYA
MAYMYO
MANDALAY
SAGAING
PAKOKKU
MYINGYAN
MYITTHA
KYAUKSE
KYAUKPADAUNG
MEIKTILA
YAMETHIN
MYOTHIT
95°
96°
97°
23°
22°
21°
20°
EAST BRANCH CANAL
MU RIVER
HLADAW BRANCH EXISTING
EXISTING MOKSOGYON BRANCH
WETLET
SADAUNG
IRRAWADDY PUMP Pl.
IRRAWADDY CANAL Pl-W.
IRRAWADDY CANAL Pl-E.
PADU
YEMYET IN
500
400
300
SCALE IN MILES
0 1 2 3 4 5 Miles
MATCH LINE A-A
SEE PLATE 14
A
MINISTRY OF NATIONAL PLANNING
MU RIVER
IRRIGATION PROJECT
GENERAL PLAN
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
DR. BY: E.J.P.
CK. BY: A.R.R.
DATE
MAY 1953
PLATE NO.
13.



MATCH LINE A-A BELOW
IRRAWADDY CANAL P2
SAGAING
AVA
TADA-U
IRRAWADDY CANAL P3
IRRAWADDY CANAL P4
IRRAWADDY PUMP P3
IRRAWADDY PUMP P4
IRRAWADDY PUMP P5
IRRAWADDY CANAL P5
IRRAWADDY CANAL P6
IRRAWADDY PUMP P6
Pump "Ac"
Ngakonyama Chaung
KANBYU
CHINDWIN PUMP P2
CHINDWIN CANAL P2
Chaungnetpaw Chaung
Bohon Chaung
Myaing Chaung
Nabet River
Pinle Chaung
Yazawin Chaung
HIGHWAY
MYOTHA
CHINDWIN RIVER
IRRAWADDY RIVER
MYINGYAN
Sindewa Chaung
Shwe Kyaung Chaung
PAKOKKU
MU RIVER
RAILWAY
IRRAWADDY PUMP P2
IRRAWADDY RIVER
MATCH LINE A-A ABOVE
PLATE 11
PLATE 12
PLATE 13
THIS SHEET
PLATE 14a
PROJECT INDEX MAP
SCALE IN MILES
Miles
MINISTRY OF NATIONAL PLANNING
MU RIVER
IRRIGATION PROJECT
GENERAL PLAN
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
DR. BY: E.J.P.
CK. BY: A.R.R.
DATE
MAY 1953
PLATE NO.
14


IRRAWADDY PUMP P7
MYENU CHAUNG
SEIKPYU
FLOW
300
250
200
SALE
IRRAWADDY RIVER
CANAL
TAUNGBO CHAUNG
200
250
300
FLOW
SALIN CHAUNG
SINBYUGYUN
SCALE IN MILES
1 1/2 0 1 2
MINISTRY OF NATIONAL PLANNING
MU RIVER
IRRIGATION PROJECT
IRRAWADDY PUMP P 7.
NEAR SEIKPYU.
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
DR. BY. EJP DATE
CK. BY. ARR MAY. 53.
PLATE NO. 14a


IRRAWADDY RIVER
SAGAING
AVA
TADA-U
YEMYET IN
IRRAWADDY RIVER
WETLET
SADAUNG
THAZIN IN
Moksogyon Branch
SHWEBO
Hladaw Branch
NGAZUN
MYOTHA
KIN-U
Old Mu Canal
ZIGON
Shwebo Main Canal
MU RIVER
MYINMU
RESERVOIR
TAZE
YE-U
Mayagan Branch
Ye-U Main Canal
WETTO DAM
KYUNHLA DAM
KYUNHLA
TABAYIN
YABIN CHAUNG
MYINGYAN
CHAUNG-U
CHINDWIN RIVER
BUDALIN
MONYWA
LEGEND
TOWN
PROJECT IRRIGATION
NEW IRRIGATION CANALS
EXISTING IRRIGATION CANALS
PUMP
ALLUVIUM
IRRAWADDIAN SERIES
PEGU SERIES
PASSAGE BED SERIES
PLEISTOCENE
UNCLASSIFIED CRYSTALLINE
SCALE IN MILE
MILES 4 2 0 4 8 MILES
MINISTRY OF NATIONAL PLANNING
MU RIVER
IRRIGATION PROJECT
GEOLOGICAL MAP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK. RANGOON.
DR. BY. E.J.P. DATE PLATE NO. 15
CK. BY. A.R.R. MAY. 53.



WEIGHTED MEAN ANNUAL RAINFALL (1915-38)		
Outlet At	KABO WEIR	DAM.
Drainage Basin	4870 Sq Mi	3470 Sq Mi
1. Arithmetic Mean	50·05 Inches	56·31
2. Thiessen Mean	54·27	59·11
3. Thiessen Maximum	80·12	86·35
4. Thiessen Minimum	31·42	35·02

Note

2. Based on mean annual rainfall.
3. Based on maximum annual rainfall.
4. Based on minimum annual rainfall.

MINISTRY OF NATIONAL PLANNING

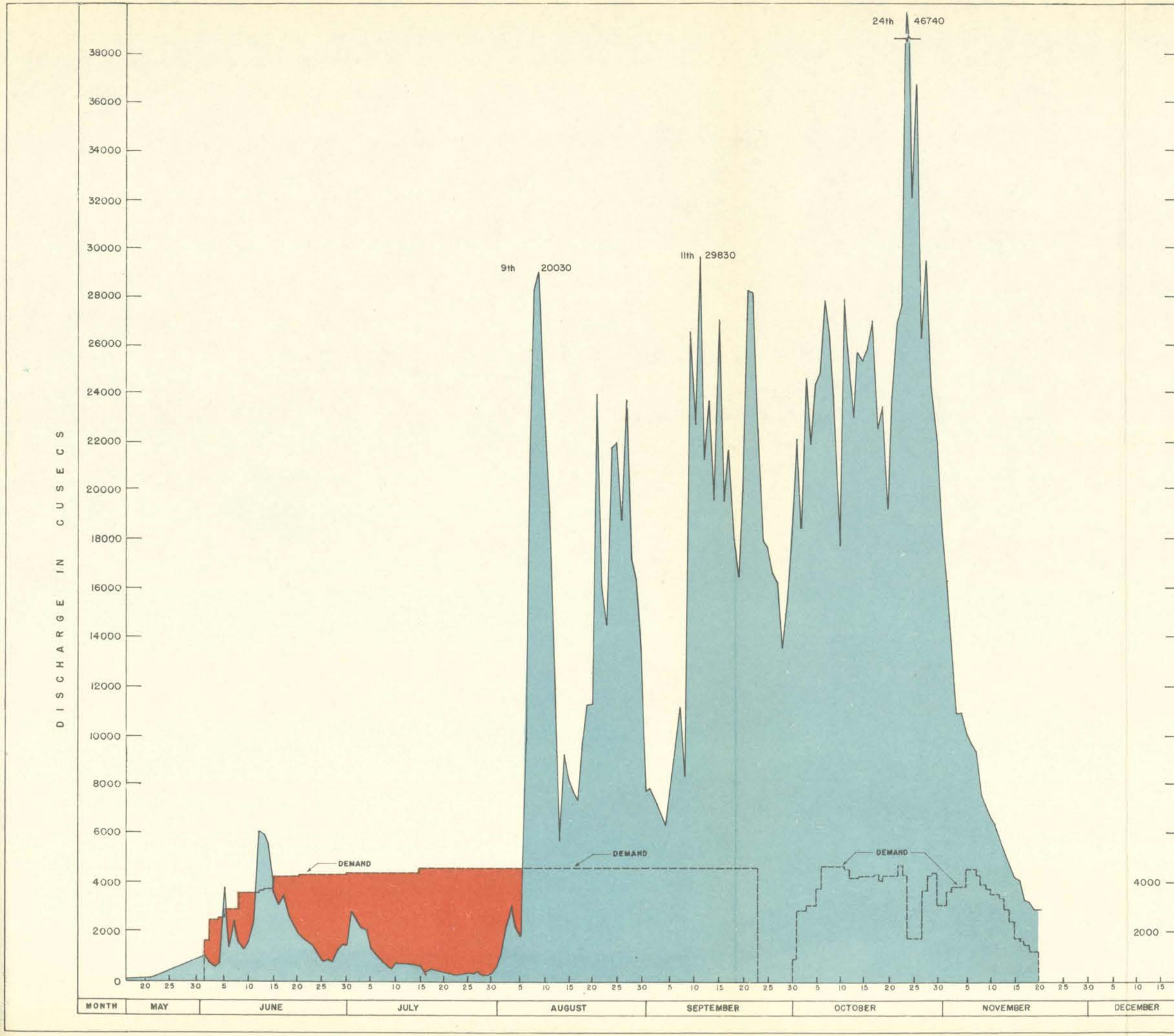
MU RIVER IRRIGATION PROJECT

THIESSEN MAP

DRAINAGE BASIN

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK. RANGOON.

DR BY: E.J.P. DATE PLATE NO. 16
CK BY: A.R.R. MAY 53.



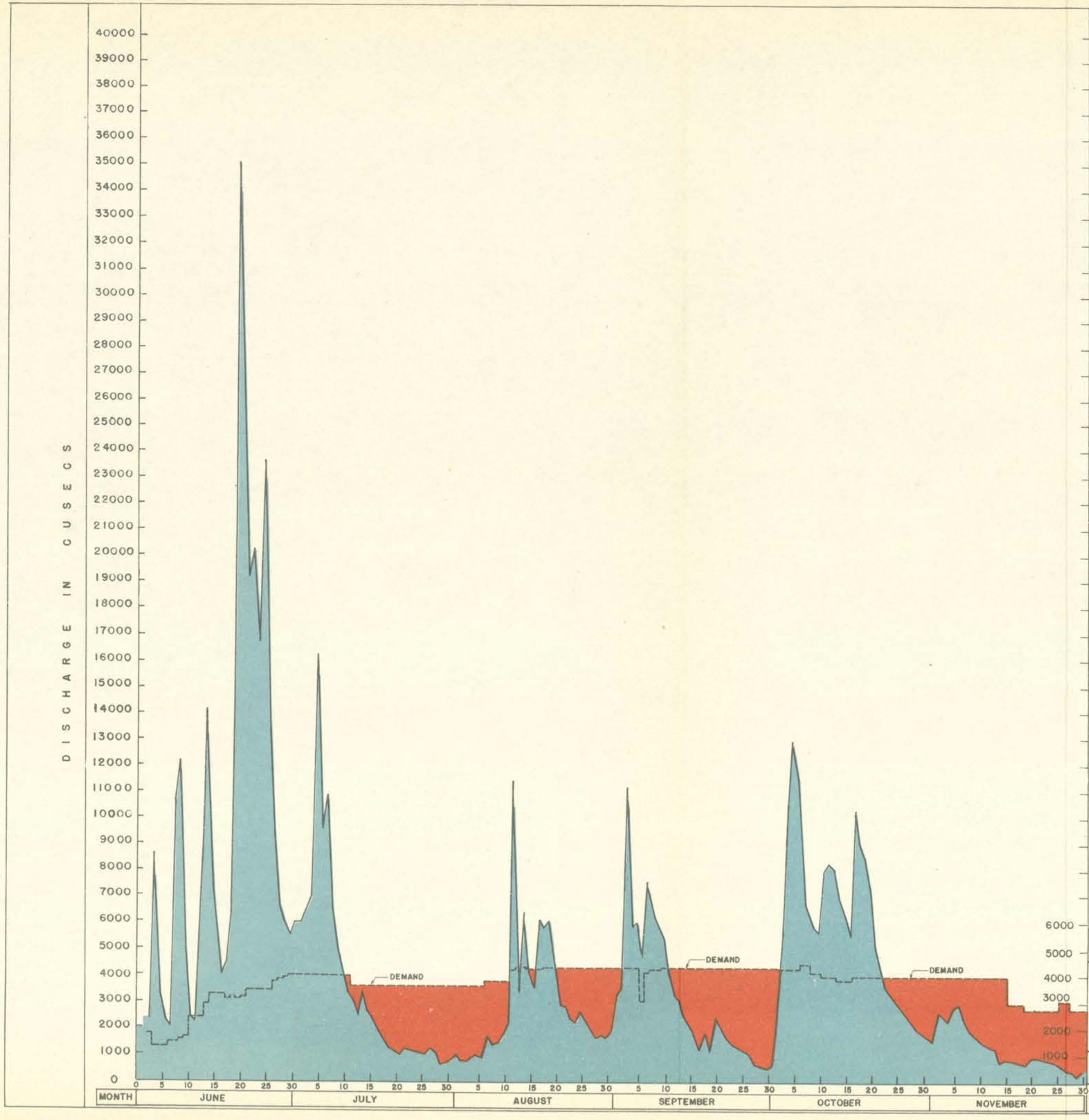
MINISTRY OF NATIONAL PLANNING

MU RIVER IRRIGATION PROJECT

DAILY HYDROGRAPH OF MU RIVER AT KABO 1947

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON

DR. BY E.J.P. DATE PLATE
CK. BY A.R.R. JULY 53 NO. **17**



MINISTRY OF NATIONAL PLANNING

MU RIVER IRRIGATION PROJECT

DAILY HYDROGRAPH OF MU RIVER AT KABO 1951

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON

DR. BY E.J.P. DATE PLATE
CK. BY A.R.R. JULY 53 NO. **18**

Field surveys at the Sinthe Chaung, Paunglaung River, Thitson Chaung, Yezin Chaung, Kyeni tank and Kandaw Village dam sites, and limited data on Thongwa Island including stream gauge heights at various stations around the Island. The field surveys are reservoir topography at Yezin Chaung, Paunglaung River, Kyeni tank and Kandaw Village sites and centerline profiles on Sinthe Chaung and Thitson Chaung dam sites.

Working statistics and reports of the existing irrigation system in Burma, in which acreages commanded, acreage irrigated annually, amount of water used and design features are recorded, were used extensively.

Five years of flow records on the Mu River and one year (1952–53) flow records on the Yezin Chaung and Paunglaung River.

Aerial photos at scale of 1 in. = 2,000 ft. on the Kandaw Village, Yamethin irrigation and Mu River irrigation project areas were available at the close of the planning and were used for cursory review and inspection.

Meteorology and hydrology data from the Meteorological Department.

Field reconnaissance trips were made to the areas under the Yamethin District irrigation project, Mu River irrigation project, Kandaw Village irrigation project, Loikaw Area irrigation project, Pakokku pump irrigation from wells, Buthidaung Area irrigation development, and a portion of Thongwa Island and the location of Meiktila Lake. Dam sites were inspected on the Sinthe and Yezin Chaungs, Paunglaung River, the Mu River at Kabo and Kandaw Village. The Shwebo, Ye-U and Old Mu Canals were inspected in operation. Farm practices were viewed and much useful data and knowledge were gained from conversations with local officials and their assistants.

(3) Preliminary Designs

All of the structures have been standardized as much as possible for all the projects. Each development location, however, has special features related to the particular conditions found at the site or suggested by previous reports or descriptions of the area. All details of design were assumed in accordance with recognized good engineering and construction practice. The cost estimating and project layouts are on this basis, and any details shown are suggestive only. All structure and canal locations will require field surveys and complete investigations of the site before the preparation of design plans.

All dams except as otherwise noted are compacted earth fill of selected material. It has been assumed that the initial construction will be at the abutments with the central closure made during the following "dry season." A temporary diversion dam upstream of the main dam will divert the stream flow through a conduit under the embankment. The conduits will remain in place after construction for incorporation in the outlet structure.

The spillway structures are all of the reinforced concrete chute type, located either at a natural saddle from the reservoir area or in a cut constructed at one of the abutments of the dam. Except at the locations where log sluicing is to be provided or the spillway is gate controlled, the sills are at the same elevation as the normal water surface (NWS) of the reservoir. Additional height is provided on the dam to accommodate the water depth over the spillway sill for the discharge capacity required at each location.

Irrigation canal headgate structures are used for the release of water to the canals only where the water level at the supply is nearly constant. Outlet structures for release of water to canals from reservoirs are conduits through the dam embankment near the stream bed elevation with gates controlled in a tower rising from the conduit invert to the top of the dam. It has been assumed that the conduits will be installed in an excavated trench which will be back filled with compacted layers of earth fill similar to the dam embankment. The outlet conduit of all tower outlet structures will be used initially for temporary diversion of stream flow during construction. The intake structures of the conduits will be provided with trash racks.

Several flumes are required as noted on the general plans for the specific projects. These are steel and similar to the Lennon type steel flume manufactured by the Armco Company. The sub-structure will be local timber.

Culverts and siphon culverts are planned at all highway, railroad, secondary road and stream crossings. They may be either reinforced concrete precast conduits, steel conduits, or formed and poured box type culverts.

The pumps at all installations are turbine type, designed to meet requirements of the particular location.

Canals, canal structures and outlet works are designed to deliver one foot of water per acre to the land in any single month operating continuously on an average of 20 hours per day, with an increase in capacity of 40% to cover all losses. The maximum water requirement per one month of the total for a crop period is one foot. This was determined from detailed studies made for the Yamethin District irrigation project on soils and crops. Canal velocities were established at 1·0 second foot minimum and 2·5 second feet maximum. $1\frac{1}{2}$:1 side slopes were assumed for all earth canals except for spillways which were assumed as 1:1.

c. Agriculture

An agricultural program planned for maximum benefits is essential under an irrigation development program to justify the high capital expenditures. The program will include many details related to full use of the land potential. It will utilize all the basic agricultural resources such as climate, soil, topography and water and the human element engaged in the various agricultural pursuits.

The present land use should be considered in relation to the improvements that may be possible because of the project. This will include particular techniques, labor and size of holdings. To make the necessary studies, production statistics must be available. General soil information was obtained from the limited agricultural literature available in Burma. Settlement records provide general information on crops and soils. "An Economic Classification of Land in Burma" by J. T. Sanders and U Ba Tin provides information of crops and yields for the five-year period ending June 1940 and helps to determine relative productivity of the areas.

Increases of agricultural production under irrigation projects will be possible not only from irrigation but also from intensive cultivation and the use of fertilizer, farm mechanization, improved farm implements and simple techniques (Chapter VIII). The provision of irrigation will result in increases in production by addition to the cultivated acreage of lands now left fallow or abandoned because of crop failures, and by double cropping as recognized under intensified agriculture.

It may be necessary to adopt special procedures to inform and educate the farmer, not only in improved cultivation techniques but also in the proper use of irrigation water. This can be done by establishing demonstration farms for the purposes of demonstrating production potential, methods and costs, and of providing research and training.

Classification of soils is essential in the establishment of an agricultural program (Chapter VIII). Classification is based on the soil profile, surface texture, slope and other characteristics. This information applied to known areas is the basic information on which the crop rotation program is planned for maximum benefits. A realization of the full farm land potential should be the ultimate goal under any project, and this can be achieved only by modern farming and a two-crop-per-year program.

In the studies to determine the possible benefits from each of the project developments, three classifications of cultivation methods as described in detail in Chapter VIII of this report were considered. These are as follows:

(1) Present methods, referring to present operational methods used in Burma.

(2) Present methods with irrigation, referring to present operational methods in Burma supplemented by improvements brought about by irrigation under the project.

(3) Modern methods with irrigation, referring to operational methods in conjunction with mechanization use known to be applicable to particular farm operations.

It is realized that cultivation will continue by present methods over most of the project areas for many years but considerable benefits will result in the proper use of sufficient irrigation provided by the project. Additional benefits derived from modern methods will depend on the rate at which they are accepted.

B. SPECIFIC PROJECTS

Those projects scheduled for "Early Implementation" under the future irrigation development program have been studied in detail, and field surveys were made where security permitted.

The source of the water supply and its use distribution is shown in Table IX–7 for the Mu River irrigation project; Table IX–11 (*see p.* 220) for the Yamethin District irrigation project; and Table IX–17 (*see p.* 236) for the Kandaw Village and Loikaw Area irrigation projects. These tables list for each project natural water resources to be developed for the irrigation water supply, the distribution of the developed supply, and the land to be served under each developed source.

Not all of the gross acreage listed in column 12 is suitable for irrigation, because of topographic features such as roughness of terrain, high areas and streams, and the villages and roads. Column 13 is a percentage of the gross, ranging from 70% to 90% representing the acreage to be irrigated and the basis for the water distribution. This percentage estimate of land suitable for irrigation is based on field inspection and map study. Column 14 is the land that is estimated as requiring irrigation under a second crop during the dry season. This is assumed at 75% of the land listed in column 13. The balance of the land cultivated in the second crop season is assumed as a non-irrigated crop. The water distribution is made on the basis of one foot per acre for supplement during the rainy season crop period on all the acreage listed under column 13, and the balance of the available supply, up to a maximum of three feet per acre, for the second crop acreage listed under column 14. Water requirement studies based on soil analysis and crop rotation plans for the Yamethin District irrigation project area have

TABLE IX – 7

MU RIVER IRRIGATION PROJECT

WATER SUPPLY AND USE DISTRIBUTION

1	2	3	4	5*	6	7	8	9	10
Source	Drainage Basin				Reservoir Storage (acre feet)				
	Area (sq. mi.)	Annual Ave. Rain (inches)	Est. Ave. Runoff (per cent)	Est. Ave. Yield (acre feet)	Use Provision	Capacity	Evaporation Loss	Dead Storage	Net Available for Irrig.
Mu River	3470	59·11	30	3,290,000	Reservoir	3,200,000	380,000	50,000	2,860,000

11	12	13	14	15	16	17	18
Location : Refer to General Plan	Land to be Served			Water Distribution (acre feet)			Remarks
	Gross Acres	Net Acres Irrigated	Net Acres 2nd Crop	1st Crop Supplement	2nd Crop Total Irrig.	Total	
Old Mu Canal	85,500	68,700	51,500	68,700	154,500	223,200	Existing Rehabilitated
New Mu Canal	66,331	52,800	39,500	52,800	118,500	171,300	
Shwebo Canal	264,129	211,500	158,500	211,500	475,500	687,000	Existing
Ye-U Canal	145,482	116,500	87,500	116,500	262,500	379,000	Existing
West Side Canal	228,000	182,500	137,000	182,500	411,000	593,500	
Monywa District and West Branch	142,208	114,000	85,500	114,000	256,500	370,500	
East Branch	169,200	118,500	89,000	118,500	267,000	385,500	
Total	1,100,850	864,500	648,500	864,500	1,945,500	2,810,000	
Chindwin River							
Canal P.1	137,600	103,000	77,200	103,000	231,600	334,600	Chindwin Pump P.1
Canal P.2	28,800	21,600	16,200	21,600	48,600	70,200	,, ,, P.2
Total	166,400	124,600	93,400	124,600	280,200	404,800	
Irrawaddy River							
Canal P.1W and P.1E	47,100	37,700	28,300	37,700	84,900	122,600	Irrawaddy Pump P.1
Canal P.2	12,800	10,300	7,700	10,300	23,100	33,400	,, ,, P.2
Canal P.3	20,500	16,400	12,300	16,400	36,900	53,300	,, ,, P.3
Canal P.4	6,400	5,100	3,800	5,100	11,400	16,500	,, ,, P.4
Canal P.5	16,500	12,400	9,300	12,400	27,900	40,300	,, ,, P.5
Canal P.6	19,200	14,400	10,800	14,400	32,400	46,800	,, ,, P.6
Canal P.7 (Seikpyu)	19,250	13,500	10,100	13,500	30,300	43,800	,, ,, P.7
Total	141,750	109,800	82,300	109,800	246,900	356,700	

*The yield of Mu Tributaries between Storage Reservoir and Kabo Diversion is not considered.

established this average distribution as sufficient to cover the crop demand and all losses from the reservoir to the growing plant.

The water supply is based on drainage basin yields with average rainfall. Should there be years of rainfall below this average, adjustments will be required in the acreage served or the crop plan, so that the total water requirements will equal the supply. The estimate of the runoff is conservative because the rainfall is based on valley records rather than the higher rainfall in the mountainous areas of the drainage basins. The flexibility of the water distribution as planned justifies the water use.

The estimated capital cost, annual charges, and benefits for all but the last four Far Future projects, are shown in Table IX–19 Part C of this report (*see p.* 242).

1. MU RIVER IRRIGATION PROJECT

The over-all development of the Mu River irrigation project is shown on the General Plan Plates 11 to 14a inclusive. This plan shows the dam and reservoir locations at Wetto and Thapanseik, the canal locations and areas in acres served under each canal division, the existing canal systems from the Kabo headworks, areas for pump irrigation and the locations of the pumps on the Chindwin and Irrawaddy Rivers, and the general topography and other physical features of the entire area to be developed under the project. Plate 14a is for the Irrawaddy pump P.7 near Seikpyu only.

a. Present Economy

The area that will receive agriculture production benefits through gravity irrigation from the project is in Shwebo, Sagaing and Lower Chindwin Districts. The areas under the river pump installations are in Sagaing, Lower Chindwin, Myingyan, Minbu and Pakokku Districts. The project development by districts with acreage and estimated population is shown in Table IX–8.

The project area is principally agricultural; most of the population is engaged in farming or dependent on agricultural production. The population density is low, that of Sagaing and Myingyan Districts being the highest. The only towns of any size in the project area are Shwebo in Shwebo District with a population of 17,827, and Monywa with a population of 26,279 on the border of the area under the Monywa Distributary and West Branch and Chindwin pump P.1. Pakokku town with a population of 29,824 is not in the project area but will benefit from Chindwin pump P.2 installation in addition to the improved economic situation brought about by the over-all development on the Chindwin and Irrawaddy Rivers. All industries are related to agricultural produce except for the silver craft, weaving and fishing.

Complete agricultural development under the project program will require changes in cultivation and labor procedures. The low population of the area, indicated in Table IX–8, will make possible the resettlement of farmers from land areas with poor production. The rainfall, 25 to 40 inches over all of the project area, is very low, and, even with present irrigation, moisture is often deficient at the beginning of the crop season. Plates 17 and 18, showing stream flow on the Mu River, indicate the uneven distribution and deficiency of rainfall as represented by stream flow and demand curves.

TABLE IX – 8

MU RIVER IRRIGATION PROJECT
PROJECT DEVELOPMENT DATA

Project Unit	*Area under Irrigation*		
	District	*Acreage*	*Estimated Population*
Old Mu Canal	Shwebo	85,500	38,400
New Mu Branch	”	66,340	30,000
Shwebo Canal	”	264,130	119,000
Ye-U Canal	”	145,480	65,500
West Side Main Canal	”	228,000	102,500
East Branch Canal	”	56,400	25,400
” ” ”	Lower Chindwin	56,400	19,200
” ” ”	Sagaing	56,400	21,400
Monywa Distributary / West Branch Canal	Lower Chindwin	142,200	48,300
Irrawaddy Pump P.1	Sagaing	47,100	16,000
” ” P.2	”	12,800	4,400
” ” P.3	”	20,500	7,000
” ” P.4	”	6,400	2,200
” ” P.5	Myingyan	16,500	6,500
” ” P.6	”	19,200	7,500
” ” P.7	Minbu	19,250	9,400
Chindwin Pump P.1	Lower Chindwin	23,000	7,800
” ” P.1	Sagaing	114,600	43,500
” ” P.2	Pakokku	28,800	12,700
Total Under Gravity System		1,100,850	469,700
Total Under Pump Systems		308,150	117,000

Several thousand acres of arable land not under cultivation are known to exist in all the districts in which the project is located. The acreage left fallow, replanted, and abandoned each year because of moisture deficiency is very high. Table IX–9 shows principal crops and acreage for each, per cent of total cultivated land sown, fallowed, replanted, or replaced and abandoned, and gross production income per acre for each district. These data are based on prewar production records converted to present prices. The gross average production income per acre sown is very low. The acreage cultivated per family must be higher than in other areas to provide a living income.

TABLE IX – 9

MU RIVER IRRIGATION PROJECT CULTIVATION AND PRODUCTION DATA

(thousand acres sown over entire district)

District	*Shwebo*	*Sagaing*	*Lower Chindwin*	*Myingyan*	*Pakokku*	*Minbu*
Product						
Rice	531·0	40·6	73·9	39·7	79·0	139·5
Groundnuts	31·8	32·7	34·6	234·8	192·3	—
Pulses	62·6	187·1	170·0	165·5	23·1	56·9
Sesamum	49·6	86·5	148·7	163·4	46·9	54·4
Millet	0·5	31·9	108·8	108·7	102·9	31·5
Maize	1·0	1·0	5·6	6·0	30·2	18·1
Cotton	7·2	114·6	63·2	65·0	—	1·2
Tobacco	0·7	6·4	2·3	0·9	10·3	2·7
Fruit, veg., etc.	9·3	5·2	6·5	8·3	2·0	3·2
Per cent						
Sown	69	73	67	66	71	63
Fallow	31	27	33	34	29	37
Replanted	5	10	13	14	10	12
Abandoned	10	24	12	8	16	8
Gross Income						
K/Acre	42·22	28·30	28·88	27·27	37·22	48·54

The average gross production income per acre for all of Burma is K71·03. Even with this low average, the divisions in which the project is located are much lower.

The project will bring into cultivation some of the arable land not now cultivated, eliminate the necessity for the fallow acreage, provide a guaranteed water supply when needed to eliminate the sowed acres which are abandoned, and provide uniform water applications, thus increasing the production per acre as well as the over-all production from increased acreage and from second cropping during the dry season.

b. Geology

The Mu River irrigation project is located entirely within the physical division of Burma known as the Central Belt, lying between the Shan Plateau division on the east and the Fold Mountain Belt division on the west. These divisions run from north to south through the entire length of Burma.

The Central Belt was the last of all the divisions to become dry land, being previously occupied by the sea and called the "Burmese Gulf." After silting-up, the site of the gulf was occupied by the lower course of the Irrawaddy River. The Central Belt is built up entirely of tertiary river-borne sediments brought down from the north by the ancestors of the present Irrawaddy and Chindwin Rivers. Marine fossils have been found as far north as the latitude of Monywa in the Shwebo district, indicating that the mouth of the river cannot have been far south of that locality.

The Mu River, flowing from north to south through the center of the project area, is one of the main tributaries of the upper Irrawaddy. It flows through an alluvium-covered basin following the course determined by the direction of the mountain trend. The river channel is wide and shallow after emerging on to the plain area from the low hills near Wetto. The deposits are principally fine sand and mud.

Two geological soil formations make up most of the valley composition. They are known as the Irrawaddian and Alluvium Series and overlie the older formation of the Pegu Series. Plate 15 is the Geology Map for the Mu irrigation project area.

c. Local Natural Conditions

(1) Meteorology

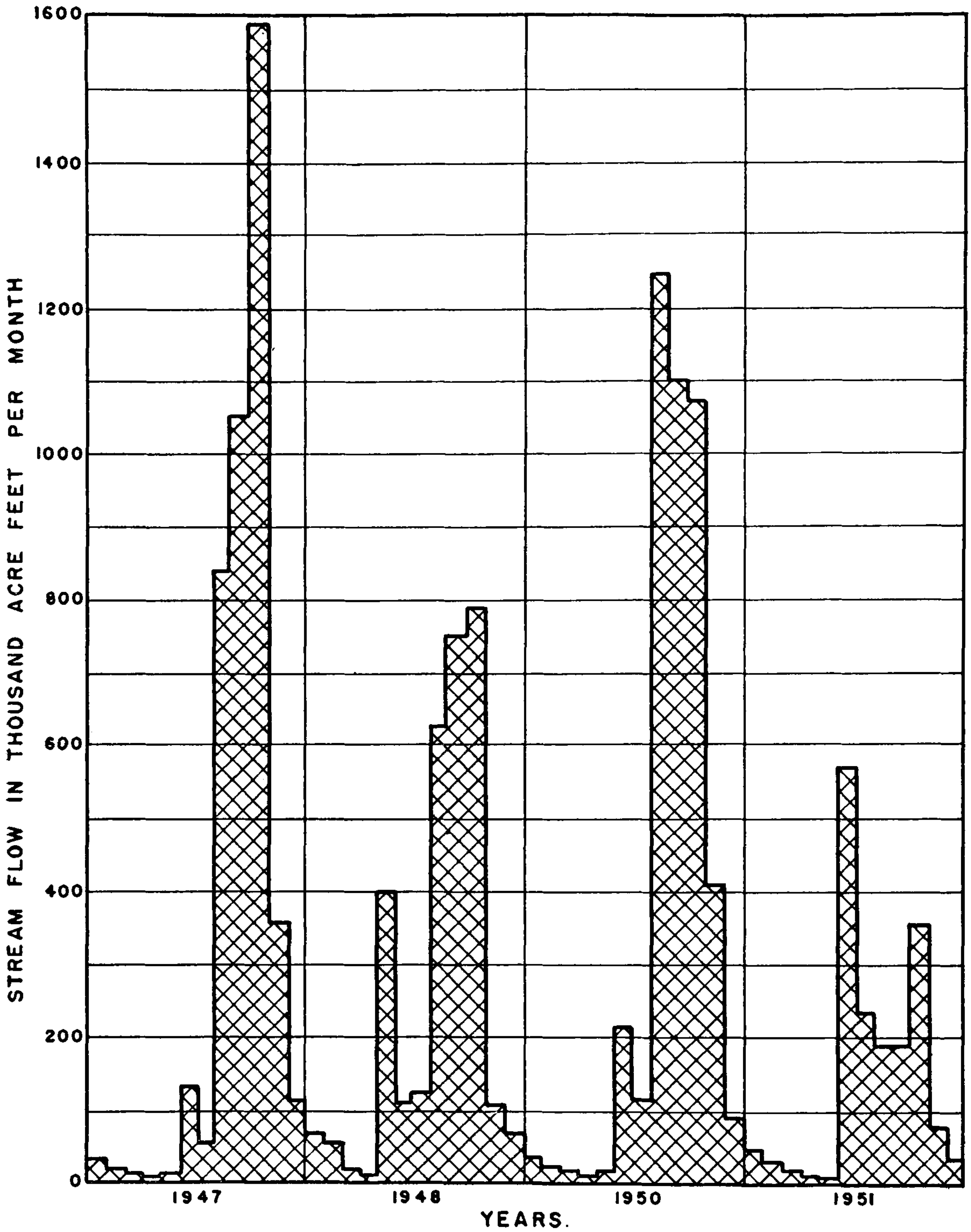
The southwest monsoon carries a considerable amount of humidity from the Bay of Bengal, resulting in the wet weather from mid-May to mid-October. These winds lose most of their moisture as they cross the Arakan and Pegu Yomas. This factor produces the Dry Zone in Central Burma, in which lies the Mu River irrigation project. However, about one third of the drainage area for the Mu River is within the Northern Hills region which has a higher rainfall than the Dry Zone.

The southwest monsoon current, after crossing the Arakan and Pegu Yomas, strikes the Shan Hills and changes its direction to southeast, accounting for the southeast current in the project area. About the beginning of November the monsoon moves from southwest to northwest. This movement of the lower currents of the southwest monsoon from Central Burma is followed by the dry northerly land winds which continue until the southwest monsoon returns with its moisture from the ocean.

The only temperature station in the project area is at Monywa. The records cover a period of 47 years. The monthly range between maximum and minimum temperatures is a maximum of 29·9° F. in March and a minimum of 14·1° F. in August. The mean monthly range for the year is 20·8° F. The mean daily minimum of 57·1° F. is in January and the maximum of 101·8° F. is in April. Since evaporation is definitely influenced by temperature ranges, the characteristics of this cycle indicate the rate of evaporation.

The normal relative humidity data at the Monywa station cover a period from 1901 to 1940, with recordings at 9.00 and 18.00 BST. The maximum relative humidity occurs at the 9.00 recording with a mean annual over the 41 years of 72%; and the minimum relative humidity occurs at the 18.00 recording with a mean annual over the 41 years of 59%. The minimum relative humidity occurs during March which implies that the maximum of evaporation during March agrees with the maximum temperature occurring in April.

Since moisture transpiration is dependent on air movement, precipitation and reservoir evaporation are affected by the winds. The maximum mean



RUNOFF FACTOR OF MU DRAINAGE BASIN

Drainage Area = 4870 Sq..Mi.

YEAR	WEIGHTED RAINFALL INCHES	MILLION ACRE FEET		RUNOFF PERCENT
		TOTAL FLOW	STREAM FLOW	
1947	40·00	10·4	4·18	40·2
1948	46·20	12·0	3·10	25·8
1950	38·80	10·1	4·34	42·9
1951	38·20	9·9	1·75	17·7

MINISTRY OF NATIONAL PLANNING

MU RIVER
IRRIGATION PROJECT

HYDROGRAPH OF MU RIVER AT KABO WEIR

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON

DR. BY. E.J.P DATE
CK. BY. ARR JUNE, 53.

PLATE NO. 19

monthly wind speed record at Monywa for an average of 24 hours is 3·9 miles per hour in July, for a 38-year period. Rainfall data of record suggest that the maximum rainfall occurs around August. The maximum wind speed for a shorter period, which is much higher than the mean wind speed, is estimated to be about 20 miles per hour.

Measured evaporation data are not available in Burma, but with the natural weather conditions known, the amount was computed by the use of Meyer's formula which has been proven by comparison with measured records as giving applicable results. The computed evaporation for the project area gives a total for the year of 51·8 inches with a maximum in April of 9·24 inches and a minimum in December of 1·75 inches. This agrees very closely with the 48 inches suggested by various writers for reservoir evaporation in the Dry Zone of Burma and with actual measurements recorded in India.

(2) Hydrology

There is a definite lack of these data sufficient in detail, period length, and at the proper location, to make correct evaluations and conclusions as required. The rainfall data available for the project area are from 12 rain-gauge stations of which but six are within the drainage basin of the Mu River. The six stations within the basin control about four-fifths of the total drainage area. These data may not fully represent the exact precipitation conditions within the drainage basin because of the station locations.

The cyclic variation in increase and decrease in rainfall was determined by plotting progressive five-year means curves for all but three of the stations, from which peak rainfall and corresponding intervening periods were tabulated. These data suggest that the rainfall indicated in the drainage basin of the project area could be classified under a five-year cycle.

A map of the project area showing the drainage basins, the Theissen polygons, the rain-gauge stations, and the tabulations of the values for extreme maximum and minimum annual rainfall computed by the Theissen method, and the mean annual rainfall computed by both methods is shown on Plate 16. Maximum 24-hour rainfall for each month at Mandalay and Monywa, for periods of 50 and 47 years respectively, show that rainfall equal or exceeding 7·52 inches could occur once in 50 years at Mandalay and 7·66 inches once in 47 years at Monywa. Since neither of these stations is in the drainage basin above the storage reservoir for this project, the amounts would not be representative of maximum rainfall in the drainage basin but could be used only as a basis for calculations.

Stream-flow data for the Mu River have been recorded at Kabo Weir which is about 38 miles downstream from the Mu River dam site. Records for the years 1946 and 1951 have been plotted and are shown on Plates 17 and 18. These indicate two extreme conditions; one of low flows in the early part of the rainy season and the other of low flows in the latter part of the rainy season. Plate 19 shows a monthly hydrograph of the flow at Kabo Weir for the years 1947, 1948, 1950 and 1951. Each of the records indicates high flows at times when the demand is low, and low flows when the irrigation demand is high.

It is impossible to establish an exact runoff factor from the information at hand because the rainfall data are not available at any of the stations except Kabo for the years for which flow data have been recorded. The runoff factors shown in the table on Plate 19 were computed by supplying the missing rainfall information from weighted rainfall over the basin calculated by the Theissen method based on records at Kabo station. Information on runoff factors corresponding to stream flow of shorter duration is also not available. The runoff factor used for yield estimates is the average for those shown on Plate 19.

The peak flow of record measured at Kabo Weir in the Mu River is 192,000 c.f.s. in the year 1928. Others recorded since 1947 range from 25,970 to 46,740 c.f.s. These records should be quite accurate since the gauging is done on the actual flow at the weir location. Peak flow at the storage reservoir should be lower because of the decrease in drainage area.

d. The Land

The land referred to is that portion of the project area which is to be irrigated under the developed project. Field data for the classification of soils were not obtained because of the insecurity in the area and lack of personnel and time for the necessary laboratory procedure. The background to cultivation studies and general soil information was obtained in the limited agricultural literature on the project area.

Information obtained from settlement reports was compiled as shown in Table IX–10 (*see next page*) for each of the districts except Sagaing, and referenced to location shown on General Soils Data Map, Plate 20. This information, in conjunction with aerial photo studies, is a general basis from which to start a soils classification program for the area. It will also be indicative of the improved cultivation practices that may be introduced to increase production.

General assumptions on production and benefits were based on detailed soil, crop, and cultivation studies made for the Yamethin District irrigation project.

TABLE IX – 10

MU RIVER IRRIGATION PROJECT

GENERAL INFORMATION ON SOILS

Tract	*District*	*General Information (crops are listed in order of relative importance)*
1	Lower Chindwin	No information.
2	„ „	Inundated silt soil; rich.
3	„ „	Red soil; eastern half and southern tongue poor. Silted soil along R.R. line the best. Millet, gram, groundnuts, sesamum and cotton grown.
4	„ „	Principally red soil; rocky and infertile in east.
5	„ „	Clay soil; best soil is along Thate Chaung. Mostly gram grown.
6	„ „	Principally red soil; mostly poor and sandy. Millet, sesamum and groundnuts grown. Along river bank, good soil with tobacco and pulses grown.
7	„ „	Hilly; apparently not suitable for agriculture.
8	„ „	Cotton tract. Pulses on border of river. Black clays occur at intervals. Upland Yas grow cotton, sesamum and beans.
9	„ „	Infertile hard sandy soil predominates with good water-retaining capacity. Toward the south, stretches of clay and bad sand occur. Some alluvial loam near S.E. corner.
10	„ „	Red sand; infertile. No silt or black soil. Large tracts of sandy soil of poorest type. Millet and sesamum with some rice in valleys.
7*a*	Shwebo	Flat, fine sandy loam; water is all that is required to produce well.
11	„	Silt and fine sand. Alluvial sands near river.
12	„	No information.
13	„	Essentially fertile but requires lots of water.
14	„	Clay soil; average to poor except where silt occurs.
15	„	Not in area.
16	„	Not in area.
17	„	Sandy soil and mixed white clay; not very fertile. Deep loam at Indaing, Kwezwe and Kayangyan; superior.
18	„	Prevailing soil is infertile. Better soil in east part of area but limited in area.
19	„	Prevailing soil yellow loam with silt. Sand near streams. Proportion of good soils is higher than adjoining tracts.
20	„	Upland soils stiff red loam with fine sand and some gravel. Black soil with sand or silt on paddy lands.
21	„	East part is hard sandy soil; deeper and more fertile loams in west and south. Whole tract suited for paddy.
24	„	Narrow shelf of alluvial land along river and islands.
25	„	Western portion is level paddy lands.
26	„	East part is stiff red loam; west soils heavier and darker.
27	„	Red sandy loam and loose yellow sand.
28	„	Black cotton soil on lowlands; upland, red and gravely.
29	„	Rich dark alluvial loam; most fertile in district. Broken and difficult to irrigate.
30	„	Clay soil; varying somewhat in quality.
31	„	Clay soil.
32	„	Clay loam with large particles.
33	„	Eastern boundary an alluvial strip; other is poor clay with limestone nodules in south.
34	„	Fertile alluvial soil.
35	„	Clay with sand and silt; steeply sloped. Heavy soils in lowland but slopes too steep for irrigation.
A	Myingyan	Silt and black loam, small amount of red clay. Millet, sesamum, legumes, groundnuts, and rice are grown.
B	Pakokku	Valley clays, silts and sands; fertile. Paddy, legumes, gram, sesamum, groundnuts, others are grown.
C	Minbu (Seikpyu)	Alluvial clays, silts, and sands; light. Maize.

e. Project Plan

The details shown on the General Plan Plates 11 to 14a inclusive are general; the planning prepared principally by the use of one inch to the mile scale maps with contours at 50-foot intervals, from field reconnaissance, and one-inch to 2,000-feet scale aerial photos. Designs and operation data are available on the existing canals but neither field surveys nor dam foundation investigations have been made on the proposed new units of the development. These will be necessary before contract design plans are prepared.

The water supply and use distribution data shown on Table IX–7 are the basis on which the project has been planned. All the estimated available water supply has been distributed to the land in the proportion required for a two-crop-per-year farm program. Brief details of the complete project development are these:

(1) Storage Reservoir and Dam

The Mu River, carrying water from a drainage basin of 4,500 square miles in the northern hills and valleys of Burma, flows south through a vast agricultural area to discharge approximately 5,800,000 acre feet annually into the Irrawaddy River. The flow at the Kabo diversion works, about 69 miles upstream from the river's mouth, averages about 4,000,000 acre feet annually, 500,000 of which is diverted for irrigation under the present Shwebo and Ye-U canal systems. Plates 17 and 18 show the waste flow and the demand periods when the excess could have been used if available. The dam planned for construction under this project on the Mu River near Thapanseik village, approximately 29 miles north of Kabo, will make possible the storage and control of all the yield from the drainage basin above that point.

The storage reservoir dam will be of compacted, selected earth fill, back of which the stored water will rise to a maximum normal elevation of 550 feet above mean sea level. The lake area thus formed will be about 130,000 acres. The villages and farmers within the reservoir area will be moved to higher ground or resettled within the project irrigation area. The improved land and agricultural facilities available to them because of the project will improve their economic and social conditions far beyond comparison with any loss.

A concrete spillway structure is planned at a natural saddle east of the left abutment of the dam and a concrete tower control outlet structure will make all releases to the river for diversions downstream. Provision will also be made in the outlet works structure design for future hydroelectric installations. The nature of the valley area in which the reservoir is formed makes possible large storage with a dam less than 90 feet high. The dam is the key to the whole project, and would immediately benefit the acreage under the present systems of the Shwebo, Ye-U and Old Mu Canals. The Mu River reservoir and storage dam are the first step in the project development. The present Ye-U and Shwebo canal systems command a gross area of approximately 412,000 acres, 265,000 acres of which now receive supplemental irrigation for the rainy season crop. The entire acreage under the system will be guaranteed a supply of water, not only for the supplement during the rainy season but the total moisture requirement for a dry season crop as well.

(2) Diversion Dam and Old Mu Canal

The Old Mu Canal was discussed under Section A–2–b as one of the existing works. This canal will be rehabilitated from a point where it crosses the railroad southerly to Shwebo, including the old Mahananda tank near Shwebo for the town water supply. The upper end of the canal will be relocated at a higher elevation for service to a new canal above the present Old Mu location.

Originally, the old Mu Canal was supplied by a diversion works at Wetto, about six miles below the proposed reservoir site. The terrain appears to be too difficult for a canal location from the storage reservoir, therefore a new diversion dam is planned for the old site. The dam will impound water at elevation 500 feet, the supply behind the dam being held constant by releases from the storage above. Canals taking off from the diversion works will start with a water surface at about this elevation. Structures for canal service on either side of the river, releases into the river for Kabo diversion, and spillway for flood flows will be included in the diversion works. Facilities for future hydroelectric installations will also be included with this construction.

The construction of the diversion works and the Old Mu Canal system are the second step in the project development. Neither field surveys nor foundation investigations have been made at this time. These will be necessary for preparation of contract design plans.

(3) West Side Canal System

The west side canal system starts on the west side of the river at the Wetto diversion works with 8,760 c.f.s. for service to 540,000 gross acres. The main canal is located approximately on the 500-foot contour to serve the land east therefrom to the Mu River. Dividing into two branches at a point about 30 miles due west of Shwebo, one branch crosses to the west to serve the Monywa area and the other branch continues southeasterly above the Ye-U Canal for additional land as far south as the Irrawaddy River.

Approximately five miles before dividing into two branches, the west side main canal drops into the Minkanbauk Chaung which flows easterly into the Mu River. The canal elevation maintained this far is not required for the lands under the east and west branches. An 80-foot drop is dissipated through a hydroelectric installation with the tailrace wasting to the river via the chaung or fed into the Ye-U Canal which crosses the chaung at this point or picked up by the west side canal at the lower elevation. The tailrace below the power house serves 311,500 gross acres, not including the 41,000 gross acres that could be picked up under the Ye-U Canal at this point. A regulating reservoir will be constructed on the Minkanbauk Chaung above the power house.

Cheap power can be generated at this power installation, and after the completion of the irrigation system from the tailrace south to the Irrawaddy River, the water will be used for irrigation after passing through the power house. The west side canal system is number three in the order of this project development. It may be divided in two parts, however, one the west side main canal including the power installation, and the other the canal system from the power house southward.

(4) Hydroelectric Power

The hydroelectric installations mentioned heretofore are discussed in more detail in Chapter XIX. The total Mu River irrigation project plan is predicated on agricultural development to two crops per year on the total area for use of the entire water supply of the river. This total development will take many years, during which time the water stored in the reservoir could be used for generation of power either at the dam site or at the west side canal site.

The dam for the storage reservoir can be economically justified for a two-crop-per-year program under the Ye-U and Shwebo Canals alone. This requires only 1,066,000 acre feet annually from the 2,800,000 net acre feet in the reservoir. The early hydroelectric potential of the project is very great under these conditions.

(5) Pump Irrigation

The Irrawaddy and Chindwin Rivers are a source of water throughout the year. Areas along their banks are suitable for cultivation on a two-crop-per-year program. Seven pump locations on the Irrawaddy River and two on the Chindwin are shown on the general plan. These installations are all at points topographically suited to support a canal location leading from the installation on the river bank. The installations and acreage commanded are shown in Table IX–7.

Pump No. 1 on the Chindwin River above Monywa may be considered a supplemental supply source after the west side canal system is completed. Although the connection of the west branch canal with the Chindwin Canal P.1 is not shown on the general plans, this will be made just above Kyehmon village. The total acreage under a combination of these two canal divisions is not shown in Table IX–7, but the over-all design is so planned that when the water supply is sufficient the entire area will be irrigated by gravity, and the pump will not be used.

Any one or all of the pump installations could be made at any time, using diesel power or electric power from a steam or diesel source. At such time as the hydroelectric power is available, the power units can be changed over. The pump installation on the Chindwin above Monywa will fit into such a schedule and make possible the irrigation of the area before a gravity canal system from the Mu River is constructed. The pump irrigation from the Chindwin and Irrawaddy Rivers is considered a part of the Mu River irrigation project because of the possibility of using electricity from the Mu River to drive the pumps. Some of the acreage under this pump irrigation was discussed originally in the Preliminary Report under the Pakokku pump irrigation project. The pump installation on the Irrawaddy River near Seikpyu is treated separately because of its isolated position in the project plan. Any one of the pump installations may be considered as a separate project.

(6) Alternative Plan

An alternative plan permits the elimination of the diversion dam at Wetto. This would necessitate the extension of both the west side main canal and the Old Mu Canal up to the storage reservoir site. Map studies indicate these would be very difficult locations and expensive to construct; however, the saving in cost by the elimination of the duplicate structures required in the two-dam plan may be more than the cost of the canals and canal structures on the relocation. Field surveys will be required before accurate cost estimates for the alternative plan can be made. This study should be made prior to the design and construction of the storage reservoir dam. Plans for field surveys and foundation investigations at the Thapanseik dam site are now being implemented.

2. YAMETHIN DISTRICT IRRIGATION PROJECT

The over-all development of the Yamethin District irrigation project is shown on the General Plan Plates 21 to 23 inclusive. These plates show reservoir locations, capacity at normal water level, water surface elevations at canal origin and other control points, areas in acres served under each canal division, areas for well irrigation, areas for pump irrigation from the Paunglaung River with suggested pump locations, the general topography and other physical features of the whole area. The source of the water supply and its use distribution is shown in Table IX–11 (*see next page*), a detailed explanation of which is found in the third paragraph of Section B.

a. Present Economy

The project area is essentially agricultural with over 50% of the population entirely dependent on farming. Rice is grown on 75% of the cultivated area. Other crops grown are sesamum, maize, pegyi, tobacco, pulses, sugar cane, groundnuts and vegetables. Paddy and timber are exported and cotton goods, kero-oil, cooking oil and salt and provision are imported. There is very little double cropping in the true sense of intensive agriculture. It is not an effective factor in crop production but is done principally to assure the cultivator some kind of a crop return. All records repeatedly state that the chief danger to the welfare of the area is the failure of early rains for the nurseries and initial crop growth, the failure of late rains for maturing, and the uneven distribution of the rainfall.

The agricultural worker is much better off than other workers. It is reported that the average income per agricultural household is approximately K850 per year and that of the non-agricultural household is approximately K510, based on prewar records converted to present prices. In addition to the income from agricultural employment or farm income, some of the workers supplement their income from other pursuits. The average household consists of three adults and two children. The population in the project area is estimated at 610,000 people; 31,180 of whom live in Toungoo, 11,167 in Yamethin and 22,025 in Pyinmana, the three large towns in the area.

Several thousand acres of arable land not under cultivation are known to exist in both districts in which the project is located. Most of the acreage under the project is presently under cultivation but with a very low production per acre. The acreage left fallow and abandoned because of moisture deficiency is very high. Based on prewar production records converted to present prices the gross production income per acre for the Yamethin District is approximately K59·82 and for the Toungoo District K97·16. The average for all of Burma is K71·03. The project will bring into cultivation some of the arable land not now cultivated, eliminate the necessity of the fallow acreage and provide a guaranteed supply of water when needed to eliminate the sowed acres which are abandoned, and thus increase the production per acre as well as the over-all production from increased acreage cultivated.

b. Geology

Two geological soil formations make up the valley composition. They are known as the Irrawaddian and Alluvium Series. The Irrawaddian Series are fluvial sands with fragmentary remains of terrestrial and aquatic vertebrates. The alluvium deposits, which cover about one half the surface area of the Sittang Valley, are partially of older alluvial clay deposits but principally of recent river alluvium. Fossils are not found in the alluvium, and its predominant color is usually a dull grey. Older alluvial clay underlies most of the Delta and lower portions of the valley.

The soil is in composition a very homogeneous, somewhat arenaceous clay of uniform yellowish color, in places assuming a more reddish color than usual, and under certain conditions of exposure and weathering, assuming an imperfect lateritic appearance superficially. It is indicated by a peculiar mottled appearance of the rock caused by the irregular manner in which the peroxide of iron occurs. The whole deposit is very homogeneous, a little more sandy in some places than in others, and with occasional layers of sand irregularly dispersed through it, the only recognizable band possessing a distinctive dark layer a few inches thick, but of wide distribution.

Along the banks of the rivers there occur extensive stretches of recent alluvium or alluvial clay. This consists of a mixture of sand and clay, and sometimes shows signs of stratification. A not uncommon form is an alteration of sand layers and clay lenticles, very similar in appearance to the commonest type of the Pegu beds.

Plate 24 is the Geological Map, covering all of the project area except the drainage basins of the water source streams.

c. Local Natural Conditions

(1) Meteorology

The upper part of the Yamethin District irrigation project area lies within the Dry Zone and the lower part of the area is in the Semi-dry Zone. The only temperature station within the project area is at Yamethin. The monthly range between maximum and minimum temperatures runs from a maximum range of 30·4° F. in February to a minimum range of 13·7° F. in August, with a mean monthly range of 20·9° F. Since evaporation is definitely influenced by the temperature range, the characteristics of the cycle indicate the rate of evaporation.

The normal relative humidity data at the Yamethin station cover the period from 1893 to 1940, with recordings at 9.00 and 18.00 hours BST. The maximum

TABLE

YAMETHIN DISTRICT

WATER SUPPLY AND

1	2	3	4	5	6	7	8	9	10
	Drainage Basin				*Reservoir Storage (acre feet)*				
Source	*Area (sq. mi.)*	*Average Annual Rain (inches)*	*Estimated Average Runoff (per cent)*	*Estimated Average Yield (acre feet)*	*Use Provision*	*Capacity*	*Evaporation Loss*	*Dead Storage*	*Net Available for Irrigation*
Thitson Chaung	119	32·6	30	62,100	Reservoir	66,000	6,000	—	56,100
Thitson Chaung	5	32·6	30	2,600	Diversion	1,600	1,000	—	1,600
Shweda Chaung	36	36·9	20	14,150	Reservoir & Diversion	13,500	5,000	—	9,150
Total				78,850	—	81,100	12,000	—	66,850
Myaungmadaw Canal	41	39·7	30	26,100	Kyeni Tank	18,500	7,500	—	18,600
Sinthe Chaung Upper	312	38·4	35	223,000	Reservoir	225,000	44,000	—	179,000
Lower	88	38·8	35	63,700	Reservoir	70,000	7,000	—	56,700
Total				312,800	—	313,500	58,500	—	254,300
Wells					Pumping				
Yezin Chaung	36	52·9	51	52,000	Reservoir	60,000	12,000	—	40,000
Total				52,000	—	60,000	12,000	—	40,000
Paunglaung River	1,741	50·4	50	2,340,000	Reservoir	280,000†			*
Subtotal									
					Pumping				‡
Subtotal									
Ngalaik Chaung	340	46·0	38	317,000	Reservoir	290,000	32,000	5,000	253,000
Total				317,000	—	290,000	32,000	5,000	253,000
Saing Chaung	145	68·0	40	210,000	Reservoir	240,000	25,000	100,000	115,000
Swa Chaung	421	71·3	40	638,000	Reservoir	400,000	40,000	50,000	310,000
Total				848,000	—	640,000	65,000	150,000	425,000

*Excess flow diverted through Supply Canal to Yezin Chaung
†Several dams are required for control of the total yield. Refer
‡Stream flow releases from reservoir. Present minimum flow

IX - 11

IRRIGATION PROJECT

USE DISTRIBUTION

11	12	13	14	15	16	17	18
	Land to be Served			*Water Distribution (acre feet)*			
Location : Refer to General Plan	*Gross Acres*	*Net Acres Irrigated*	*Net Acres Second Crop*	*First Crop Supplement*	*Second Crop Total Irrigated*	*Total*	*Remarks*
Teinnyetkon Canal	7,500	5,250	—	—	—	—	Yield may be diverted to existing tanks when in excess of storage facilities.
Thitson Canal	25,000	17,450	—	—	—	—	
	32,500	22,700	17,000	22,700	44,150	66,850	
Existing Canals North from Kyeni Tank; Sinthe-N Canal	88,100	66,000	49,500	—	—	—	Yield may be diverted to existing tanks or for initial flooding when in excess of storage facilities.
Sinthe-S Canal	22,600	15,820	11,800	—	—	—	
	110,700	81,820	61,300	81,820	172,480	254,300	
	73,500	51,500	38,500	51,500	77,000	128,500	
Yezin High Level Canal	3,500	1,750	—	1,750	—	1,750	
Yezin District No. 1	17,280	15,550	7,600	15,550	22,800	38,350	
	20,780	17,300	7,600	17,300	22,800	40,100	
Yezin District No. 1	6,000	—	4,050	—	12,150	12,150	
Yezin District No. 2	9,240	7,400	5,550	7,400	16,650	24,050	
Yezin Canal	14,930	12,000	9,000	12,000	27,000	39,000	
Supply Canal	5,300	4,000	3,000	4,000	9,000	13,000	
	35,470	23,400	21,600	23,400	64,800	88,200	
P.1-N	3,840	2,880	2,160	2,880	6,480	9,360	Controlled flow from reservoir storage assures the pumping requirements. Pump operation is scheduled for 10-hour periods during peak power generation.
P.1-S	29,000	21,700	16,300	21,700	48,900	70,600	
P.2-N and S	18,500	13,000	9,750	13,000	29,250	42,250	
P.3-N	4,100	3,280	2,460	3,280	7,380	10,660	
P.3-S	16,800	13,450	10,000	13,450	30,000	43,450	
	72,240	54,310	40,670	54,310	122,010	176,320	
Ngalaik District No. 1	39,700	35,700	26,800	—	—	—	The excess yield will be used for passing of log rafts.
Ngalaik Canal	20,560	16,450	12,300	—	—	—	
Ngalaik District No. 2	18,100	12,700	9,500	—	—	—	
Ngalaik Canal	16,000	12,000	9,000	—	—	—	
	94,360	76,850	57,600	76,850	172,800	249,650	
Saing-N Canal	36,500	25,600	19,200	—	—	—	The excess yield will be used for passing of log rafts. Reservoirs are interconnected.
Swa-S Canal	133,400	107,000	81,000	—	—	—	
	169,900	132,600	100,200	132,600	300,600	433,200	

Reservoir and Distribution System.
o Hydroelectric Report for details of Hydro Development.
ufficient for P.1-N and S only.

relative humidity occurs at the 9.00 recording with a mean annual over the 48 years of 74% and the minimum relative humidity at the 18.00 recording with a mean annual over the 48 years of 66%. The minimum value of relative humidity occurs during March which implies that the maximum evaporation is during March. This agrees closely with the maximum temperature recorded during April.

Since moisture transpiration is dependent on air movement, precipitation and reservoir evaporation are affected by the wind. The maximum mean monthly wind speed recorded at Yamethin from 1931 to 1940 for an average of 24 hours was 6·2 miles per hour in July. The maximum wind speed for a shorter period is estimated to be about 12 miles per hour. The minimum mean monthly wind speed for the same period was 1·3 miles per hour in December. Since air movement affects transpiration of moisture it may be concluded that maximum precipitation occurs in August. The rainfall data of record suggest that the maximum occurs around August and September.

Reservoir storage is definitely affected by evaporation. Measured evaporation data are not available in Burma but with the natural weather conditions known, the amount was computed by the use of Meyer's formula. The computed evaporation for the year is 49·57 inches with a maximum in April of 8·15 inches and a minimum in December of 2·00 inches. This total evaporation agrees with the 48 inches suggested by various writers for reservoir evaporation in the Dry Zone of Burma and with actual measurements recorded in India.

(2) Hydrology

There is a definite lack of these data sufficient in detail, period length, and at proper location, to make correct evaluations and conclusions as required. The only rainfall data available for the project area are from rain-gauge stations entirely outside the drainage basins from which the project water originates. These data may not represent exact precipitation conditions within the drainage basins.

The cyclic variation in rainfall was determined by plotting progressive five-year means curves for each station from which peak rainfall and corresponding intervening periods were tabulated. These data suggest that the rainfall intensity in the drainage basins of the project could be classified under a seven-year cycle.

A map of the project arca showing drainage basins, isohyetals, Theissen polygons, rain-gauge stations and a tabulation of the values for extreme maximum and minimum annual rainfall computed by the Theissen method and the mean annual rainfall computed by all three methods is shown on Plate 25. Records show that the maximum 24-hour 45-year rainfall at Yamethin is 5·6 inches and that the 24-hour 60-year rainfall at Toungoo is 6·55 inches.

Stream-flow records for the Yezin Chaung and Paunglaung River, for April 1952 to January 1953, computed from daily gauge readings and a rating curve prepared from stream-flow measurements at various gauge heights, are listed in Tables IX–12 and IX–13.

The flow data for both streams indicate very high yields from the drainage basins. The flow is excessive for the rainfall recorded at Pyinmana and one may immediately conclude that the rainfall in the mountain region of the drainage basin is much higher than the available records indicate. A study of the basin shapes, locations, and sizes verifies this as the possible reason for the high flow on the Paunglaung River, but the small size and location of the Yezin Chaung drainage basin does not justify the difference evidenced by the flow measurements. High sustained flows continue during the start of the dry months. These are no doubt from underground storage of previous rainfall but the over-all flow is still too large, suggesting the possibility of the supply coming from underground areas outside the stream drainage basin indicated by surface topography. Continuous stream-flow measurements and rainfall records from mountain stations over a period of years will establish the correct statistics.

It is impossible to establish accurate runoff factors from the information at hand because all the rain-gauge stations are in the valleys and thus reflect only valley rainfall; stream-flow data are only available on two streams and these for part of one year only; and storm periods are not recorded as such but are reflected only by 24-hour totals.

An examination of the flow (Tables IX–12 and IX–13), and a comparison with rain-gauge records at Pyinmana show that the rainfall is reflected by the flow at concurrent periods. One storm was chosen from the records and the hydrographs were prepared as shown on Plates 26 and 27. The runoff factors were computed for this storm and the time required for the water to flow from each drainage basin is also indicated on the plates. These runoff time periods suggest a basis for estimating peak flows with only drainage area and rainfall known and runoff factor assumed.

Flood flows of record are available on the drainage area for Meiktila Lake and Nyaungyan Tank, on the Thitson Chaung, and on the Zawgyi and Paunglaung Rivers. The first three named originate in and flow from the northern end of the Pegu Yomas. The last two originate in and flow from the Shan Hills. Methods used in determining the flows for the last three streams appear quite good. This information

TABLE IX – 12

YEZIN CHAUNG DRAINAGE BASIN
STREAM FLOW – 1952

(area 36 sq. mi.)

Rainfall in inches*	*Jan.–Feb.*	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
	0·34	2·24	—	1·74	6·41	12·40	11·48	10·83	8·51	0·74	—
1			13	10	27	27	125	400	178	521	65
2			13	10	19	22	311	335	178	203	65
3			10	10	36	36	79	338	386	203	50
4			10	10	32	32	547	401	178	178	50
5			10	10	47	27	321	306	178	156	50
6			10	10	51	36	238	298	184	133	50
7			10	10	36	101	190	238	221	106	50
8			10	10	57	36	178	197	371	106	50
9			10	10	13	36	178	830	932	184	50
10			10	10	13	62	278	447	454	141	50
11			10	10	13	36	246	277	226	133	50
12			10	10	13	41	178	209	322	186	50
13			10	10	13	41	296	220	299	133	50
14			10	10	13	65	657	218	304	133	50
15			10	10	13	61	432	178	206	106	50
16	Estimated Flow	Estimated Flow	10	10	19	50	321	191	203	106	50
17			10	23	21	36	298	184	231	106	50
18			10	10	15	27	253	256	203	106	36
19			10	10	28	66	487	178	197	106	36
20			10	13	22	41	415	1,330	366	106	36
21			10	26	15	36	362	840	358	106	36
22			10	18	13	306	253	640	239	80	36
23			10	18	13	161	178	506	238	80	36
24			10	47	13	159	163	354	215	80	36
25			10	13	13	163	456	197	230	80	36
26			10	13	18	178	695	425	197	80	36
27			10	13	13	178	467	423	242	65	36
28			10	13	105	185	535	169	231	65	36
29			10	26	75	299	321	197	281	65	36
30			10	46	204	326	1,054	178	197	65	36
31			—	21	—	209	443	—	212	—	36
Total†	1,100	350	306	470	983	3,079	10,955	10,958	8,394	3,918	1,384

*Annual Rainfall, Pyinmana (based on Pyinmana rainfall over the entire watershed) = 54·7 inches or 4·56 feet.

†Annual runoff, Yezin Chaung = 41,897 d.s.f.

$$\text{Runoff factor} = \frac{41{,}897 \times 2}{36 \times 640 \times 4{\cdot}56} = 80\%.$$

TABLE IX - 13

PAUNGLAUNG RIVER DRAINAGE BASIN
STREAM FLOW - 1952

(area 1,741 sq. mi.)

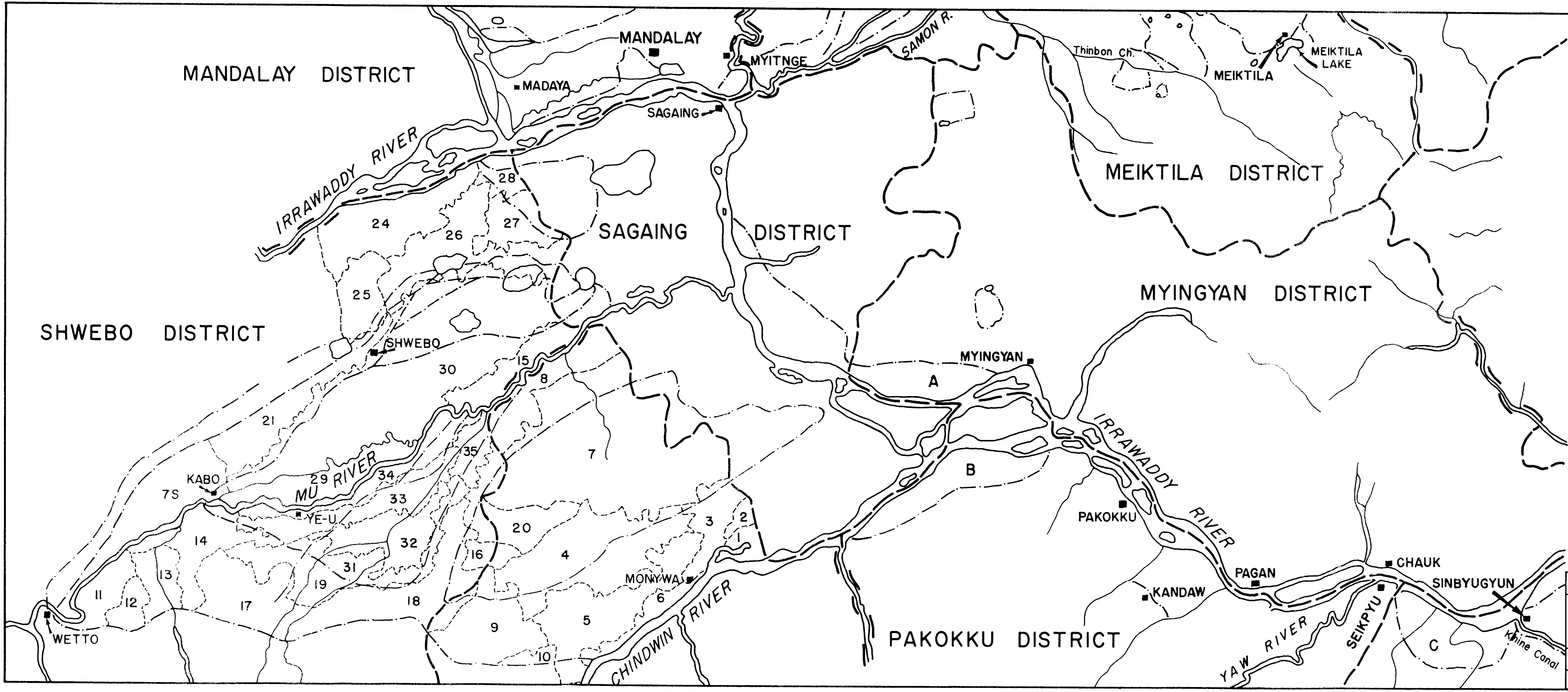
	Feb.–Mar.	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*
Rainfall in inches*	2·24	—	1·74	6·41	12·40	11·48	10·83	8·51	0·74	—	0·34
1	Estimated discharge 60 days at 2·0 = 120·0 d.s.f.	say 9 days 1·0= at 9·0 d.s.f.	1·0	3·4	6·3	18·2	20·1	14·0	10·5	4·7	Say 31 days at 3·0 = 93·0 d.s.f.
2			1·0	3·4	6·2	17·0	18·0	13·0	9·6	4·7	
3			1·0	3·8	7·0	16·4	13·2	13·2	8·9	4·5	
4			1·0	3·8	5·7	18·4	14·9	11·6	8·4	4·5	
5			0·7	4·4	5·8	19·1	14·0	10·5	8·0	4·5	
6			1·5	4·1	4·3	17·0	13·7	10·5	7·8	4·5	
7			2·0	2·9	4·8	14·6	12·8	10·5	7·6	4·4	
8			1·5	2·0	4·4	14·4	12·3	10·7	7·5	4·4	
9			1·0	2·0	4·3	13·9	19·1	13·2	7·6	4·3	
10		1·0	1·0	1·5	4·3	14·0	23·9	14·9	7·6	4·3	
11		1·0	0·7	1·5	5·3	14·6	21·0	13·7	7·5	4·1	
12		1·0	0·7	1·0	7·0	15·6	18·6	13·0	7·1	4·0	
13		1·0	1·0	1·0	6·8	14·4	17·2	13·3	7·0	4·0	
14		1·0	1·0	1·3	5·7	17·2	17·8	11·9	6·7	3·9	
15		1·0	0·7	2·0	5·8	19·1	16·6	10·4	6·5	3·9	2·8
16		1·0	0·7	2·0	6·5	17·4	15·1	11·9	6·5	3·9	
17		1·0	0·4	2·3	7·1	16·2	14·0	10·4	6·3	3·8	
18		1·0	0·4	1·5	7·6	15·1	12·8	10·1	6·2	3·8	
19		1·0	0·7	2·0	10·1	15·8	13·5	9·3	6·0	3·8	
20		1·0	1·5	1·8	13·0	15·3	19·0	9·3	5·9	3·6	
21		1·3	2·0	1·8	10·4	14·7	26·4	11·8	5·9	3·6	
22		1·3	4·8	1·5	10·1	14·0	25·0	11·2	5·7	3·6	
23		1·0	2·3	1·8	10·2	13·5	22·2	10·1	5·6	3·6	
24		1·0	1·5	2·0	11·4	13·7	19·7	9·4	5·4	3·6	
25		1·0	1·5	3·1	11·4	15·5	17·4	9·4	5·3	3·6	
26		1·0	1·8	4·3	11·4	17·2	22·4	9·1	5·1	3·6	
27		1·0	2·3	3·9	11·9	18·0	19·3	9·4	5·1	3·5	
28		0·7	2·6	4·8	17·6	17·2	18·0	8·9	5·0	3·5	
29		0·7	2·6	5·7	22·6	15·5	14·9	9·3	4·8	3·5	
30		0·7	2·8	6·5	22·2	21·4	13·9	10·7	4·8	3·5	
31		—	3·4	—	20·8	27·5†	—	11·8	—	3·4	2·9
Total‡	120·0	29·7	47·1	83·1	287·0	511·8	530·0	346·5	201·9	122·6	93·0

*Annual Rainfall, Pyinmana (based on Pyinmana rainfall over the entire watershed) = 54·7 inches or 4·56 feet.

†Estimated.

‡Annual runoff, Paunglaung River at dam site = 2,373·5 d.s.f. (runoff figures are in thousands).

$$\text{Runoff factor} = \frac{2{,}373{\cdot}5 \times 1{,}000 \times 2}{4{\cdot}56 \times 640 \times 1{,}741} = 93{\cdot}4\%.$$



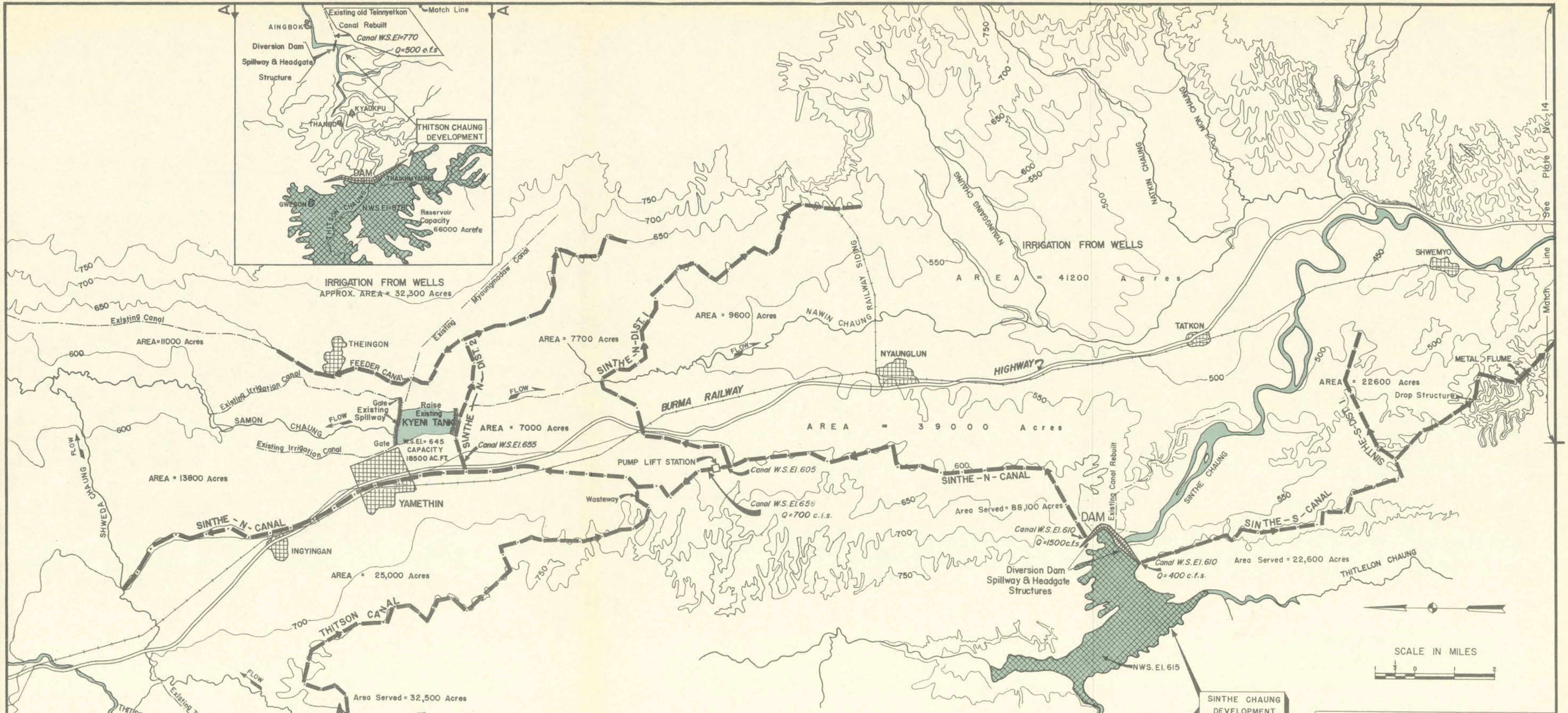
MINISTRY OF NATIONAL PLANNING

MU RIVER IRRIGATION PROJECT

GENERAL INFORMATION ON SOILS

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON.

DR. BY A.R.R. DATE JULY 53. PLATE NO 20
CK. BY E.J.P.



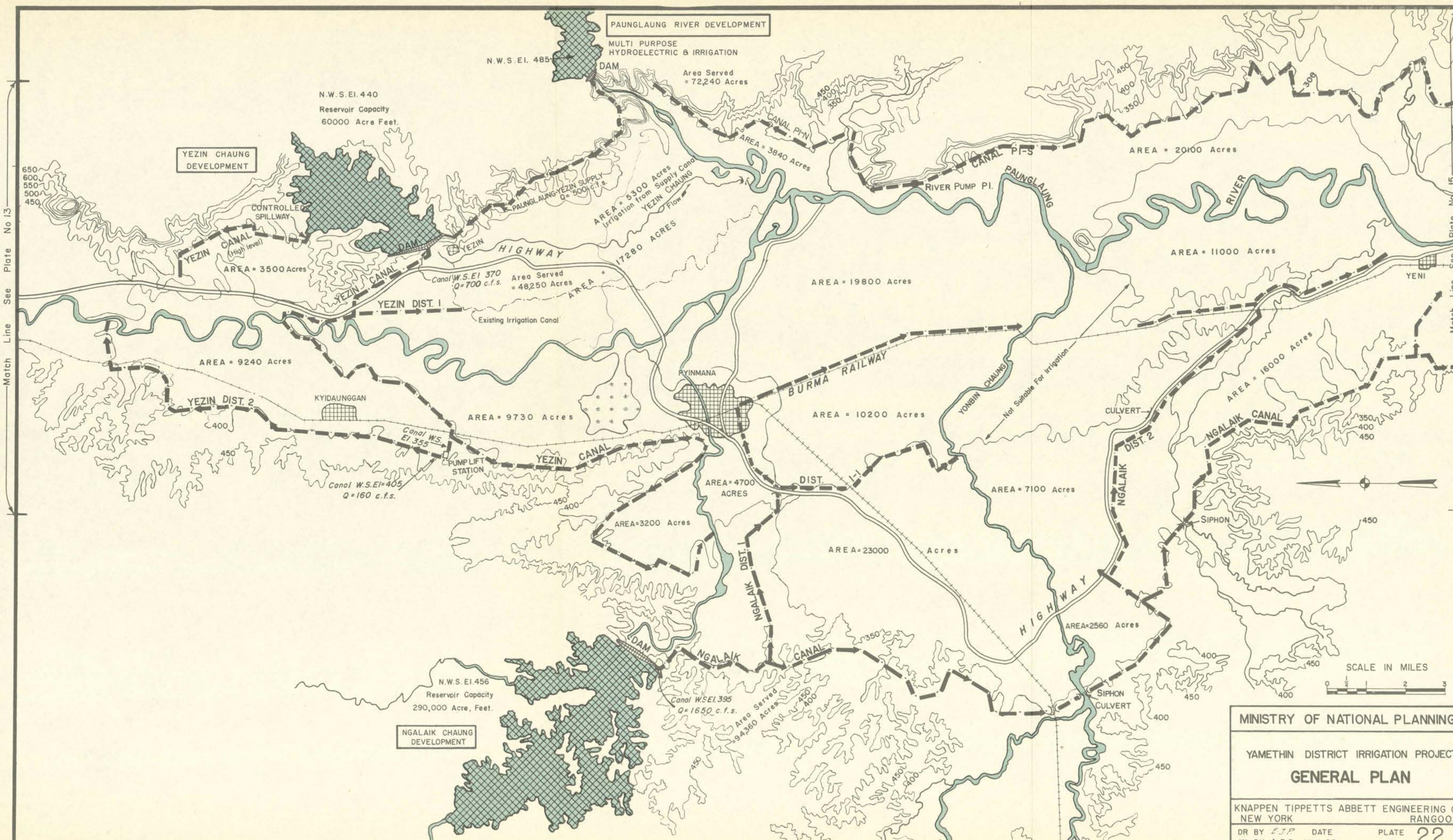
MINISTRY OF NATIONAL PLANNING

YAMETHIN DISTRICT IRRIGATION PROJECT

GENERAL PLAN

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON

DR. BY E.J.R. CK. BY A.R.R. DATE MAY. 1953. PLATE NO 21



MINISTRY OF NATIONAL PLANNING

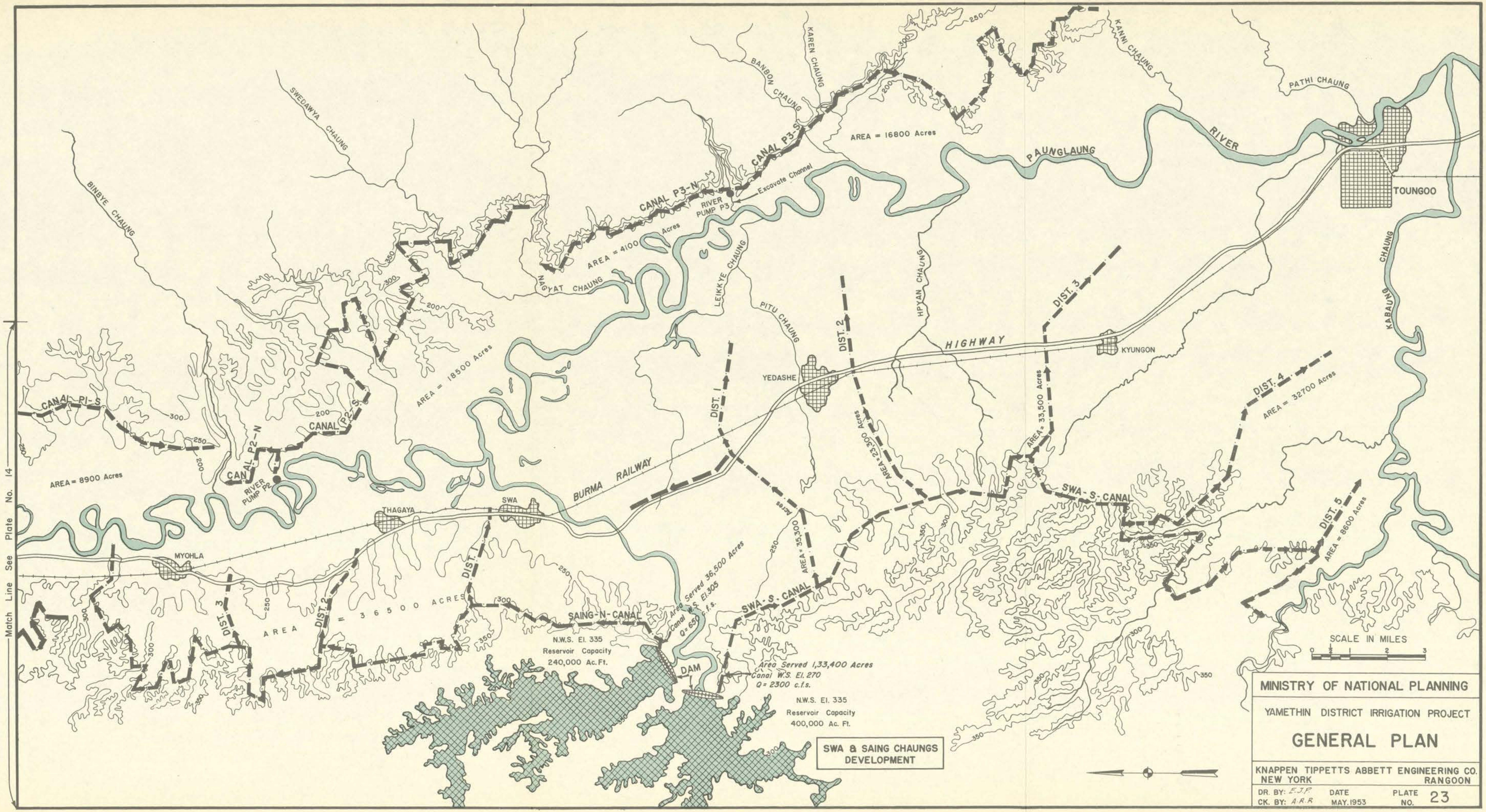
YAMETHIN DISTRICT IRRIGATION PROJECT

GENERAL PLAN

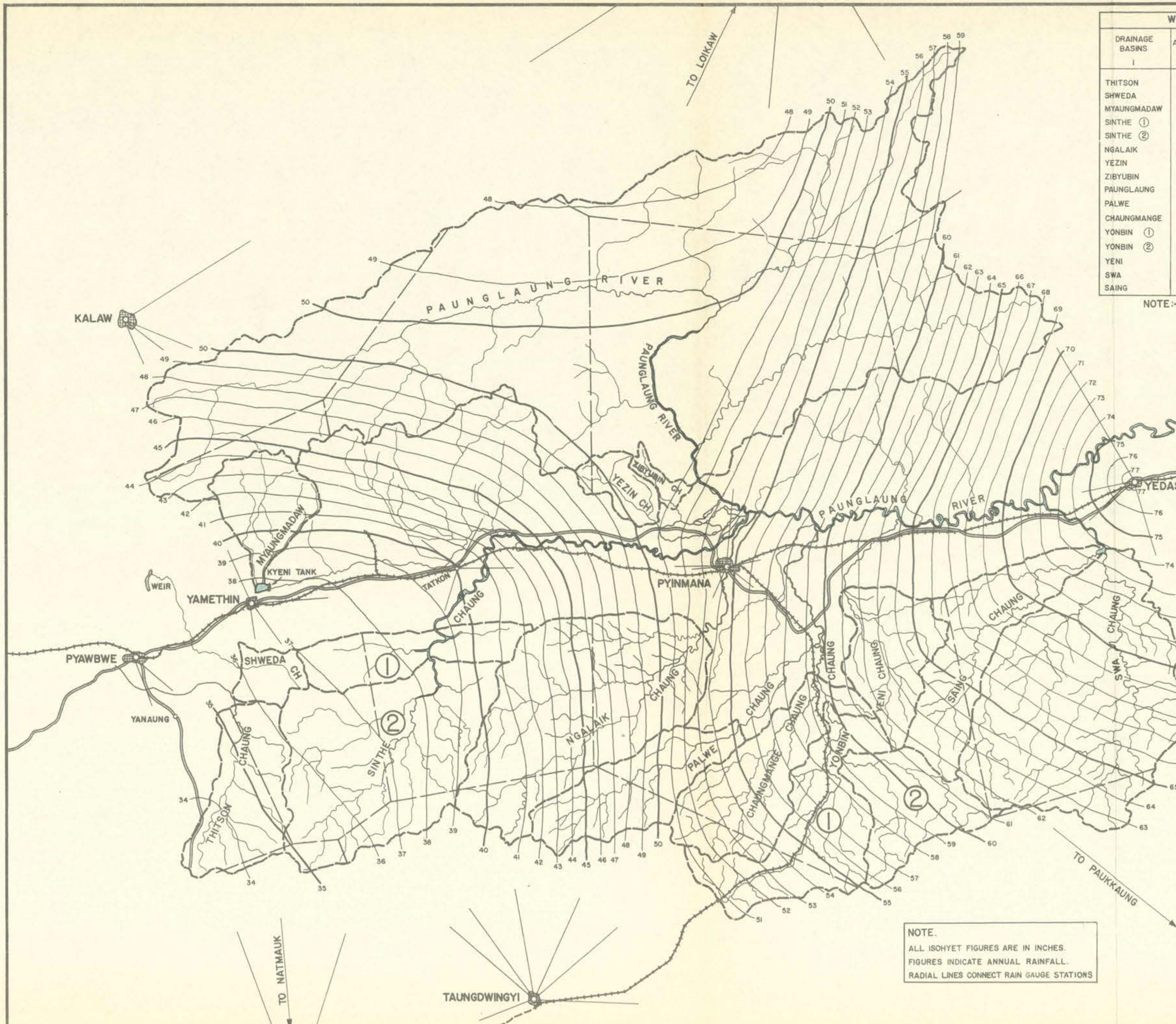
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK RANGOON

DR BY E.J.P. DATE
CK. BY. A.R.R. MAY 53.

PLATE NO 22


MINISTRY OF NATIONAL PLANNING
YAMETHIN DISTRICT IRRIGATION PROJECT
GENERAL PLAN
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
DR. BY: E.J.P.
CK. BY: A.R.R.
DATE MAY.1953
PLATE NO. 23
SCALE IN MILES
SWA & SAING CHAUNGS DEVELOPMENT
Match Line See Plate No. 14
TOUNGOO
KYUNGON
YEDASHE
SWA
THAGAYA
MYOHLA
PAUNGLAUNG RIVER
HIGHWAY
BURMA RAILWAY
PATHI CHAUNG
KANNI CHAUNG
KAREN CHAUNG
BANBON CHAUNG
SWEDAWYA CHAUNG
BINBYE CHAUNG
NAGYAT CHAUNG
LEIKKYE CHAUNG
PITU CHAUNG
HPYAN CHAUNG
KABAUNG CHAUNG
CANAL P3-S
CANAL P3-N
RIVER PUMP P3
Excavate Channel
CANAL P2-S
CANAL P2-N
RIVER PUMP P2
CANAL PI-S
CANAL
AREA = 16800 Acres
AREA = 4100 Acres
AREA = 18500 Acres
AREA = 8900 Acres
AREA = 36500 ACRES
AREA = 23,300 Acres
AREA = 33,500 Acres
AREA = 32700 Acres
AREA = 35,300 Acres
AREA = 8600 Acres
DIST. 1
DIST. 2
DIST. 3
DIST. 4
DIST. 5
SWA-S-CANAL
SAING-N-CANAL
Area Served 36,500 Acres
Canal W.S. El. 305
Q= 650 c.f.s.
N.W.S. El. 335
Reservoir Capacity
240,000 Ac. Ft.
DAM
Area Served 1,33,400 Acres
Canal W.S. El. 270
Q= 2300 c.f.s.
N.W.S. El. 335
Reservoir Capacity
400,000 Ac. Ft.

IRRIGATED AREA BOUNDARY
PAUNGLAUNG DAM
KYENI TANK
YAMETHIN
PYAWBWE
YEZIN DAM
KYIDAUNGGAN
PYINMANA
SINTHE DAM
YEDASHE
TOUNGOO
NGALAIK DAM
SWA & SAING DAM
THITSON DAM
LEGEND
TOWN
IRRIGATION BOUNDARY
ALLUVIUM
COAL MEASURES
GRANITE
IRRAWADDIAN SERIES
PEGU SERIES
UNCLASSIFIED CRYSTALLINE
SCALE IN MILES
0
5
10
MINISTRY OF NATIONAL PLANNING
YAMETHIN DISTRICT
IRRIGATION PROJECT
GEOLOGICAL MAP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK
RANGOON
DR. BY
DATE
PLATE NO
CK. BY A.R.R.
MAY 53
24



DRAINAGE BASINS 1	AREA SQ.MI. 2	ARITHMETIC MEAN INCHES 3	ISOHYETAL MEAN INCHES 4	MIN. THEISSEN MEAN INCHES 5	THEISSEN MEAN INCHES 6	MAX. THEISSEN MEAN INCHES 7
WEIGHTED MEAN ANNUAL RAINFALL (1919-38)						
THITSON	119	33.13	34.70	20.42	32.62	42.81
SHWEDA	36	36.94	36.03	23.69	36.94	49.64
MYAUNGMADAW	79	39.70	40.51	28.94	39.70	60.47
SINTHE (1)	88	38.34	38.35	27.16	38.77	56.80
SINTHE (2)	312	37.72	36.95	26.10	38.39	54.57
NGALAIK	340	44.98	45.08	33.60	46.03	66.78
YEZIN	36	47.15	50.19	39.19	52.94	75.90
ZIBYUBIN	14	54.60	50.44	40.47	54.60	77.83
PAUNGLAUNG	1741	50.43	52.41	35.60	50.39	73.59
PALWE	122	48.07	55.45	33.88	47.36	65.10
CHAUNGMANGE	135	48.07	54.73	38 00	51.89	73.00
YONBIN (1)	166	48.07	50.25	36.33	50.10	69.84
YONBIN (2)	105	54.60	53.43	40.47	54.60	77.83
YENI	103	54.60	63.23	40.47	54.60	77.83
SWA	421	62.77	66.96	47.42	71.29	117.66
SAING	145	65.93	66.65	44.45	68.95	105.00

NOTE:-

COL. 2- AREAS ABOVE DAM LOCATIONS.
COL. 5- BASED ON MINIMUM ANNUAL RAINFALL.
COL. 6- BASED ON AVERAGE ANNUAL RAINFALL.
COL. 7- BASED ON MAXIMUM ANNUAL RAINFALL.

NOTE.
ALL ISOHYET FIGURES ARE IN INCHES.
FIGURES INDICATE ANNUAL RAINFALL.
RADIAL LINES CONNECT RAIN GAUGE STATIONS

MINISTRY OF NATIONAL PLANNING

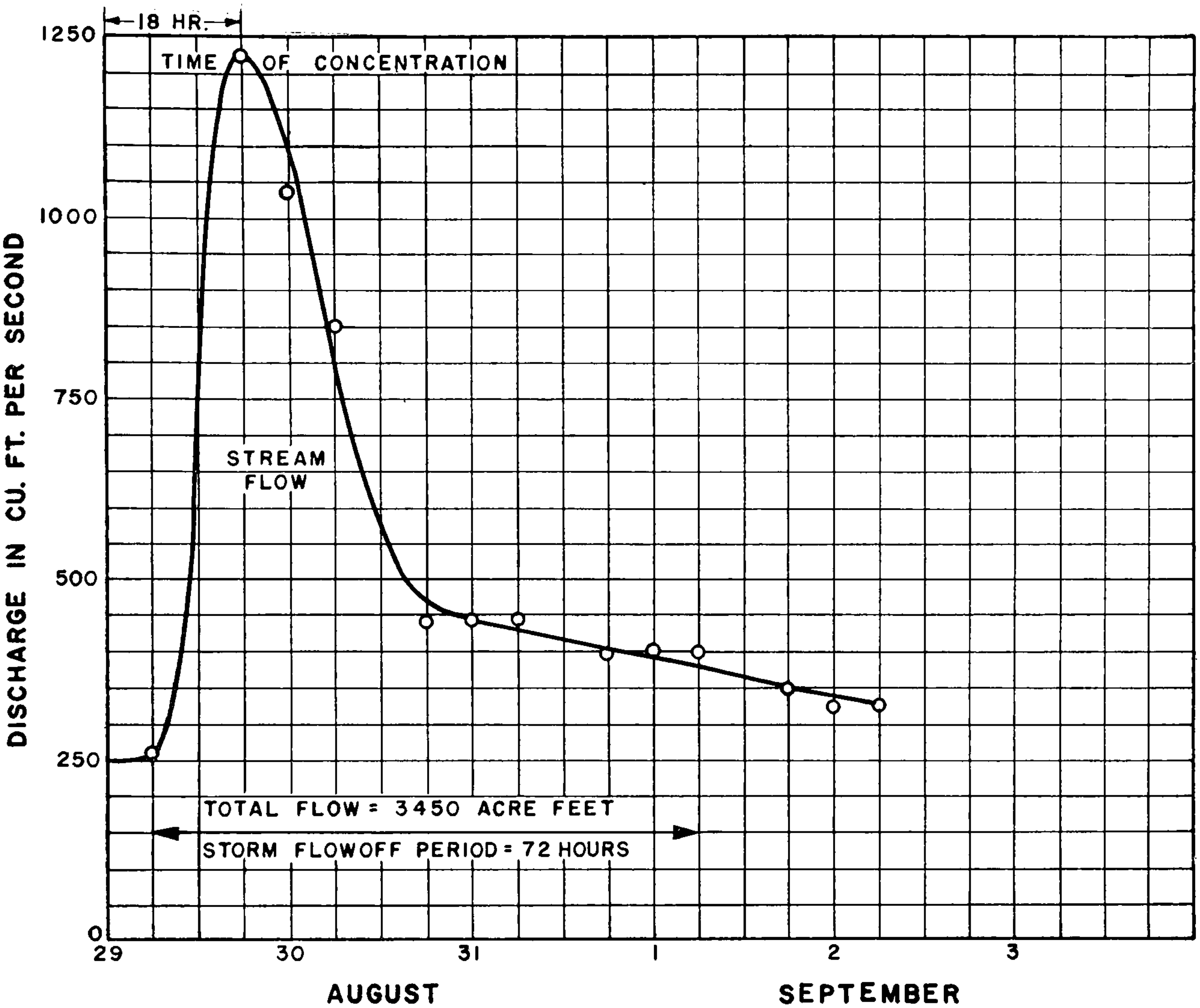
YAMETHIN DISTRICT IRRIGATION PROJECT

DRAINAGE BASINS

THEISSEN AND ISOHYETS MAP

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEWYORK. RANGOON.

DR BY. E.J.P. DATE
CK BY. A.R.R. MAY. 1953. PLATE NO. 25



$$\text{RUNOFF} = \frac{3450}{\frac{3.51}{12} \times 36 \times 640} = 0.512$$

HYDROGRAPH DATA FOR 3·51–INCH
STORM OF 29 AUG., 1952 FOR 24 HOURS
OVER YEZIN D. A. 36 SQ. MI.

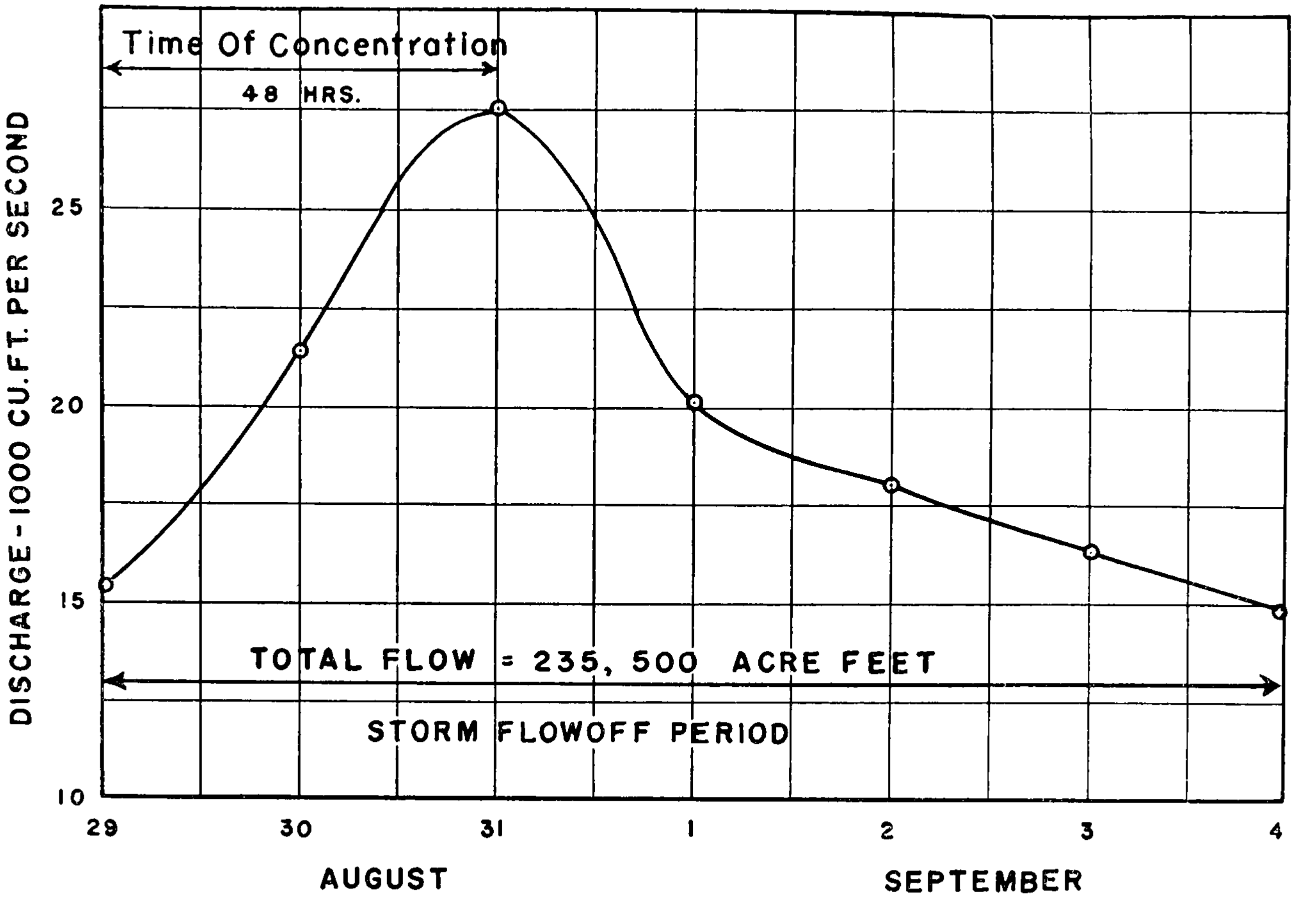
DATE	TIME	C. F. S.	DATE	TIME	C. F. S.
AUG. 29	6 P. M.	260	SEPT. 1	6 A. M.	400
AUG. 30	6 A. M	1225		12 P. M.	400
	12 P. M.	1035		6 P. M.	400
	6 P. M	850	SEPT. 2	6 A. M	350
AUG. 31	6 A. M.	443		12 P. M.	328
	12 P. M.	443		6 P. M.	328
	6 P. M.	443			

MINISTRY OF NATIONAL PLANNING

YAMETHIN DISTRICT
IRRIGATION PROJECT
STORM HYDROGRAPH
ON YEZIN

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON

DR. BY. E.P. DATE MAY, 53. PLATE NO. **26**
CK. BY. A.R.R



HYDROGRAPH DATA

3.51" STORM - AUG 29, 1952.

PAUNGLAUNG D.A. = 1741 SQ. MI.

DATE	FLOW	
AUG. 29	15460 C.F.S.	
30	21420 "	
31	27500 "	*
1	20090 "	
2	18000 "	
3	16400 "	
4	14920 "	

* ESTIMATED

$$\text{Runoff} = \frac{235,500}{1741 \times 640 \times \frac{3.51}{12}} = 0.72$$

MINISTRY OF NATIONAL PLANNING

YAMETHIN DISTRICT
IRRIGATION PROJECT

STORM HYDROGRAPH

ON PAUNGLAUNG

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON

DR. BY E.W. DATE PLATE NO **27**
CH. BY A.R.R. MAY 53

may be used as a basis for comparing estimates of peak flows used in the project designs. The data are shown in Table IX–14.

TABLE IX – 14

RECORDED PEAK FLOOD FLOWS

Meiktila Lake Drainage Basin. Area 240·5 sq. mi. 5·56 inches in 7 hours at Meiktila, Sept. 11, 1910.

Date of Storm	Total Rainfall	Lake	Inflow	Runoff	
		Total Acre Feet	*Peak c.f.s.*	*Per Cent*	*c.f.s. per sq. mi.*
Oct. 2– 9, 1900	10·97	56,100	16,000	40	67
Nov. 5–12, 1908	9·56	48,700	20,000	40	84
Sept. 10–12, 1910	4·28	30,900	44,640	57	188
May 3– 6, 1920	8·04	25,505	75,120	25	315
Oct. 13–15, 1921	4·07	33,136	52,800	63·4	222
Oct. 23–26, 1926	7·21	45,519	31,224	49·5	131
Nov. 4– 8, 1935	11·00	95,075	129,612	67·6	545

Nyaungyan Tank Drainage Basin. Area 450 sq. mi. Sept. 11, 1910. Storm 5·56 inches 2 a.m. to 8 a.m.

Time	*Max. Flow c.f.s.*	*c.f.s. per sq. mi.*
6 a.m. to 8 a.m.	31,266	69
8 to 9	57,844	128
9 to 10	57,455	128
10 to 12	93,700	208
12 to 1 p.m.	116,389	258
1 p.m. to 2	86,309	192
2 to 5	60,251	134
5 to 6.30	54,984	122
6.30 to 9	49,756	110
9 to 10	69,290	154

Data on the Nyaungyan Tank were taken from "Irrigation Pocket Book," compiled by Robert Burton Buckley, CSI, Chief Engineer Indian Irrigation Dept. (retired).

Thitson Chaung Drainage Basin. Area 145 sq. mi. 5·22 inches in 24 hours, Nov. 3, 1935.

Flood 1917: 18,000 c.f.s.; max. flow, 124 c.f.s. per sq. mi.
Flood 1935: 13,300 c.f.s.; max. flow, 92 c.f.s. per sq. mi.
Flood 1948: 16,000 c.f.s.; max. flow, 110 c.f.s. per sq. mi.

Zawgyi River Drainage Basin. Area 1,578 sq. mi.
90,000 c.f.s.; max. flow, 57 c.f.s. per sq. mi.

Paunglaung River Drainage Basin. Area 995 sq. mi.
80,000 c.f.s.; max. flow, 80 c.f.s. per sq. mi.

(3) Use of Data

The available data are not all directly usable but may be a basis for establishing assumptions and criteria.

All the meteorology data are sufficient for use in the project planning. The valley rain-gauge stations are in the same general vicinity as the agricultural land; therefore the records are applicable for establishing water requirements over and above the natural supply.

The mean average rainfall determined by the Theissen method was used to compute the yield from the drainage basins of the various streams. No allowance was made for the possible increase in the amount of rainfall which may have occurred in the mountainous areas of the basins because there is no way of determining the increase. The value used is conservative, and since the use distribution of the irrigation water is based on the supply of water from this rainfall, the planning is on the conservative side. Should there be more rainfall, the water use allocation per acre may be increased or the acreage served may be expanded. The reservoir volume required for the estimated yield established the height of the dam, therefore a greater yield because of more rainfall in the drainage basins will further guarantee the storage supply for the land represented by the reservoir capacity.

The available data are insufficient to compute runoff factors. Comparison of the drainage basins of the project with those of similar characteristics and known runoffs has made it possible to establish the runoff factors shown in Table IX–11, column 4. These are also believed to be conservative, and if actual flows prove them to be low it will only tend to make the project more feasible, since the economic benefits are proportional to the acreage for which sufficient water is available.

The rainfall, runoff factor, and time of runoff are important for estimating peak flows for spillway designs. This design feature of the project planning cannot be based on a low estimate of these values. The spillways at each of the reservoirs are designed for storms occurring when the reservoir is full; therefore capacities must be large enough for maximum requirements. This being at the end or near end of the rainy season the use probability factor is reduced but nevertheless the provision must be made for the unusual storm which may occur at that time. Since all the records are incomplete, design assumptions were established as follows:

(a) A maximum single 24-hour storm of record is projected on the drainage basin with a runoff of 70%.

(b) The dam is designed with additional height to absorb this total inflow above normal water surface (NWS) shown on the plates for the various stream developments.

(c) The spillway design assumes this inflow will be discharged in 72 to 144 hours, depending on the drainage basin size, with peak discharge three times the average. Additional spillway capacity is available if required, through the tower control outlet structure and limited use of the freeboard on the dam, over and above that provided for rise over the spillway sill.

(d) At such time as operation experience and more exact and detailed data make possible closer control, gates may be added to the spillways for greater reservoir storage capacities and flood control, and more water supply carry-over to seasons of below-normal rainfall. The rainy period evaporation losses and the rainy season supplemental irrigation discharges may also be recovered in this way. The installation of such gates, however, will necessitate close operation at all times and special watchfulness and storm predictions during the rainy season.

d. The Land

Nearly 75% of the project area is presently devoted to paddy production, and the major portion of this is under paddy monoculture. A considerable acreage of the Yamethin District, which is the northern half of the area, is dependent on supplemental water from small stream diversion sources.

The land of this project area which is to be irrigated under the over-all development was given rather detailed study leading to general soil classification and agricultural recommendations. This study was attended by limitations in regard to time and agricultural literature and data available, collection of field samples because of the unrest in the country, laboratory facilities and personnel. The lack of research into new crops for Burma imposed a serious limitation in the preparation of crop rotation plans. Studies were made, however, leading to quite accurate conclusions for the project, and establishing a plan of procedure for continued studies.

The classification of soil was based upon the soil profile, surface texture, slope and other characteristics. Soil profile data were considered in terms of its derivation, age and degree of weathering, permeability at varying levels, and whether of primary or secondary formation. A Geologic Soil Map (Plate 24) was used for the determination of part of this information and laboratory tests supplied the remainder. Surface soil textures were determined by physical analyses in the soil laboratory. Slopes were estimated from aerial photographs of the area. Drainage requirements, the erosion status of the soil, and microrelief characteristics were taken from aerial photographs. The presence of alkali, pH value, and the soil nutrient levels were investigated in the soil laboratory.

Soil profiles were characterized generally by low surface and subsoil permeability. The soils consist almost wholly of secondary formation alluvium and similar heavy clays of the Irrawaddy Series. Surface texturcs vary widely with the principal characteristics of an impermeable, or nearly impermeable, subsoil overlain with surface soils of somewhat lighter texture. Slopes arc gcncrally ideal with small intervening areas of rough topography.

The soil pH was found to vary from an extremely acid reaction in the south to neutral in the north. Soil nutrient levels varied widely with differing soil types examined. In general there was a nitrogen and a phosphorus deficiency. Potassium ions were not present in dctrimental quantities. In general the magnesium-replaceable calcium levels were in good balance.

With due consideration given to each of the soil characteristics determined, a classification of soil into grades was made. Soil grading was based upon a numerical ratio of each soil sample analyzed, giving values to the soil characteristics examined. Grade I soil is suitable for a wide range of crops, with only the surface soil texture acting to limit the crop types. Grade II is soil suitable for most crops with one or more factors tending to favor certain crops and reduce the growing of others. Grade III soils are those having pronounced characteristics that combine to restrict or exclude certain crops. Grade IV is poor soil suitable for very few crops or a single one.

One hundred and fifty soil samples were taken in the project area. At each of 65 locations a surface sample was taken together with a sample of the subsoil. Ten locations were bored to a 6-foot depth with samples taken at each foot. Plates 28 to 30 inclusive are the soil maps for this project.

The determination of irrigation requirements was made in detail, taking into consideration crop types and soils on which grown, and the consumptive use of water for each crop. The Blaney-Criddle method was used for determining consumptive use and irrigation requirements of the actual crops to be grown. This method gives consideration to daytime hours and to temperature as does the general method for a whole valley discussed heretofore in Section A-3-b of this chapter.

Table IX–15 lists the crop irrigation requirements. The factor "K" is a consumptive use coefficient developed from actual measurements of consumptive use in tank and soil moisture field studies in the United States. The values have been modified to meet humid climatic conditions of the southeastern area of the United States and are considered valid for use in Burma under equivalent conditions of humidity and latitude. "U" is the consumptive use of water by the crop, in inches, for the growing season specified. "R" indicates rainfall in inches over the project area. "RE" is the effective rainfall over the area. Topography, soil, vegetative cover, rainfall intensity and other factors were considered in arriving at a determination of effective precipitation. The relatively flat terrain throughout the project area was considered to lose 5% of the rainfall as runoff waste. Predominantly heavy soils of the area were calculated to lose 3% of the rainfall to percolation waste. It was considered that 5% would be lost due to the type and density of the vegetative cover. Surface runoff losses due to rainfall intensity were considered to approximate 17% and those of other causes 7%. It is calculated that 63% of the rainfall will be used by crops. "I" indicates the amount of irrigation water, in inches, that must be supplied to crops for optimum growth. Thirty per cent losses of water supplied to the crop have been calculated to occur. It is considered that half the loss will be to surface runoff, and the other half to deep percolation.

All crops planned for the project area appear in Table IX–15 together with growing period and irrigation requirement information. The rainfall differs considerably from north to south, therefore the relative irrigation requirements have been calculated separately for the northern and the southern portions. The letters "N" and "S" in the table represent this division. Locations in between are a variation from one to the other. Detailed studies and programs for crop rotations, considering only those crops grown in Burma at this time, were made and the maximum water requirement in one month of the crop season was found to be from 10 to 12 inches.

e. Project Plan

All the details shown on General Plan Plates 21 to 23 inclusive are general, the planning prepared principally by use of one inch to the mile scale maps with contours at 50-foot intervals, and from field reconnaissance. Field surveys were made of the reservoir areas on the Yezin Chaung and Kyeni tank, topography and centerline of the dam site on the Thitson and Yezin Chaungs and Paunglaung River and centerline at the lower dam site on the Sinthe Chaung. Foundation investigations were not made at any of the dam sites except the Thitson Chaung which was made in 1931 and is neither conclusive nor complete.

A description of each development unit of the over-all project is as follows:

(1) Thitson Chaung Development

The Thitson Chaung has been a source of water for irrigation in the area north and west of Yamethin in the past. The supply was limited, however, to natural stream flow, diverting only if the water was available when needed. The disused system, known as the Teinnyetkon Canal and its distributaries, at one time served a small area between the Thitson and Shweda Chaungs, diverting from the Thitson Chaung just

TABLE IX – 15

CROP IRRIGATION REQUIREMENTS

(in inches)

Season	*Crop*	"*K*"	"*U*"	"*R*"		"*RE*" (63%)		"*U*"—"*RE*"		"*I*" (70%)	
				N	*S*	*N*	*S*	*N*	*S*	*N*	*S*
June 1–Nov. 25	Rice	1·00	40·9	27·8	69·1	17·6	43·5	23·4	6·6	33·7	9·4
Jan. 1–Apr. 15	Rice	1·00	21·8	1·4	1·2	0·9	0·7	21·0	21·1	30·0	30·2
Jan. 14–Apr. 15	Sesamum	0·65	12·4	1·4	1·2	0·9	0·7	11·6	11·7	16·6	16·7
Dec. 15–Mar. 15	Sesamum	0·65	11·2	0·6	0·3	0·4	0·2	10·9	11·1	15·5	15·8
Dec. 1–Feb. 28	Maize	0·70	11·5	0·7	0·3	0·4	0·2	11·1	11·3	15·9	16·2
Jan. 1–Mar. 31	Maize	0·70	12·6	0·4	0·2	0·2	0·1	12·4	12·5	17·6	17·9
June 1–Oct. 31	Garden	0·55	19·8	26·6	68·0	16·8	42·3	3·5	—	5·0	—
Dec. 1–Apr. 30	Garden	0·55	17·1	2·9	2·3	1·8	1·4	15·3	15·7	21·9	22·4
Jan. 1–June 30	Sugar Cane	0·70	28·7	12·4	22·2	7·8	13·9	20·9	18·1	29·8	25·8
July 1–Dec. 31	Sugar Cane	0·70	27·9	23·8	55·8	15·0	35·2	13·0	7·4	18·5	10·6
June 1–Oct. 31	Pulses	0·60	21·6	26·6	68·0	16·9	42·8	7·1	—	10·1	—
Nov. 1–Mar. 31	Pulses	0·60	17·7	2·3	1·7	1·4	1·0	16·2	16·7	23·1	23·7
June 1–Oct. 15	Groundnuts	0·65	21·3	24·3	64·6	15·3	40·7	6·2	—	8·9	—
Oct. 1–Feb. 15	Groundnuts	0·65	17·1	6·5	8·4	4·0	5·2	13·0	11·8	18·6	16·9
Dec. 15–Apr. 15	Tobacco	0·60	13·5	1·7	1·3	0·6	0·6	12·9	12·9	18·4	18·5
Nov. 15–Apr. 15	Cotton	0·55	16·6	2·6	2·0	1·6	1·2	15·0	15·4	21·5	22·1
Dec. 1–Mar. 31	Wheat	0·60	14·1	0·9	0·4	0·5	0·2	13·6	13·9	19·3	19·8
Jan. 1–Apr. 30	G. Manure	0·65	16·7	2·5	2·2	1·5	1·3	15·1	15·4	21·6	21·9
June 1–Oct. 15	G. Manure	0·65	21·3	24·3	64·6	15·3	40·7	5·9	—	8·5	—
Jan. 1–Apr. 30	F. Grass	0·65	16·7	2·5	2·2	1·5	1·3	15·1	15·4	21·6	21·9
June 1–Oct. 15	F. Grass	0·65	21·3	24·3	64·6	15·3	40·7	5·9	—	8·5	—

above Ainbok village. The diversion weir was destroyed and the canal system has been in a bad state of repair for many years. This source of water will be redeveloped for irrigation of lands previously served and for an additional area of arable land west of Yamethin which is too high for service from any other water source.

The development will include the construction of a dam across the Thitson Chaung approximately six miles above the old weir location for storage of all the runoff, a diversion dam at the old location, rehabilitation of the old Teinnyetkon Canal, and enlargement of the old Zidaw Distributary for a supply canal to extend eastward across the Shweda Chaung toward Yamethin and in a southerly direction therefrom at an elevation approximately on contour 750. A low embankment constructed across the Shweda Chaung valley will catch all runoff from that chaung and form a small reservoir through which the proposed supply canal will be carried. Water not used from this supply canal will be wasted at its terminus through a connecting canal to the Sinthe-N Canal leading northerly from the Sinthe Chaung reservoir.

A geological report dated March, 1931, by Dr. Coggin Brown for a dam site on the chaung some 12 miles northwest of Yamethin and about one mile above the old Teinnyetkon weir location was adverse to the site but suggested the possibility of a more suitable one farther west in the Pegu formation. A later geological study and report of a site approximately six miles upstream, including the digging of test pits and alignment surveys, is on the dam location for this project. The location is in the more solid rocks of the Pegu formation and although the geological report is not entirely favorable, the investigations that were made do not show conclusive data nor are they sufficient to substantiate the opinion. Under present-day knowledge of dam construction, difficulties much greater than those indicated in the report can be overcome. Before the preparation of design plans however, it is recommended that more detailed and complete investigations of the site be made.

These investigations and field surveys should include an alternative site at the old weir location. Should the alternative site be found satisfactory for the storage dam, the diversion works would be unnecessary and the over-all cost reduced.

(2) Sinthe Chaung Development

Although the Nawin Chaung may be considered the source of the Sittang River, the Sinthe Chaung rising in the Pegu Yomas and entering the valley some 20 miles southeast of Yamethin is the first major tributary. It joins the Nawin Chaung near Shwemyo Bluff on the Mandalay trunk road, and the combined flow continues therefrom under the name of the Sinthe Chaung. The catchment area is not large but the total flow for a season represents a supply of great value for irrigation of lands in the vicinity.

The waters of the Sinthe Chaung have been considered for irrigation on a number of occasions in the past. A small irrigation system existed years ago but was never satisfactory because diversion was possible only when the chaung was in flood. Reconstruction of this system was considered in about 1927 to irrigate an estimated 16,000 acres, but the plan did not materialize because of the intermittent water supply in the river, and because the relative levels of the ground and river were such that a high crest wall was required on the diversion weir to command the relatively small area.

The Sinthe Chaung development provides for the construction of two dams, one at each range of hills through which the chaung passes before it enters the valley. The dam in the upper range of hills is to be a concrete structure with an overflow spillway and sluice gates to supply the lower reservoir. All of the water stored above the upper dam will be usable for irrigation and will be released to the lower reservoir as needed. The dam at the Myaukhmyaik village site is to be rolled earth fill with a concrete spillway structure and canal headgate at the left abutment, a concrete canal headgate structure at the right abutment, and a concrete tower control outlet structure for low-level releases into an old existing canal system.

Two canals carry water from the lower reservoir, one northerly named the Sinthe-N Canal, and the other southerly named the Sinthe-S Canal. These canal locations were made with a view to commanding all land that appeared to be topographically suited for irrigation from the base of the foothills to the low point of the valley. Field surveys were not possible because of the unsettled conditions in the area.

The Sinthe-N Canal will follow the contour for gravity flow to a point near Kyabin-in village, where a pump installation will raise the water to a higher level canal for continuation to lands around and north of Yamethin. This canal system will also feed the Kyeni tank operation at the southeast corner of Yamethin. The high-level canal will continue north to the Shweda Chaung, supplementing various small systems along the way, including those from the Kyeni tank. Two secondary canals will extend from the Sinthe-N Canal; one to continue northeasterly on the contour below the pump station, crossing the highway, railway and the Nawin Chaung for command of an area on the east side of the valley; the other canal branching off above the pump station and to continue at a high level across the Nawin Chaung along the south embankment of the Kyeni tank. This high-level branch will serve the area between the two branches, supplement the Kyeni tank supply and connect with an existing high-level canal along the foothills east of the Samon Chaung.

The interconnection of the distribution system from the Sinthe development with the Kyeni tank and other small irrigation systems around Yamethin, will firm the water supply for the whole area and make possible more economical use of all the natural water resources.

The Sinthe-S canal location will follow the contour southward from the reservoir to a point near Pyokke village. The terrain through which the lower end of this canal will be located is very rough but by damming streams to provide lakes through which to carry the water instead of using flumes or siphons, and constructing drops into these small lakes to lower the canal level as the slope of the land decreases southward, construction difficulties will be reduced.

The project includes the improvement of the existing Kyeni tank facilities, not only physically but also by correlation with the Sinthe Chaung irrigation canal system. Improvements will be made in the collection system which supplies the tank, to increase the catchment area and the amount of runoff intercepted. The embankments of the tank will be raised so that the capacity will be increased to approximately 18,000 acre feet. Close control of the releases from the tank, together with the water supplied from the Sinthe Chaung canals, will make it possible to serve the area adequately. All the yield from the small drainage areas supplying the tank can be controlled and used.

The construction on the Kyeni tank is principally the raising and extending of the existing embankments to increase the capacity of the tank, and to decrease the leakage at the north embankment. Evidence indicates that the present bund was constructed without adequate bonding to the original ground. At the highest portion of the north embankment leakage is evident and there has been slippage of the downstream face. The south embankment is to be increased in height sufficient for one bank of the irrigation canal.

There has been very little field information on either of the two dam sites on the Sinthe Chaung. The upper location is in a narrow valley with steep banks, especially on the right. The existence of this narrow neck connecting two separate valleys suggests very hard material. A concrete dam is planned for this site because the foundation material appears to be suitable for such a structure and also because it is desirable to construct the spillway integrally with the dam.

The lower dam site is at the wide outlet from the lower range of hills. Reports are that the base is entirely of sand for a considerable depth. Tests were made with a pressure bearing rod which theoretically indicates the location of harder materials at the depth where the pressure shows an increase. These high pressures were recorded at approximately 30 feet depth along the dam centerline. Test pits to check the accuracy of these findings were not made.

Detailed investigations of the dam sites and field surveys for the entire project will be necessary before design plans are prepared. An alternative plan for one dam on the Sinthe Chaung at the upper site, with the canals running therefrom, should be studied. This will require surveys for canal and structures locations in sufficient detail to make comparative cost estimates.

(3) Yezin Chaung Development

A canal system running southerly on the ridge between the Yezin and Sinthe Chaungs is now supplied for supplemental irrigation from a temporary-type diversion structure on the Yezin Chaung at the southern end of Yezin village. The yield from the drainage basin of the Yezin Chaung is limited because of the small area. There is some flow throughout the year as evidenced from the recorded flow shown in table IX–12, but rather than construct a permanent diversion structure for natural stream flow, a dam to form a reservoir for the total yield is part of the project plan.

All the agricultural area accessible to the Yezin Chaung irrigation development cannot be served from that source because of the inadequacy of the water supply. A canal distribution system for the entire area on both sides of the Sinthe Chaung has been planned with a supply canal connecting the Yezin Chaung reservoir and the Paunglaung River for the additional water required. The water supply and use distribution Table IX–11 shows in column 12 a total area under the Yezin Canal system of 56,250 acres, 20,780 of which are served from the Yezin Chaung source and 35,470 acres from the Paunglaung River source. Column 10 shows the water supply available from each source and column 17 the water required to serve the acreages adequately. The additional water needed to serve the entire agricultural area on both sides of the Sinthe Chaung is thus supplied from the Paunglaung River during period of excess in that river. The impounded flow of the Yezin Chaung is held in storage for use when the Paunglaung River supply is not available.

A pump lift is provided in the Yezin Canal on the west side of the Sinthe Chaung to raise water for delivery to higher-level land north of Kyidaunggan village.

(4) Paunglaung River

The development of the Paunglaung River is definitely for multi-purpose irrigation and hydroelectric power. Its place in the irrigation development of the entire Yamethin district irrigation project is very important, as is evidenced by the General Plan, Plates 21 to 23 inclusive. In addition to making possible the irrigation of 35,470 acres under the Yezin Chaung development as discussed heretofore, the water supply in the river below the hydroelectric installation will make possible pump installations to irrigate 72,240 acres, and the generation of electrical energy will supply cheap power for the pump installations on the river, the canal pump lift in the Yezin Chaung system for 9,240 acres, the canal pump lift in the Sinthe Chaung system for 39,500 acres and the well irrigation, discussed later, for 73,500 acres. The construction of a concrete dam and the hydroelectric generating equipment on the river at a site approximately three miles above Kyidaung village will provide all these facilities as well as furnish power through transmission lines to villages for domestic and industrial use up and down the valley. This water resource is in an advantageous position at the half-way point of an over-all valley development.

The storage capacity of the reservoir created by the dam on the Paunglaung River will be insufficient to store all the yield from the drainage area because of the narrowness of the valley. The runoff measurements recorded in Table IX–13 show a high stream flow for most of the year. Storage is needed at the present time only for carry-over during the low flows and for head to develop power. Additional storage may be developed up river at a later date when the demand for power increases.

The supply canal to the Yezin Chaung dam will be served from a gate in the right abutment of the dam. Water will flow from the reservoir for the total Yezin system irrigation during the months of excess supply in the Paunglaung River. The yield from the Yezin Chaung drainage basin will be held in reserve for use when needed, the Yezin storage acting as regulation for the system.

The pump installations on the river bank at the various locations from the river's entry into the valley southerly to Toungoo are planned for operation during a 10-hour period to coincide with the peak power generation. This will assure a sufficient water supply by release from the reservoir, even during the period of present low natural stream flow.

The geological report on the dam site was favorable in every respect. The dam site and the eastern and western portions of the reservoir basin are occupied by granites and mixed gneisses which have been formed by the intimate association of the granitic material with the rocks of the coal measures and are found near the junction of the granites with the coal measures. It is in an area of exposed bedrock with the flanks covered by residuum from rock decay and tanks. A saddle for use as a spillway is at the left abutment.

The reservoir site is underlain by rocks which are more or less impermeable except for limestones. Their position, structure relation to granite, and the topography of the area suggest that there is little chance of leakage through the limestone formation.

Provision for earthquake effects must be made in the dam design. The location is near a major boundary fault line between the crystalline rocks of the Shan Plateau on the east and the tertiary rocks on the west. Many earthquakes have been attributed to movements along this fault line.

The details of the hydroelectric development on this river are discussed in Chapter XIX.

(5) Ngalaik Chaung Development

West of Pyinmana, a stream originating in the Pegu Yomas emerges on the plain and discharges into the Sinthe Chaung east of Pyinmana. The entire yield is now wasted except for minor diversions above Pyangabye village. The development of this water resource for irrigation is planned to be effected by the construction of a dam at the narrow point of the valley west of Pyangabye village to store the flow in a reservoir. A natural saddle for the location of a spillway exists east of the dam site. The canal distribution system from the reservoir will command all the area on the west side of the Paunglaung River from Pyinmana south, crossing the Yonbin and Yenee Chaungs southerly to Yeni village.

Consideration was given to the development of the Yonbin Chaung, but it was abandoned because the reservoir would inundate the railway running up its valley. The water supply from the Ngalaik Chaung is sufficient for the entire acreage in the area, consequently the development of either the Yonbin or Yeni Chaungs was not necessary.

Foundation investigations and surveys will be required before design plans can be started.

(6) Saing and Swa Chaungs Development

The Swa Chaung of which the Saing Chaung is a branch, is the southernmost water resource for development in the project. The total yield from this large drainage basin now flows freely into the

Paunglaung River, often flooding the agriculture land and causing damage to the railway and highway during flood periods. Construction of a dam across these streams to form a reservoir for storage of the runoff will provide not only water for irrigation but also flood control.

The confluence of the Saing and Swa Chaungs is outside the range of hills from which the chaungs originate, consequently a single dam could not be built across the Swa Chaung for both streams. The two dams are planned as a continuous embankment, forming two reservoirs. Saddles make natural connections between the two reservoirs, and another saddle beyond the right abutment of the Swa Chaung dam provides a spillway location for the entire drainage basin area of both chaungs.

The area commanded by the irrigation system from the Swa Chaung reservoir lies entirely on the west side of the valley south of the east-west route of the Swa Chaung as it flows to the Paunglaung River. The area commanded by the irrigation system from the Saing Chaung reservoir lies entirely on the west side of the valley, north of the east-west route of the Swa Chaung as it flows to the Paunglaung River. There is sufficient yield from both drainage basin areas to serve adequately all the area from Yeni village south to Toungoo with enough excess for log sluicing from the reservoir. The spillway will be provided with sluice gates for this purpose.

Foundation investigations have not been made at this dam site.

(7) Well Irrigation Development

Surface water supply is not available for all the arable land in the project area north of Tatkon. Along the base of the Shan Hills, on the east side of the valley from Tatkon north, are hundreds of acres on which irrigation is not practiced. The water supply is limited to small streams, tanks, and rainfall collected in the bunds. The well irrigation development, as a unit of the Yamethin irrigation project, provides for the tapping of the subsurface water supply to irrigate this area properly.

Data gathered on existing open wells, and the fact that stream flow from the Shan Hills is practically continuous throughout the year, indicate the possible existence of a good underground water supply. Investigations of the dry streams may also disclose underground flow which could be tapped by means of infiltration galleries.

The proper depth, size and spacing of wells can be determined only by test wells and borings. This information will determine whether the wells will be individual installations or an interconnected series discharging into a main canal from which a distribution system could be constructed. The estimate of cost for this report is based on one installation for every 160 acres and a lift of 30 feet. If it is found that infiltration galleries in the water courses are feasible after field investigations are made, the cost of such construction would be much lower.

The wells are to be bored or drilled and lined with steel casing perforated where it passes through or extends into the water-bearing sand and gravel. Only the main supply canals are included in the construction estimate where pumping units are planned to operate together. Independent pumping units will bc necessary for small isolated areas. These have been estimated at 30% of the total pumping requirements.

Power for the operation of the pumps for this development was discussed under the Paunglaung River development. Until such time as this power is available, dual drive heads may be provided on the pumps for conversion to electric drive later.

3. KANDAW VILLAGE IRRIGATION PROJECT

The Kandaw village project is shown on General Plan Plate 31. The plan shows the dam and reservoir location near Kandaw village about 15 miles west of Pakokku, data pertinent to the reservoir capacity, canal locations, areas to be served under each canal division, drainage basin for the reservoir water supply, the general topography and other physical features of the whole area. The source of the water supply and its use distribution is shown in Table IX–17A (*see p.* 236), a detailed explanation of which is found in the third paragraph of Section B.

a. Present Economy

The area that will receive benefits from thc project by increased agricultural production through irrigation and domestic water from the storage reservoir is in Pakokku District. It is strictly agricultural with incomes derived entirely from agricultural production. Very few of the living necessities are purchased outside the area, and the everyday clothing is spun from raw cotton grown and prepared by the villagers.

The rainfall is very low, averaging approximately 25 inches annually. This falls in flash showers with the result that its full value is not received. During the long period of the dry season, members of each of the village families spend much time and effort in carrying and transporting water for domestic use.

Pakokku town, with a population of 29,824, is about 15 miles east of Kandaw village. The whole area shows the influence of the early history centered about Pagan some 40 miles downstream. It is said that race-horse breeding was an important business before the war, and many of the race-horses were brought to the area from Rangoon because of the dry climate.

Production is low in Pakokku District, and the acreage abandoned because of crop failure is high. Groundnuts are the main crop as shown with other information on the main crops in Table IX–9.

Kandaw, Kanyat, Kandein, and Kangyingon villages, situated around the project storage reservoir, will benefit from the water for domestic use.

b. Geology

The sand rock, sandstones and clays of the Irrawaddian Series have a very extensive distribution. The project area is alluvial, with Irrawadian materials in the drainage basin of the stream source and extending southward into the upper end of the cultivated area. The soil is a reddish fine sand with a small amount of clay silt. The general area from Pakokku to Kandaw is rolling hills with rather deep gulleys and stream courses pointing to the Irrawaddy River. Small valley areas and ridges between the gulleys make up the cultivated acreage. The project area is one of these valley areas.

c. Local Natural Conditions

(1) Meteorology

The southwest monsoon current travels over a wide expanse of land from the west before it reaches the Pakokku area. Pakokku is somewhat north of the direct path of the monsoon and the rainfall at the Arakan coast directly west of the project area is less than farther south, indicating less moisture carried by the air current as it starts over the Yomas and Chin Hills dividing India and Burma. The moisture is lost rapidly as it crosses this land area so that by the time Pakokku is reached not much is left, and the rainfall for the area is very low.

(2) Hydrology

The rain-gauge station at Tabya seven miles from Kandaw village records an average annual rainfall of 25 inches. This should be quite accurate for the drainage basin. The General Plan Plate 31 shows the drainage area of the stream supplying the project water storage. This is a very small area, and local physical evidence indicates a rapid storm runoff. The runoff factor was therefore estimated at 60%.

The estimated rainfall and runoff data for the supplemental supply from the Chaungmagaing Chaung are computed on the same basis as that from the Gwebin Chaung. Flow data are not available on either of the source streams, but it is quite certain that flow occurs only at a rainfall period, and that the stream is dry at other times.

(3) Use of Data

The data available were used as recorded for all the preliminary designs. The spillway design is based on a maximum single 24-hour storm record with a runoff of 80%. The dam is designed with sufficient height to absorb this total inflow above normal water surface and the spillway outlet to discharge this inflow within 72 hours with the peak discharge three times the average.

d. The Land

A number of soil samples, both surface and subsoil, were collected in the area to be irrigated. These were analyzed, as described briefly for soil classification in Chapter VIII on Agriculture, and approximately the same as for the Yamethin District irrigation project discussed heretofore. The land under this project was given rather detailed study leading to general soil classification and agricultural recommendations. The Soil Map (Plate 32) shows these classifications and the locations for each. The soil

TABLE IX – 16

KANDAW

CROP IRRIGATION REQUIREMENTS

(in inches)

Season	*Crop*	*"K"*	*"U"*	*"R"*	*"RE" (58%)*	*"U" – "RE"*	*"I" (50%)*
May 1–Aug. 15	Groundnuts	0·65	21·94	12·10	7·00	14·94	29·88
May 1–July 30	Sesamum	0·65	14·93	9·41	5·46	9·47	18·94
Aug. 1–Oct. 30	Sesamum	0·65	13·62	14·12	8·20	5·42	10·84
Aug. 1–Dec. 15	Groundnuts	0·65	19·22	15·51	9·00	10·22	20·44
Aug. 1–Oct. 30	Maize	0·70	14·68	14·12	8·20	6·46	12·92
Aug. 1–Nov. 15	Millet	0·60	14·34	14·77	8·55	5·79	11·58
June 1–Oct. 30	Pulses	0·65	23·44	20·69	12·00	11·44	22·88

grading was based upon a numerical rating of each soil sample analyzed, assigning relative values to the soil characteristics examined.

Four per cent of the soil in the area to be irrigated under the project was found to be sandy loams Grades I and II suitable for corn, millet and legumes; 60% was found to be sandy Grade III suitable for groundnuts and sesamum.

The determination of irrigation requirements was made in detail, taking into consideration crop types and soils on which grown, and the consumptive use of water for each crop. The Blaney-Criddle method was used for determining consumptive use and irrigation requirements of the actual crops to be grown.

Table IX–16 lists the irrigation requirements of the crops best suited to be grown in the area. The factors have been described previously in paragraph B-2-d. The relatively flat terrain throughout the project area was considered to lose 3% of the rainfall as runoff waste. Predominately sandy soils of the area were calculated to lose 10% of the rainfall to percolation waste. It was considered that 5% would be lost due to the type and density of the vegetative cover. Surface runoff losses due to rainfall intensity were considered to approximate 17% and those from other causes 7%. It is calculated that 58% of the rainfall will be used by crops. Fifty per cent losses of water supplied to the crop have been calculated to occur. It is considered that half the loss will be through surface runoff, and the other half to deep percolation.

Most of the soil is very rich and well adapted to groundnuts if water for irrigation is available and nitrogen fertilizer is added. It has been estimated that the per-acre yield could be increased four times over the present by addition of water and nitrogen and improved seed and cultivation methods.

The amount of water supplement to rainfall required per crop season is estimated at 20 inches, using the data in Table IX–16 and computed as follows :

Groundnuts	48 per cent	×	25·00	=	12·00
Sesamum	12 per cent	×	15·00	=	1·80
Corn	15 per cent	×	12·92	=	1·94
Millet	10 per cent	×	11·58	=	1·15
Legumes	15 per cent	×	22·88	=	3·44
	100 per cent				20·33

Only one crop per year is planned for because of the limited water supply. If it is found that the water supply is more than estimated, a second crop will add to the benefits.

e. Project Plan

All the details shown on the General Plan Plate 31 are general. The over-all planning was prepared by use of one inch to the mile scale maps and from field reconnaissance. A field topographic survey was made on the reservoir area and dam location. The reservoir capacity was calculated from this survey.

The source of supply and use distribution data contained in Table IX–17A (*see next page*), together with the General Plan Plate 31 are self-explanatory. The yield from the small drainage area supplying the reservoir may be insufficient for the reservoir capacity and the agriculture and village requirements. The project development plan includes the diversion of the flow of the Chaungmagaing Chaung east of the Gwebin Chaung, to the Kandaw Village reservoir. This feature of the project development could wait until the reservoir embankment is constructed and one or two years' operation gives more complete data on the area. On the other hand, the additional water supply source will increase the acreage served and provide a greater guarantee of the supply.

Only one crop per year has been scheduled under use distribution because of the small water supply and the large amount of water required to irrigate the sandy soil and to supplement the low rainfall. The project total cost is high as shown in the Estimate of Cost and Benefits Table IX–19, Section C of this chapter (*see p.* 242). Its justification may not be determined entirely from an economic standpoint, however, but the social, sanitary and living benefits brought to the villages in the vicinity should also be considered.

Complete field surveys and design plans may reduce the cost as estimated, but it is also suggested that test borings and studies of the underground water supply should be made to determine the possibility of the water being supplied from wells. If such a supply were found in sufficient quantity, the costly reservoir embankment shown in the project plan could be eliminated.

4. LOIKAW AREA IRRIGATION PROJECT

The general plan of this development is shown on Plate 33. The source of the water supply and its use distribution is shown in Table IX–17B (*see p.* 237), a detailed explanation of which is found in the third paragraph of Section B.

a. Present Economy

The project location is the Kayah State in the Shan Plateau. The Karen group of races (including Padaungs and Toungthus) make up three fourths of the population and most of the remainder belong to the Shan race. The Shans normally inhabit the valleys and much of the flat tableland, while the more primitive animistic tribes live in the hills, chiefly perhaps to avoid the malaria of the plains to which they are susceptible. The estimated population density is 16 per square mile with about 79,000 persons in the whole state.

Irrigation from mountain streams and lakes is fairly common, the rice growing in many places on step terraces high up the mountain valleys. The area is self-sufficient in rice. Groundnuts are common on the higher sandy ground. Other crops are oranges, papayas, vegetables, and maize. Other economic products are tin, teakwood and tungsten. The average rainfall at Loikaw for a 35-year period is 46 inches. The temperature ranges from about 46° to 91°F.

Transportation facilities in the valley are limited to the highway running north to south for the entire length, and to air travel. The locality is isolated to the extent that there is not an east-west road connection to the central belt of Burma except at Taunggyi, about 100 miles north of Loikaw. Future over-all developments for Burma include a proposed highway from Loikaw to Pyinmana.

b. Geology

The area in the trough between two ranges of hills, known as the Yawnghwe Valley, is typical of many of its kind in the Shan Plateau. Sediment washed in from the surrounding hills by short, fast-flowing streams has filled the original depression. The valley area lies at about elevation 2,900 feet.

Inle Lake lies at the northern end of this valley, occupying a low area that has not been entirely filled with sediment. Alluvial plains formed at its two ends are indicative of what has taken place in the whole valley over the course of time. Drainage into the lake is from both hill ranges, but the main flow is from the area north and west. All the silt brought down by the streams is deposited before it reaches the middle of the lake. It is probable that a large tract south of the lake was once under water and has been gradually filled in by the deposition of silt. The lake originally may have been a hundred miles long and several hundred feet deep.

TABLE IX – 17A

KANDAW VILLAGE IRRIGATION PROJECT

WATER SUPPLY AND USE DISTRIBUTION

1	2	3	4	5	6	7	8	9	10
	Drainage Basin				*Reservoir Storage (acre feet)*				
Source	*Area (sq. mi.)*	*Annual Average Rainfall (ins.)*	*Estimated Average Runoff (per cent)*	*Estimated Average Yield (acre feet)*	*Use Provision*	*Capacity*	*Evaporation Loss*	*Dead Storage*	*Net Available for Irrigation*
KANDAW VILLAGE									
Gwebin Chaung	18	*25	60	14,400	Reservoir	18,000	2,400	—	12,000
Chaungmagaing Chaung	11	*25	60	8,800	Diversion	—	—	—	8,800
Total	—	—	—	23,200	—	—	—	—	20,800

11	12	13	14	15	16	17	18
	Land to be Served			*Water Distribution (acre feet)*			
Location: Refer to General Plan	*Gross Acres*	*Net Acres Irrigated*	*Net Acres 2nd Crop*	*1st Crop Supplement*	*2nd Crop Total Irrigation*	*Total*	*Remarks*
KANDAW VILLAGE	15,600	12,500	—	20,800	—	20,800	Dry Season Crop not Planned

*Tabya rain-gauge station.

TABLE IX – 17B

LOIKAW AREA IRRIGATION PROJECT
WATER SUPPLY AND USE DISTRIBUTION

1	2	3	4	5	6	7	8	9	10
	Drainage Basin				*Reservoir Storage (acre feet)*				
Source	*Area (sq. mi.)*	*Annual Average Rainfall (ins.)*	*Estimated Average Runoff (per cent)*	*Estimated Average Yield (acre feet)*	*Use Provision*	*Capacity*	*Evaporation Loss*	*Dead Storage*	*Net Available for Irrigation*
LOIKAW AREA									
Inle Lake	1,383	48	33	1,170,000	Gate control	—	—	—	170,000
Balu Chaung	1,185	46	33	960,000	Pump	—	—	—	*
Total	—	—	—	2,130,000	—	—	—	—	—

11	12	13	14	15	16	17	18
	Land to be Served			*Water Distribution (acre feet)*			
Location: Refer to General Plan	*Gross Acres*	*Net Acres Irrigated*	*Net Acres 2nd Crop*	*1st Crop Supplement*	*2nd Crop Total Irrigation*	*Total*	*Remarks*
LOIKAW AREA							
Namtok Canal	12,950	9,700	7,300	9,700	21,900	31,600	Pump
Pekon Canal	11,750	8,800	6,600	8,800	19,800	28,600	”
East Loikaw Canal	9,000	6,800	5,100	6,800	15,300	22,100	”
West Loikaw Canal	16,800	12,600	9,500	12,600	28,500	41,100	”
Total	50,500	37,900	28,500	37,900	85,500	123,400	

*Flow available when needed.

The river which flows from the lake disappears underground and again emerges as the Balu Chaung which continues southward through the length of the entire valley and finds its way to the Salween River. Falls occur below Loikaw, but the river from the lake to Loikaw flows rather quietly through a wide valley with an occasional narrowing in the hills to form high stream banks.

c. Local Natural Conditions

(1) Meteorology

The southwest monsoon from the Bay of Bengal crosses the Arakan and Pegu Yomas until it strikes the Shan Plateau and the higher mountains between Burma and China. The wind then turns toward the north in a wide arc so that the wind direction over most of Burma is from the southeast during the monsoon period. As the period comes to a close, north winds gradually take over until the direction has completely changed. These northerly land winds continue until the monsoon returns again with its moisture.

The temperature records available are for the station at Loikaw during 1952. The maximum temperature of 91·1°F. occurred in April and the minimum temperature of 46·4°F. occurred in January. The minimum monthly variation was in July with 4·6° and the maximum in February with 36·3°. The mean monthly variation in temperature was 21·7°. Since evaporation is definitely influenced by temperature ranges, the characteristics of the cycle give some idea of the rate of evaporation.

Moisture transpiration is dependent on air movement and precipitation is therefore affected by the winds. The maximum monthly wind speed record at Loikaw in 1952 for an average of 24 hours was 4·9 miles per hour in August. Rainfall data of record for the same period indicate maximum rainfall in the same month.

(2) Hydrology

The rainfall data for the project area were taken at two stations, Loikaw and Yawnghwe. Both stations are in the valley, but since the drainage areas for the individual chaungs flowing into Inle Lake and Balu Chaung are small, and the valley itself is part of a great plateau, the records should be quite representative of the whole area. Rainfall records for the two stations are shown in Table IX–18.

Stream-flow records of the Balu Chaung taken at Loikaw for October, November and December, 1952, and January to June inclusive, 1953, are shown in Table IX–18. Records for July through September were estimated from a constructed flow curve using rainfall records for a 35-year period. There is sufficient natural flow in the river most of the year with possible storage during the months of April, May and June. These flows may be increased from Inle Lake storage if means of regulating the lake flow are provided.

Table IX–17B shows the estimated yield from both the Inle Lake drainage area and the Balu Chaung drainage area below the lake. The amount of runoff was determined as shown in Table IX–18. There is ample water supply from both sources for the project, and very little regulation would be required in the lake for the entire irrigation requirements, not counting the flow in the Chaung.

The runoff as indicated by the stream-flow record is very low for the characteristics of the drainage areas. Geology of the area indicates the possibility that the water often disappears below ground, especially from a lake such as the one in the valley. The low stream flow at Loikaw would indicate that some of the water supply in the area is lost in this way, possibly feeding other streams flowing from the plateau.

d. The Land

Very few data are available regarding soil and production in the Yawnghwe Valley except for the information gained from field reconnaissance and discussion with local officials. The geology of the area gives some idea of the soil types. Most of the soil is a reddish sandy loam, possibly heavier in the valleys as evidenced by the paddy cultivation. Groundnuts, maize and even some paddy are grown on the upland slopes. Tall grass grows on the higher plateau areas.

The valley is well suited to livestock. Temperature, rainfall and altitude, together with rich upland areas for grazing and rich lowland for production of feeds, are ideal for such an industry. Gram and groundnut production combined with dairy and livestock would be an ideal combination.

e. Project Plan

The part of the project development by which the agriculture area is to be irrigated is shown on General Plan Plate 33. The water is to be raised from the Balu Chaung by pumping, with four installations, two on each bank of the river. These locations together with the canals, areas in acres to be served under each unit, the general topography, and other physical features of the area are shown on the plan.

All the details shown are general, the planning prepared entirely by use of one inch to the mile scale maps with contours at 50-foot intervals, and from information gathered on field reconnaissance and discussion with officials familiar with the area.

Diversion to canals by pumping was the means most suitable for the purpose because of the nature of the topography. A dam in the vicinity of the pump installations would flood good farm land above, and a dam above would require long canals to serve the area suitable for irrigation. A weir is planned for construction just below the pumps, however, for the purpose of regulating the water surface to a constant elevation as high as the chaung banks will allow without overflow. This will keep the pumping head constant and possibly as low as ten feet. (Actual head will require surveys before it can be determined accurately.)

The supply of water flowing in the Balu Chaung annually is much in excess of what will be required for two crops per year. This is clearly shown in Table IX 17B described heretofore. The months of April, May and June, however, may be deficient as shown by the stream-flow record, Table IX–18, if the chaung flow is not regulated. This regulation may be obtained by constructing control gates in the chaung near Samka village to hold back storage in Inle Lake for use during the months needed. This regulation could also be used for spreading out the supply in the chaung to increase the minimum flow for the hydro-electric installation proposed below Loikaw. Refer to Chapter XIX of the over-all report for this hydro-electric project discussion.

Information of record on Inle Lake indicates that the depth varies from 12 feet in the dry season to 20 feet in the rainy season. This would suggest

TABLE IX – 18

BALU CHAUNG

STREAM FLOW 1952 – 53

(thousands of c.f.s.)

Balu Chaung Drainage Area = 1,185 sq. mi. Inle Lake Drainage Area = 1,383 sq. mi.

	1953						*35-Year Record*			*1952*		
	Jan.	*Feb.*	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
1	1·26	1·04	0·75	0·47	1·04	0·35	Estimated discharge 31 days at 5·98	Estimated discharge 31 days at 6·52	Estimated discharge 30 days at 6·6	7·20	5·20	2·17
2	1·26	1·02	0·75	0·48	1·02	0·36				7·10	5·05	2·09
3	1·26	1·01	0·73	0·48	1·01	0·36				7·10	4·92	2·02
4	1·26	1·02	0·72	0·48	1·01	0·36				7·00	4·72	1·93
5	1·25	1·00	0·71	0·42	1·00	0·36				6·95	4·52	1·92
6	1·26	1·00	0·69	0·41	1·00	0·36				6·95	4·37	1·87
7	1·25	0·99	0·68	0·48	0·70	0·36				6·90	4·22	1·83
8	1·24	0·97	0·64	0·47	0·66	0·36				6·90	4·05	1·80
9	1·24	0·97	0·64	0·41	0·73	0·42				6·80	3·92	1·77
10	1·23	0·96	0·63	0·45	0·67	0·49				6·80	3·82	1·69
11	1·22	0·96	0·61	0·40	0·64	0·49				6·80	3·72	1·68
12	1·21	0·95	0·61	0·40	0·65	0·47				6·70	3·70	1·68
13	1·21	0·94	0·60	0·39	0·59	0·47				6·60	3·61	1·68
14	1·20	0·94	0·59	0·39	0·60	0·48				6·55	3·52	1·65
15	1·18	0·92	0·58	0·39	0·56	0·64				6·50	3·34	1·65
16	1·15	0·90	0·57	0·37	0·54	0·66				6·42	3·30	1·62
17	1·13	0·89	0·56	0·37	0·51	0·63				6·35	3·32	1·57
18	1·10	0·89	0·56	0·36	0·51	0·60				6·20	3·10	1·55
19	1·10	0·88	0·55	0·36	0·41	0·79				6·15	3·02	1·55
20	1·09	0·87	0·55	0·37	0·33	0·71				6·12	2·94	1·55
21	1·08	0·86	0·55	0·36	0·32	0·66				6·05	2·87	1·52
22	1·06	0·86	0·55	0·36	0·32	0·62				6·02	2·78	1·49
23	1·04	0·85	0·57	0·36	0·32	0·56				5·95	2·72	1·48
24	1·04	0·84	0·54	0·36	0·35	0·60				5·75	2·62	1·45
25	1·03	0·82	0·54	0·36	0·36	0·60				5·75	2·54	1·41
26	1·03	0·81	0·52	0·36	0·36	0·60				5·80	2·48	1·40
27	1·02	0·79	0·50	0·36	0·36	0·53				5·70	2·42	1·37
28	1·01	0·78	0·49	0·36	0·36	0·53				5·55	2·32	1·33
29	1·00	—	0·49	0·38	0·36	0·51				5·42	2·26	1·32
30	1·02	—	0·47	0·40	0·36	0·51				5·30	2·21	1·29
31	1·08	—	0·45	—	0·42	—				5·25	—	—
	35·51	25·73	18·39	12·01	18·07	15·44	185·00	202·00	198·00	196·63	103·48	49·33

RAINFALL IN INCHES

	Years Record	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total*
Loikaw	35	0·18	0·22	0·49	1·66	5·68	6·66	7·41	8·16	7·92	5·04	1·96	0·67	46·03
Yawnghwe	33	0·07	0·19	0·42	2·12	6·79	5·79	6·99	8·91	8·31	5·18	2·39	0·51	47·67

Average rainfall = 3·9 inches.

$$\text{Runoff factor} = \frac{1059{\cdot}59 \times 1{,}000 \times 2}{3{\cdot}9 \times 640 \times 2{,}568} = 33\%.$$

that the lake could be regulated by at least the amount retained in eight feet without bringing hardship to present occupants of the shore line. The volume of this eight feet of storage was estimated at 160,000 acre feet, based on the area of the lake as indicated on the one inch to the mile scale maps. The surface area of the lake is hard to determine because of its great spread during high water. It is believed that this volume is a conservative estimate and that together with intermediate regulation it would guarantee a minimum flow throughout the year of over 1,000 c.f.s.

Field surveys, reconnaissance and investigations will be required before contract design plans are prepared. The irrigation project together with the hydroelectric project downstream will provide initial requirements for an over-all economic development of the Yawnghwe Valley.

C. ESTIMATE OF COSTS AND BENEFITS

The economic feasibility of any development is dependent on the benefits that may be derived therefrom. Estimated benefits are balanced against the estimated cost of the works including interest and amortization. The total estimate of cost, annual benefits, annual charges and ratio of cost to benefits for the first 12 projects listed in Table IX–4 of this report are shown in Table IX–19 (*see p.* 243). The Mu River irrigation project and the Yamethin District irrigation project are sub-divided into project stages and the data shown for each division. The land area in gross acres to be served under each development is also shown.

1. ESTIMATE OF COST

All cost estimating is based on materials and material quantities derived from preliminary designs and suggestive structure details. Unit costs are based on known unit price bids for similar items, on the assumption that the construction will be done by or under experienced contractors and in accordance with recognized good engineering and construction practice. Reinforcing and structural steel, gates, pipe and equipment, and on some projects, contractors' overhead and profit, are considered as foreign expenditures.

The costing does not include the distribution system for individual farm or ownership services. This part of the irrigation system exists in most places at this time and will require only revision and improvement. The nature of the present farm plot layout makes the development of a complete new distribution system impractical. This may be done later as the farm methods are improved. A nominal amount has been included in the estimate for initial improvements in the existing distribution system and farm plot layout.

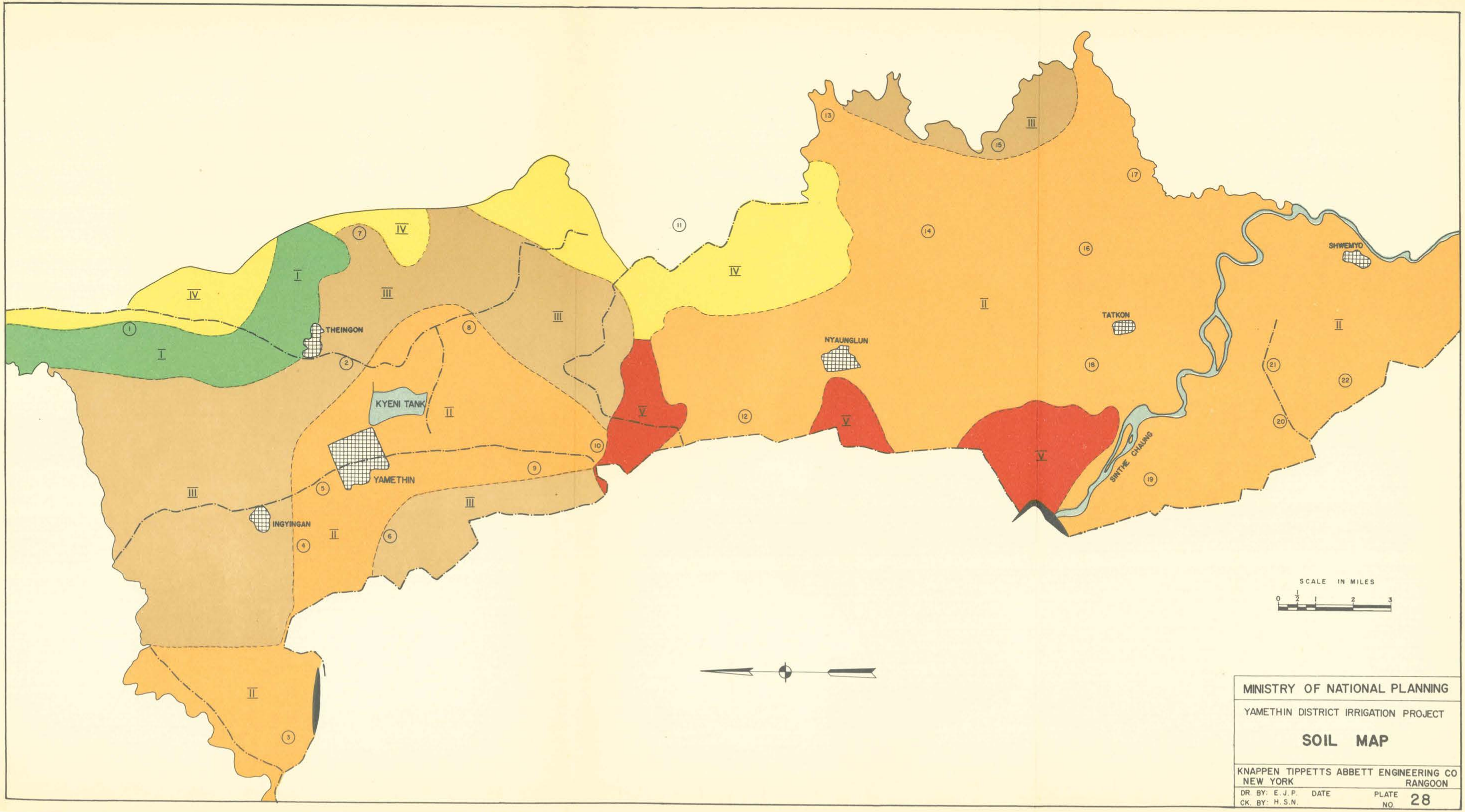
Engineering includes design and construction, plans, specifications and supervision, field surveys and topographic mapping, investigations, technical assistance, construction engineering and inspection. Foreign expenditures are assumed for the design and construction plans, specifications and supervision as specified for project units in Table IX–20 (*see p.* 246), topographic mapping and technical assistance for investigations, and local designing, plan preparation and supervision. All field surveys required for the design and preparation of plans and the construction engineering staff are assumed as local expenditures.

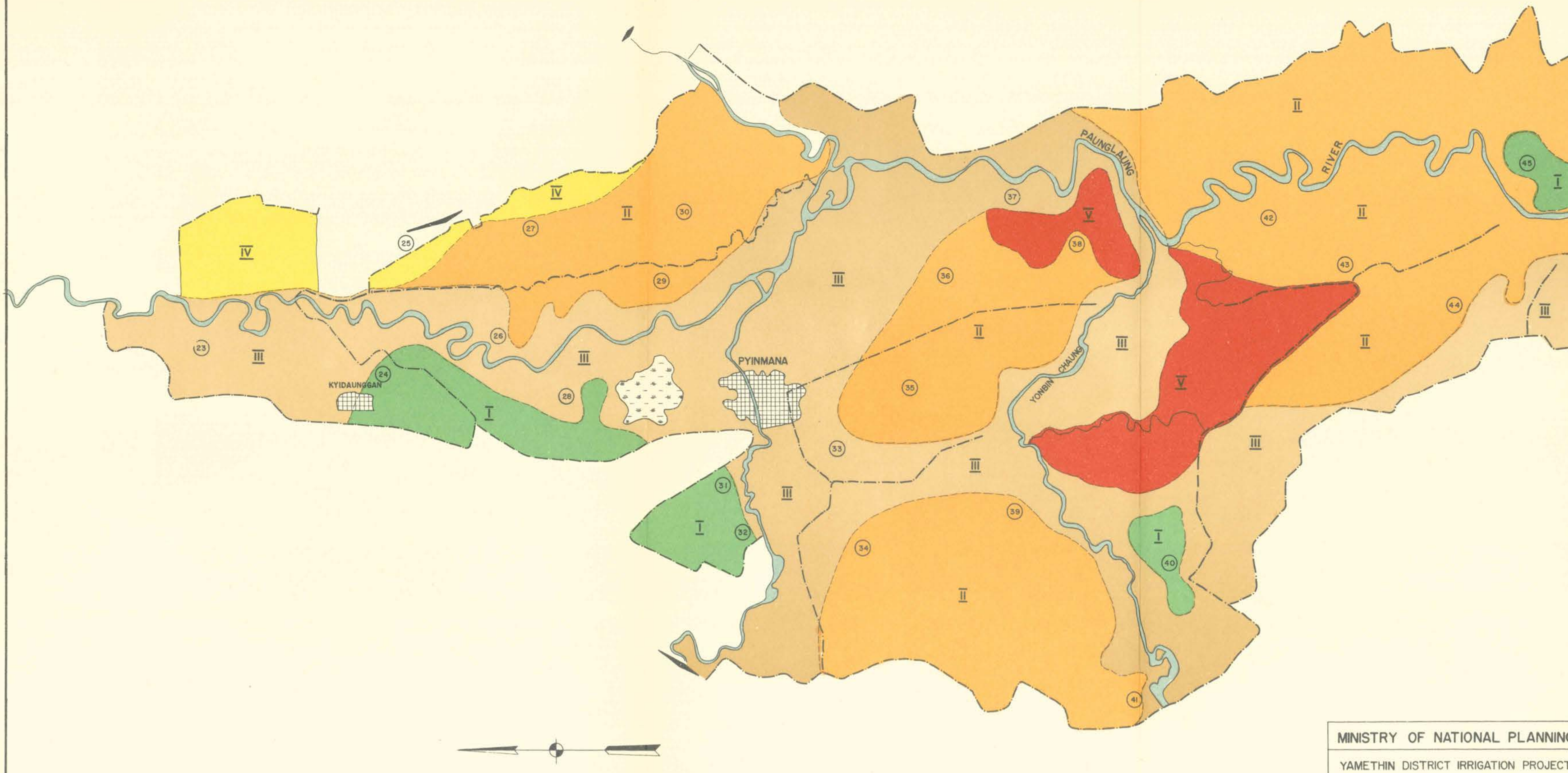
2. BENEFITS

The benefits are direct returns from crop production resulting from the facilities of the project. These are net income benefits over and above present production using records of acreage shown and yield for each crop for a five-year period ending June, 1940. Indirect benefits such as increased transportation, local business, labor opportunities, and living conditions will result from a project development, but these have not been included.

Benefits from two classifications of cultivation methods have been estimated and are shown in Table IX–19. These classifications were described in Section A-3-c of this chapter. The benefit to the farmer from production is the increased crop production value over present income including farm operation costs. The benefit to the Government is the profit to SAMB from increased rice exports due to the increased production, and the decreases in imports or increase in exports of certain crops because of the increases of production of those crops. The values shown are ultimate maximum benefits for both classifications of cultivation methods.

Present production is based on the data contained in the report "An Economic Classification of Land in Burma" by J. T. Sanders and U Ba Tin. The percentage of acreage shown therein as matured for each district is used in this computation for each of the project units. Production under "Present Methods" with irrigation assumes all the net acreage under a project as producing one crop per year. This represents an increase in matured acres of from 20% to 30% over the present and is part of the benefits from the project. Other benefits are those from increase in yield from controlled water. Benefits under "Modern Methods" are from increased yields because of sufficient water, fertilizer where practical, improved seeds, crop rotation and improved cultivation methods, and a full double crop program. All increased rice production is assumed as exported in


THEINGON
KYENI TANK
YAMETHIN
INGYINGAN
NYAUNGLUN
TATKON
SHWEMYO
SINTHE CHAUNG
I
II
III
IV
V
SCALE IN MILES
0 ½ 1 2 3
MINISTRY OF NATIONAL PLANNING
YAMETHIN DISTRICT IRRIGATION PROJECT
SOIL MAP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK RANGOON
DR. BY: E. J. P. DATE
CK. BY: H. S. N.
PLATE NO. 28



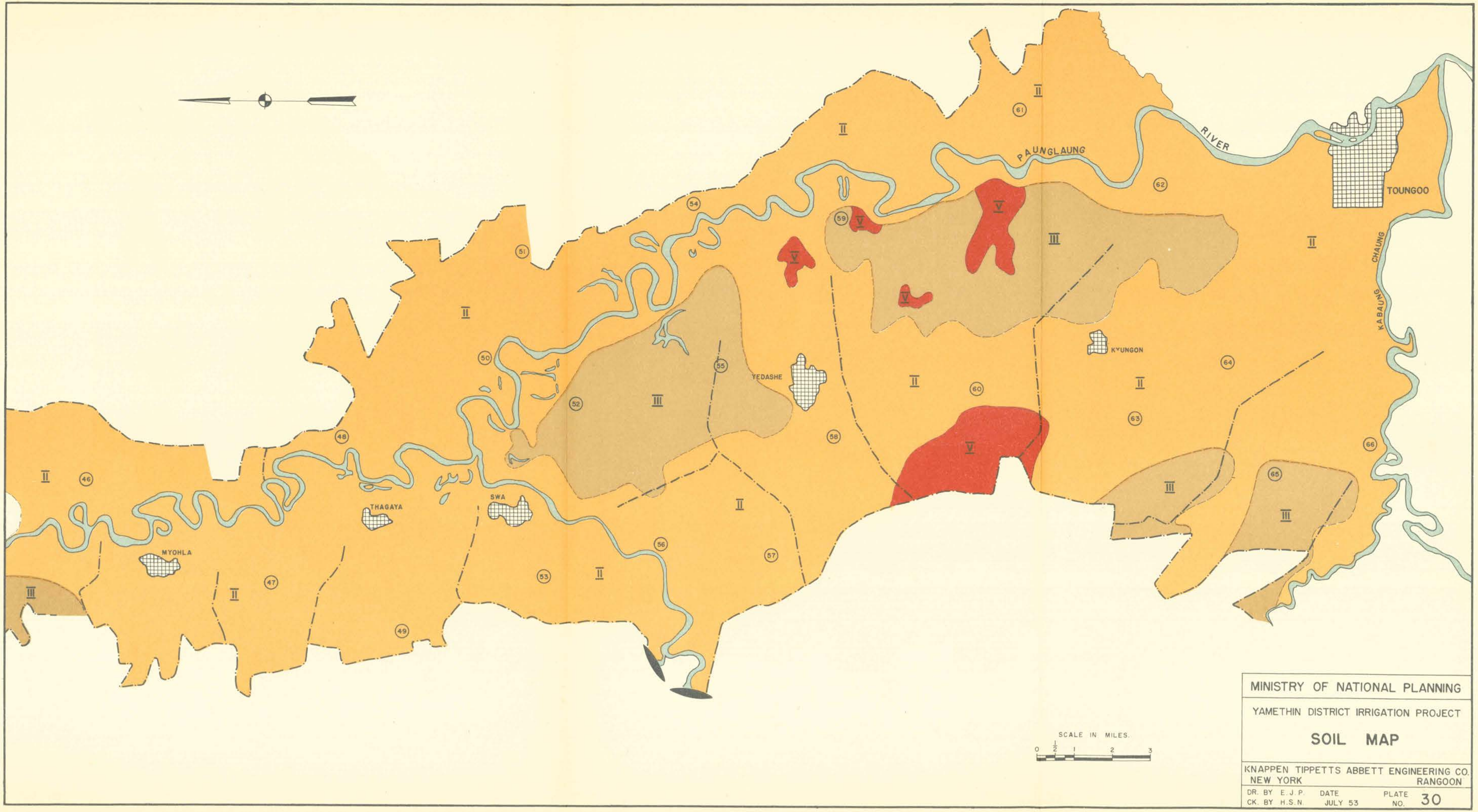
MINISTRY OF NATIONAL PLANNING

YAMETHIN DISTRICT IRRIGATION PROJECT

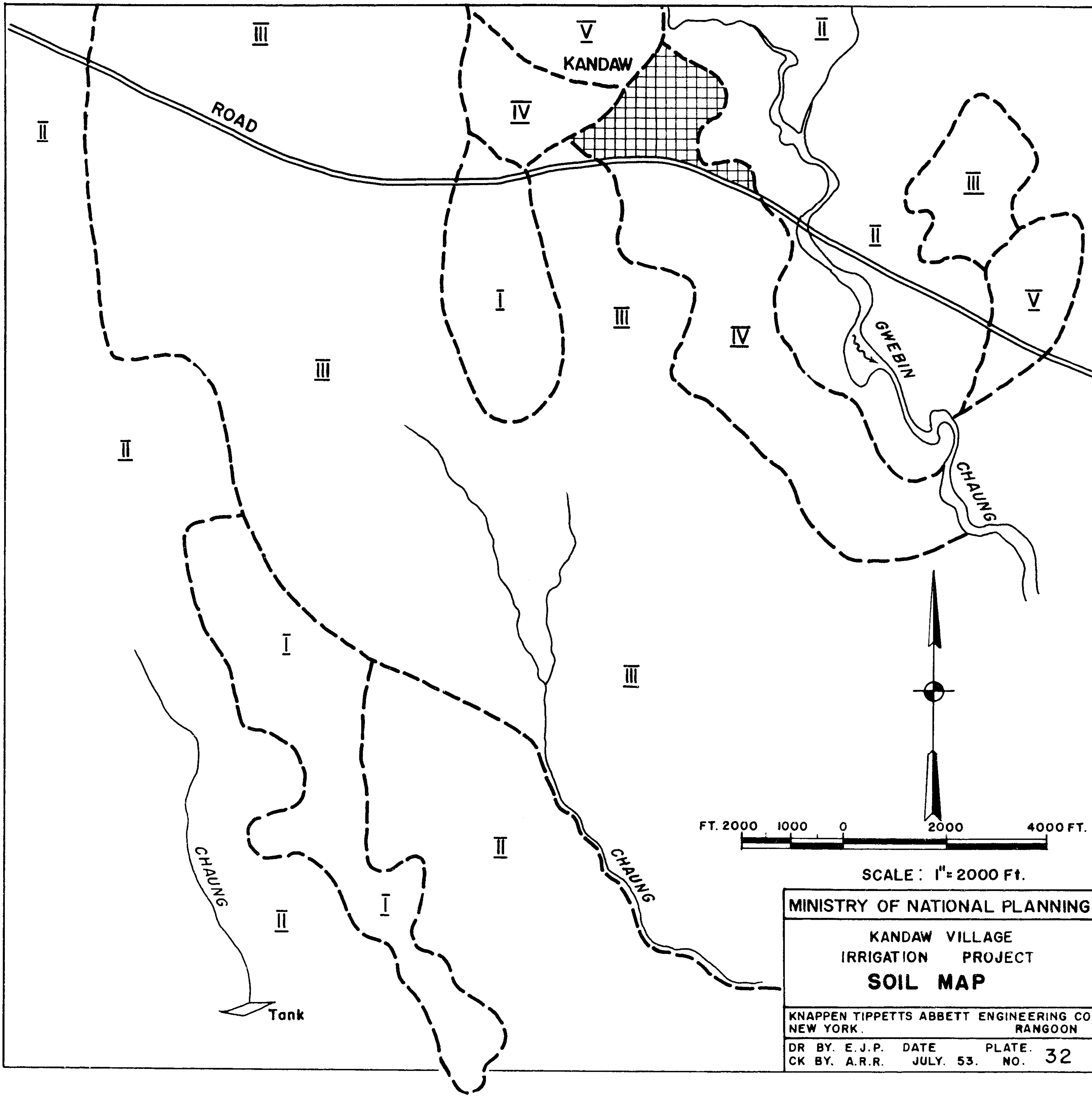
SOIL MAP

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON

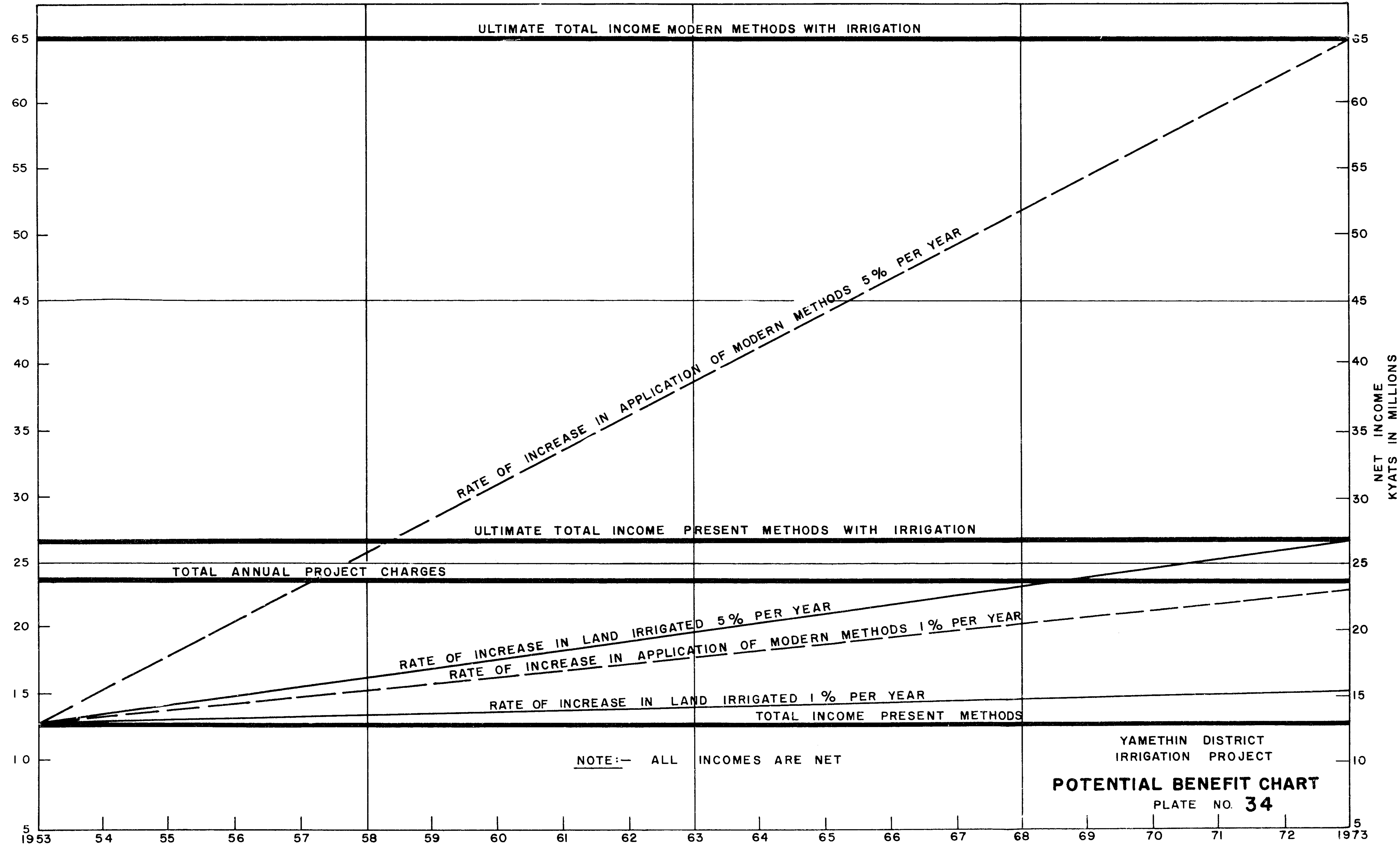
DR. BY E.J.P. DATE PLATE
CK. BY H.S.N. JULY 53 NO. 29


PAUNGLAUNG
RIVER
TOUNGOO
KABAUNG CHAUNG
KYUNGON
YEDASHE
THAGAYA
SWA
MYOHLA
SCALE IN MILES.
MINISTRY OF NATIONAL PLANNING
YAMETHIN DISTRICT IRRIGATION PROJECT
SOIL MAP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
DR. BY E. J. P.
CK. BY H. S. N.
DATE
JULY 53
PLATE NO. 30

DIVERSION DAM
682
450
NGAPAUNGGAN
250
KANTHONZE
Chaung
Chaungmagaing
200
500
300
350
Gwebin Chaung
550
THEKKEGYIN
Supply Canal
450
TANBINGAN
SAINGGAUNG
East Canal
DAM
400
THITBINGYI
400
Gwebin Chaung
DAHATCHAUK
Chaung
BE
THAMINBOK
Thandaung
KANDAW
ANAUK MAGYIGAN
KANYAT
West Canal
KALAGYAUNG
MYAUNGDWIN
550
KANDEIN
AUNGTHA
KANTHIT
Nyaunggar Kan.
Kyunbobin Kan
350
KANBYINGON
.357
W.S. Elev. 450
Reservoir Capacity
18000 Ac. Ft.
.456
450
500
SHIMMAGAN
SCALE IN MILES
1/2
0
1
SHIMMAGAN MYAUKSU
864
.636
300
PALAN-O
ZIGON
550
500
MINISTRY OF NATIONAL PLANNING
KANDAW VILLAGE
IRRIGATION PROJECT
GENERAL PLAN
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK.
RANGOON.
DR BY E.J.P.
CK BY A.R.R.
DATE
JULY. 53.
PLATE
NO.
31


III
V
KANDAW
II
ROAD
II
IV
III
II
V
I
III
IV
GWEBIN
III
II
CHAUNG
I
III
II
CHAUNG
I
II
CHAUNG
Tank
FT. 2000 1000 0 2000 4000 FT.
SCALE : 1" = 2000 Ft.
MINISTRY OF NATIONAL PLANNING
KANDAW VILLAGE
IRRIGATION PROJECT
SOIL MAP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO
NEW YORK. RANGOON
DR BY. E.J.P. DATE PLATE.
CK BY. A.R.R. JULY. 53. NO. 32


NAMTOK CANAL
NAMTOK
SAKOI
AREA = 12950 Acres
AREA = 11750 Acres
PUMP
PEKON
PEKON-CANAL
PUMP
FLOW
PUMPS
WEIR
MONG-PAI
EAST-LOIKAW-CANAL
AREA = 9000 Acres
BA-LU CHAUNG
LOIKAW
HIGHWAY
AREA = 16800 Acres
WEST-LOIKAW-CANAL
NAMME KON
NGWEDAUNG
Mi. 1 ½ 0 1 MILE
SCALE IN MILES
MINISTRY OF NATIONAL PLANNING
LOIKAW AREA IRRIGATION PROJECT
GENERAL PLAN
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK. RANGOON
DR. BY E.J.P. DATE PLATE
CK. BY A.R.R. JULY, 53. NO. 33



YAMETHIN DISTRICT
IRRIGATION PROJECT

POTENTIAL BENEFIT CHART

PLATE NO. 34

addition to the present exports. Increased production in groundnuts and sesamum is also a benefit to the nation because of its effect on imports of these products. Areas presently high in rice acreage will show higher benefits because of the increases in exports of that product.

Benefits for different rates of development for both classifications of cultivation using the Yamethin District irrigation project as a model are shown in Plate 34, together with the present total net production income and the potential production incomes from both classifications. The total annual charges for the project are also indicated. The chart graphically shows the rate of development necessary for production to balance the annual charges and the total potential benefits that are possible from the land. The chart is prepared for one project only, but is typical for all those recommended. The potential benefits on other projects may be even greater.

3. ANNUAL CHARGES

The annual charges shown in Table IX–19 are cost of power for pumping, operation and maintenance of the project system, and interest and amortization of the investment. These individual charges were computed as follows:

Interest

Local money expenditures	4%
Foreign money expenditures ..	5%

Amortization—Same rate of interest

50-year life on all units of the project except pump equipment

25-year life on all pump equipment

Operation and Maintenance

Dams and embankments ..	1% of cost
Structures and canals ..	5% of cost
Power for pumping	Pyas 15 per kWh

The long life assumed for gates and equipment other than pumping is believed feasible because of the high operation and maintenance. The short life assumed for the dam and embankments resulted from the heavy silt content of the streams. The initial power costs will be high but as the power demand increases so that the hydroelectric installations operate at greater capacity, power costs will decrease materially.

4. RATIO COST TO BENEFITS

The ratio of cost to benefits in Table IX–19 is net benefits annually as against total annual charges. Ratios for both classifications of cultivation methods are shown. These ratios clearly indicate the projects most feasible for development from the standpoint of economics. Indirect benefits have not been included in this Report because all projects are considered as being equal in this respect.

Ratios of cost to benefits for the "Storage Reservoir and Dam" and "West Side Canal System" under the Mu River irrigation project are higher than other units of the project. This is because the benefits for the storage reservoir and dam are from the Shwebo and Ye-U systems which are constructed and in operation and are not charged against the project; and the "West Side Canal System" charges contain no costs of the storage reservoir and dam.

The Yezin system, Paunglaung River supply and Paunglaung River pumping units of the Yamethin District irrigation project are made possible by water from the Paunglaung River development. Therefore the annual charges on a portion of the Paunglaung River dam and reservoir capital cost are allocated to these units of the project. The amount of the annual charges is based on K95,00,000 which is the portion of the total cost of the hydroelectric development estimated as contributing to irrigation benefits. These annual charges are included in the total charges against the project units for computing the benefit-to-cost ratio. The Paunglaung River hydroelectric project discussion in Chapter XIX includes the total estimate of cost for the dam and reservoir, but shows this credit in computing the estimated cost of power. None of the capital cost is included in the Yamethin District irrigation project units, Table IX–19.

D. RECOMMENDATIONS

1. CONTINUATION OF PROJECT STUDIES

The studies and details used in the preparation of the projects presented in this Report are incomplete. Sufficient data were available only for preliminary planning to determine economic and physical feasibility of a particular development. Detailed field surveys are necessary for exact location of project units and for preparation of contract design plans.

It is recommended:

a. Surveys

That field explorations and surveys for dam locations and topography, reservoir capacity and area, canal locations, and structure site topography proceed as rapidly as possible on all those projects selected for "Early Implementation"; that procedure be in accordance with the schedule of priority and selection of the project units; and that the work be performed by either the Department of Irrigation personnel or parties selected for the purpose, all under the supervision and direction of the Ministry of National Planning.

TABLE

ESTIMATED CAPITAL COST,

1	2	3	4	5
	Proposed Development			
Project	*Gross Acres*	*Estimated Cost (K)*		
		Works	*Engineering*	*Total*
Mu River Irrigation				
Storage Reservoir and Dam	—	3,86,09,700	48,01,300	4,34,11,000
Diversion Dam and Old Mu Canal	151,831	3,90,94,150	40,43,850	4,31,38,000
West Side Canal System	539,408	4,21,78,000	38,05,000	4,59,83,000
Chindwin River Pumping	166,400	1,89,34,000	31,53,000	2,20,87,000
Irrawaddy River Pumping	122,500	1,57,62,300	25,76,700	1,83,39,000
Seikpyu Installation	19,250	17,94,200	3,97,800	21,92,000
Total	999,389	15,63,72,350	1,87,77,650	17,51,50,000
Yamethin District Irrigation				
Sinthe Chaung Development—Gravity	22,600	3,57,80,700	51,73,300	4,09,54,000
Sinthe Chaung above Pump and Kyeni Tank	88,100	1,34,30,500	19,45,500	1,53,76,000
Thitson Chaung Development	32,500	1,95,89,400	28,31,600	2,24,21,000
Well Pump Irrigation	73,500	1,33,34,200	20,34,800	1,53,69,000
Yezin Chaung Development	20,780	1,93,80,100	27,38,900	2,21,19,000
Yezin System—Paunglaung River Supply	35,470	78,95,500	14,55,500	93,51,000
Paunglaung River Pumping	72,240	1,28,91,600	19,63,400	1,48,55,000
Ngalaik Chaung Development	94,360	3,20,21,400	46,42,600	3,66,64,000
Swa and Saing Chaungs Development	169,900	7,38,51,500	1,04,30,500	8,42,82,000
Total	609,450	22,81,74,900	3,32,16,100	26,13,91,000
Kandaw Village Irrigation	15,600	67,29,710	8,15,290	75,45,000
Loikaw Area Irrigation	50,500	66,30,100	7,70,900	74,01,000
Meiktila Lake Silt Removal	Not Estimated—Additional study data and investigations required			
Pakokku Pump Irrigation from Wells	‡40	21,600	2,400	§24,000
Lower Delta Pump Irrigation				
Thongwa Island	70,000	1,23,70,600	6,18,400	1,29,89,000
Yandoon Island	157,000	2,20,56,000	11,03,000	2,31,59,000
Henzada-Zalun	300,000	3,06,07,000	15,31,000	3,21,38,000
Maubin Island	121,000	1,38,99,000	6,95,000	1,45,94,000
Pegu Area	40,000	98,36,000	4,84,000	1,03,20,000
Total	688,000	8,87,68,600	44,31,400	9,32,00,000
Buthidaung Area Pump Irrigation	100,000	75,10,000	7,50,000	82,60,000

*No allowance has been made for indirect benefits.

†Does not include charges from Paunglaung River development

‡Gross acres per pump installation.

§Results of field investigations and test wells may reduce this cost.

IX – 19

ANNUAL CHARGES AND BENEFITS

6	7	8	9	10	11	12	13
Net Annual Benefits (K)*		*Annual Charges (K)*				*Ratio*	
						Benefit to Cost	
Present Farm Methods	*Modern Farm Methods*	*Operation and Maintenance*	*Power for Pumping*	*Interest and Amortization*	*Total Charges*	*Present Farm Methods*	*Modern Farm Methods*
1,79,38,000	7,87,00,000	10,34,007	—	21,94,666	32,28,673	5·55	24·40
65,90,000	2,90,59,000	13,61,090	—	21,50,670	35,11,760	1·88	8·28
2,15,10,000	8,32,30,000	16,97,758	—	11,25,306	28,23,064	7·62	29·40
60,19,000	1,93,69,000	8,77,890	5,73,760	12,19,640	26,71,290	2·26	7·24
45,46,000	1,41,03,000	7,41,520	2,94,750	10,65,680	21,01,950	2·16	6·70
7,44,000	23,76,000	81,080	1,03,620	1,19,100	3,03,800	2·46	7·84
5,73,47,000	22,68,37,000	57,93,345	9,72,130	78,75,062	1,46,40,537	3·90	15·50
15,48,000	59,30,000	8,20,280	—	20,60,639	28,80,919	0·54	2·06
6,72,000	25,80,000	3,71,110	9,22,500	7,88,618	20,82,228	0·32	1·24
8,74,000	33,50,000	5,59,630	—	10,75,062	16,34,692	0·54	2·05
15,24,000	58,50,000	4,20,900	7,51,500	9,83,659	21,56,059	0·71	2·72
5,11,000	19,60,000	3,83,150	—	11,09,720	14,92,870	0·34	1·31
6,90,000	26,50,000	4,03,610	1,31,000	5,76,200	†11,10,810	0·52	1·98
16,08,000	61,50,000	6,38,075	14,61,000	8,69,559	†29,68,634	0·50	1·92
22,68,000	87,00,000	10,37,973	—	18,59,698	28,97,671	0·78	3·00
45,12,000	1,50,00,000	21,94,100	—	42,48,948	64,43,048	0·70	2·33
1,42,07,000	5,21,70,000	68,28,828	33,66,000	1,35,72,103	2,36,66,931	0·60	2·20
6,31,000	11,35,000	3,70,130	—	3,69,420	7,39,550	0·85	1·54
11,15,000	42,80,000	2,82,120	6,51,570	4,48,790	13,82,480	0·81	3·10
2,020	3,630	700	510	1,580	2,790	0·73	1·30
32,80,000	1,46,40,000	5,58,000	4,42,000	7,18,580	17,18,580	1·91	8·53
78,90,000	2,95,50,000	11,46,180	6,80,000	13,47,832	31,74,012	2·48	9·30
70,70,000	5,02,60,000	18,03,400	25,70,000	11,80,300	55,53,700	1·27	9·05
41,40,000	2,20,40,000	6,86,950	5,54,000	8,67,364	21,08,314	1·96	10·45
10,55,000	72,75,000	4,85,650	3,44,000	5,86,240	14,15,890	0·75	5·14
—	—	46,80,180	45,90,000	47,00,316	1,39,70,496	—	—
31,30,000	1,76,40,000	6,50,000	1,82,000	5,58,600	13,90,600	2·25	12·10

applicable to the Unit. See Section C–4 for explanation.

b. Topographic Mapping

That aerial photo coverage for and including topographic mapping at two-foot contour intervals, and mosaic pictures at scale of one inch to 660 feet be provided for the areas to be served under each project.

c. Investigations

That all dam locations be fully investigated prior to design for foundation stability, leakage and other physical characteristics by borings and laboratory compaction tests, test pits, and soil tests of borrow areas for dam embankment materials; and that soil investigations be made by borings along canal locations and the need for lining determined.

d. Alternative Plans

That alternative plans mentioned heretofore be fully studied and considered from detailed field surveys, explorations, and detailed estimates, particularly the possible elimination of the diversion dam on the Mu River irrigation project, the possible elimination of the diversion dam on the Thitson Chaung development and the lower dam on the Sinthe Chaung development of the Yamethin District irrigation project, and possible sub-surface water source in the Kandaw Village project area to replace the present project plan.

e. Soil Classification and Crop Studies

That classification of the soils in the areas to be irrigated under each project be made in accordance with techniques described in Chapter VIII on Agriculture; and that crop and crop rotation plans suitable to each type of soil and grade be established.

f. Underground Water Resource

That test borings and wells be started without delay in the Yamethin District, Pakokku District and Sagaing District to determine water table and supply and other data for installation of domestic and irrigation wells.

g. Hydrologic Data

That stream-flow gauging be continued and new stations established on all streams, especially those within project developments; that rain-gauge stations be established in the mountains and the records correlated with stream-flow gauging; and that automatic rainfall and stream-flow recorders be installed to obtain continuous records.

2. CONSTRUCTION

Heavy construction, although it has some aspects in common with manufacturing, is a unique industry. No other industry shares comparable requirements for thorough scientific exploration of the site; for climatic and hydrographic record; for geologic and topographic maps; for detailed engineering analyses and drawings; for rapid mobilization and competent supervision of technical field forces and powerful construction equipment; for careful specification and inspection of structures, equipment and materials; and above all for skilled coordination and timing of mobilization, operations and deliveries. Normally, three principals are concerned in such construction work: the Government for which the work is being performed; the engineer who, representing the Government, furnishes the professional and technical skill required in the planning, administration and supervision of construction; and the contractor who furnishes the material, labor and equipment necessary for the physical accomplishment of the work. A customary and necessary exception to these functions is the furnishing by the Government of key or special materials and equipment under specifications prepared by the engineer.

Practically all important public and private irrigation works are constructed by contracting firms who specialize in the particular type of work represented by the projects. Qualified contractors are experienced in the administration of construction operation, including purchase of materials and management of labor. They maintain an organization of trained supervisors, mechanics and workmen who will be available for work with local labor. This specialization does not exist in Burma because of the lack of experience. Local contractors are in a position, however, to take a vital part in the project construction under proper guidance and assistance. They will no doubt furnish the bulk of the construction force.

The engineer is a very important link in a construction program. It is important that he have ability and experience in the line of work represented by the project construction. Upon the award of a contract he assumes direction of the work, approving all construction methods and supervising all operations on behalf of the owner. He is usually represented on the job by an experienced resident engineer and a staff of engineer inspectors and laboratory specialists who control the work, workmanship, materials and equipment. The engineer enforces the provisions of the plans and specifications, and within the limitations of discretion provided in the contract, authorizes appropriate changes and extras.

There are several types of construction contracts under which the project work may be authorized. Any contract must contain a real agreement or meeting of the minds; the subject matter must be lawful; there must be a valid consideration; the parties must be legally competent; and the contract must comply with the provisions of the law with regard to form. Because of the uncertainties and administrative difficulties of construction in this area, competitive bidding procedures might prove so unattractive to contractors that negotiated contracts would be necessary. In general, this type of contract is based on the premise that the Government will pay the actual cost of the work plus some compensation for the services, facilities, and technical knowledge of the contractor.

It is recommended:

a. Construction Schedule and Estimated Expenditures

That the schedule shown in Table IX–20 (*see p.* 246) be adopted for early implementation.

b. Construction Method

That the method of construction be as shown in Table IX–20 for each unit of the project; that the construction be by local or foreign contractor as listed; that construction listed for local contract be supervised by foreign technical personnel employed by the Government; that force account or day labor method of construction be not used for any of the work because of lack of experienced supervisory and procurement personnel unless and until long-range training develops a staff of demonstrated capability.

c. Contracts

That notices be published advising that competitive bids will be received for all the work to be done by local contract, either independently or for a general contractor, and that the award will be given to the lowest qualified bidder.

(1) Competitive Bid Contract

That all local contracts, including subcontracts under a foreign general contract, be on a competitive bid basis, either lump sum or unit price.

(2) Negotiated Bid Contract

That foreign contracts be negotiated on a cost-plus-fixed-fee basis, with a profit sharing clause, with the fixed fee based on a preliminary estimate of the work and the profit sharing provision allowing the contractor a share of any saving if the actual cost is less than the original estimate.

3. DESIGN, SPECIFICATION AND SUPERVISION OF CONSTRUCTION

In general, personnel experienced in field exploration, design, preparation of specifications and supervision of heavy construction are not available in Burma. It is therefore recommended that contracts be negotiated with appropriate foreign engineering firms to furnish the key personnel required to supervise, supplement and train available Burmese engineers in the performance of these necessary functions. Different projects or major segments of different projects may be given to different firms, but all phases of one piece of work from exploration through supervision of construction should be handled by one firm to insure continuity and to prevent the misinterpretations and evasions of responsibility otherwise inevitable. The cost-plus-percentage-fee contract with a fixed minimum is the customary and desirable form of contract for professional services of this kind.

4. ORGANIZATION FOR PLANNING

Project planning is distinguished from the preparation of designs and specifications in the degree to which field data are complete and accurate. "Plans," as distinguished from "designs and specifications," may be based on meager reconnaissance, with topography, foundation conditions, water supply and costs explored only sufficiently to insure that some economic solution exists. As the Government of Burma is now constituted, this function properly rests with the Ministry of National Planning. The further exhaustive exploration required and the preparation of designs and specifications for a project would properly be the function of the engineering firm retained on the project in collaboration with both the Ministry of National Planning and the Department of Irrigation, utilizing the field forces and engineering staffs of both agencies to the limit of their availability. If the design and construction functions of the Department of Irrigation are absorbed in a new Ministry of Engineering Services as recommended in Chapter VI, the work should be carried on with the principal engineering assistance being furnished by that agency.

5. OPERATION AND MAINTENANCE

a. Department of Irrigation

The development and operation of irrigation systems has both engineering and agricultural aspects. The design and construction of irrigation works requires a wide variety of engineering talent familiar with electrical, mechanical, structural, hydraulic and earth features of many kinds. The application of water to crops requires agricultural knowledge in the fields of agronomy, soil chemistry and agricultural engineering. The staffing of the Ministry of Agriculture to provide both the engineering and agricultural staffs would be difficult, and, if similar engineering skills are to be required by other ministries for power, flood control and similar heavy construction operations, perhaps an unnecessary duplication.

It is therefore recommended:

(1) Organization

That the Department of Irrigation continue under the Ministry of Agriculture, but only as an agency for

TABLE

CONSTRUCTION SCHEDULE

(In

Project	*Design and Supervision*	*Contract*		*1st Year*	*2nd Year*
		By Whom	*Type*		
Mu River Irrigation					
Storage Reservoir and Dam	Foreign	Foreign	General	35,00,000	1,05,13,000
Diversion and Old Mu Canal	Foreign	Foreign	General	—	78,39,000
West Side Canal System	—	—	—	—	—
West Side Canal	Foreign	Foreign	General	—	—
Branch System	Local	Local	Subcontract	—	—
Chindwin River Pumping	Foreign	Local	Separate	—	—
Irrawaddy River Pumping	Local	Local	Separate	—	—
Seikpyu Installation	Local	Local	Separate	—	21,92,000
Yamethin District Irrigation					
Sinthe Chaung Dams and	Foreign	Foreign	General	66,93,000	1,14,95,000
Gravity Irrigation System	Foreign	Local	Subcontract	—	—
Sinthe System, Pump and Above	Local	Local	Separate	53,73,000	21,18,000
Thitson Chaung	Foreign	Local	General	9,77,000	64,24,000
Well Pumping	Local	Local	Separate	4,50,000	14,09,000
Yezin Chaung Dam and	Foreign	Foreign	General	—	—
Irrigation System	Foreign	Local	Subcontract	—	—
Paunglaung—Yezin System	Foreign	Local	General	—	—
Paunglaung River Pumping	Local	Local	Separate	—	—
Ngalaik Chaung	Local	Local	General	—	—
Swa and Saing Chaungs	Local	Local	General	—	—
Kandaw Village Irrigation	Local	Local	General	27,97,000	47,48,000
Loikaw Area Irrigation	Foreign	Local	Separate	6,62,000	14,02,000
Total	—	—	—	2,04,52,000	4,81,40,000

IX - 20

AND EXPENDITURES
Kyats)

3rd Year	*4th Year*	*5th Year*	*6th Year*	*7th Year*	*8th Year*	*9th Year*	*10th Year*
1,81,62,000	1,12,36,000	—	—	—	—	—	—
98,64,000	1,12,25,000	1,42,10,000	—	—	—	—	—
—	57,30,000	70,45,000	1,85,15,000	1,46,93,000	—	—	—
43,54,000	47,38,000	66,73,000	63,22,000	—	—	—	—
32,49,000	37,70,000	39,70,000	36,75,000	36,75,000	—	—	—
1,26,43,000	1,01,23,000	—	—	—	—	—	—
23,46,000	27,87,000	27,52,000	—	—	—	—	—
85,64,000	64,56,000	—	—	—	—	—	—
14,11,000	14,61,000	17,55,000	17,55,000	17,55,000	17,91,000	17,91,000	17,91,000
—	73,80,000	1,47,39,000	—	—	—	—	—
—	—	39,51,000	54,00,000	—	—	—	—
—	—	—	32,62,000	34,51,000	33,99,000	34,49,000	12,94,000
—	—	45,77,000	1,63,47,000	93,67,000	63,73,000	—	—
—	—	—	—	1,73,39,000	3,10,88,000	2,73,67,000	84,88,000
14,85,000	19,30,000	19,22,000	—	—	—	—	—
6,20,78,000	6,68,36,000	6,15,94,000	5,52,76,000	5,02,80,000	4,26,51,000	3,26,07,000	1,15,73,000

Total Expenditures 45,14,87,000

supervision of water distribution, application of water to the land, farm drainage practices, relations with water users, and methods of irrigation farming; that the functions of dredging, river control, flood control, design, construction, reservoir operation, heavy maintenance operations, and general field exploration and field data gathering for design be assigned appropriately to the proposed new Ministry of Engineering Services and the Mercantile Marine Department; and that a new code be prepared to replace the 1933 Public Works Department Code.

(2) Maintenance Equipment

That equipment such as mechanical loaders, draglines, graders, compressors and pumps for dewatering be purchased for more efficient maintenance; that a communications system be installed.

(3) Water Control and Measurement

That all service openings be provided with gates for the measurement of water releases, and that strict control be maintained on the amounts discharged; that each area to be irrigated from a service be studied for crop water use requirements, and that assistance be given the cultivators in ways and means of economically using the available supply.

(4) Water Code and Priority of Use

That a Water and Priority of Use Code be established relating to use of water and the rights of the various users; that all irrigation installations be recorded with the Department of Irrigation, indicating source of supply, installation details, land to be irrigated and location.

(5) Operational Manual

That a new Maintenance, Operation and Inspection Manual be written to replace the present Manual of Departmental Instructions, last printed in 1943.

b. Irrigation Practices

The irrigation developments proposed are extensive and will require large expenditures of funds. Full benefits will depend on the degree of skill with which farm operations are adapted to irrigation. Proper use of water and the correct amount used, drainage provided with its use, use of the right crop for the soil and other practices which facilitate the economical use of the available resources will be the deciding factors in project success. Teaching and demonstration of irrigation practices for water control, measurement, application and drainage are all-important, not only for economy but for proper plant growth and soil use.

It is recommended that the demonstration farms for the promotion and demonstration of improved cultivation practices discussed in Chapter VIII also be used for teaching and demonstrating proper irrigation practices.

6. SPECIFIC PROJECTS

It is recommended that the implementation of the following developments proceed without delay, with the year 1953–54 the target date for starting:

(a) Mu River Irrigation Project—Storage Reservoir Dam.
- (1) Investigations and surveys.
- (2) Design.
- (3) Construction.

(b) Yamethin District Irrigation Project—Sinthe Chaung Development.
- (1) Investigations and surveys.
- (2) Design.
- (3) Construction.

(c) Kandaw Village Irrigation Project.
- (1) Investigations and surveys.
- (2) Design.
- (3) Construction.

(d) Yamethin District Irrigation Project—Thitson Chaung Development. Well Irrigation Development.
- (1) Investigations, surveys and test wells.
- (2) Design.

(e) Loikaw Area Irrigation Project.
- (1) Investigations and surveys.

It is recommended that as soon as surveys and investigations have proceeded in sufficient detail, design contracts be negotiated for the first two items.

PART IV

TRANSPORTATION

CHAPTER X

TRANSPORTATION SYSTEM

A. PRESENT SITUATION

1. THE IMPORTANCE OF TRANSPORT

In the general sense, transportation is a form of communication. Together with signal communication, transportation shares the responsibility for the interchange of information and goods. Without the two, there can be neither cultural nor material progress. An efficient transportation system, once brought within the economic and geographic reach of the general population, in addition to meeting immediate and obvious requirements, stimulates the spontaneous and independent growth in settlement, production and trade of all kinds. No quantitative measure of this by-product of transportation has been devised, but it is reasonable to predict that it can amount to several times the original volume of activity in a given area in a few years.

Conversely, the failure of transport and communications quickly reduces any civilization to chaos and lowers the living standard of its people to the barest subsistence standard.

2. INFLUENCE OF TOPOGRAPHY

Surface transportation preferably follows a water grade. The mountain chains and rivers of Burma lie roughly north and south. Transverse communication is more difficult except by air. In the delta region, stream crossings are so numerous that water and air must substitute almost entirely for road and rail. The mountainous terrain along the boundaries of Burma makes communication with her neighbors difficult by land. Sea and air will therefore doubtless remain the dominant forms of foreign transport for a long time.

3. EXISTING TRANSPORT

The effect of the recent war, the postwar reconstruction, the debilitating effects of insurgent activities, and the present status of each of these several modes of transportation, road, rail, air, sea and river, are described in the separate chapters dealing with each of these subjects. In general, schedules and services are limited by lack of road, railway, aerodrome and port improvements, and by the continuing depredations of insurgents. With respect to the latter problem, it may be said in passing that, although some developments must await the full restoration of civil order, to some extent transportation and development must be pushed into the fringes of the disturbed areas with such local protection as can be provided in order to introduce those very opportunities for production, trade and employment which in themselves will aid in alleviating the disaffection.

B. INTERRELATIONS

1. RELATION TO OTHER DEVELOPMENTS

The function of a transportation system for Burma is to handle the domestic and foreign commerce created by the cultural, industrial and agricultural activity of the nation. To a certain extent also, the developments in these fields will provide the fuel, equipment and supplies with which to support transport.

2. INTERDEPENDENCE OF TRANSPORTATION MODES

The several modes of transportation are among themselves both competitive and complementary. Each has its sphere in which it is able to provide the most economic service, but this sphere is not fixed and may change with the changing nature of the traffic, costs of operation, or extension into new areas. Waterways should cost the least to operate per ton mile, and have marked advantages for handling local commodities for which delivery time is relatively unimportant. The railways are suited to approximately constant traffic loads and long hauls for which regularity and reliability of schedules are important. Road transport affords maximum flexibility of routes and schedules and door-to-door service, but is not always able to provide for continuing large tonnage movement over the long hauls. However, private transport may compete successfully for either short- or long-haul traffic in certain commodities. The airways sell speed, and are competitive in any commodity which can afford the premium costs. Airways also sometimes provide the only access to locations to which surface transport is denied either by the high cost of road or rail construction or by the blocking of surface routes by natural causes or hostile military action.

In general, the presence of several modes of transport in one community permits the widest diversity of industrial and agricultural development in that community. Though a community may at one time be adequately served by one or more modes of transport, it does not necessarily follow that the addition of another mode of transport might not be advantageous. The presence of a new mode of transport may stimulate the production or exchange of new or additional commodities not previously produced. It may be said, therefore, that the common goal of all the transport systems should be to provide the widest variety of service and the most frequent and convenient service to every community, the current or potential traffic of which will support the service, either independently of the economics of any other activity or in combination with the economics of another mode of transportation or activity, whose development justifies the sharing of a transport facility's economic burden.

3. DELINEATION OF TRANSPORT FUNCTIONS

The functions and services furnished by the several modes of transportation are separately described in succeeding chapters. To bring these functions into clear perspective, it is suggested that, in addition to the common functions stated in the preceding paragraph, the separate functions of these several modes of transportation should be defined in terms somewhat similar to the following.

a. Seaports

At designated seaports, to plan, provide, operate and maintain facilities for ocean and river shipping: channels, harbor structures, handling facilities for passengers and freight, terminal facilities for private and public agencies serving or served by water transport, communications and navigation aids. To license, lease, and otherwise direct and control the use of port facilities, and to direct and control waterborne traffic.

b. Ocean Shipping

To plan, provide, subsidize and operate ocean-going vessels in domestic and foreign service.

c. Inland Waterways

To plan, provide, subsidize, and operate river vessels in domestic service on the navigable rivers. To plan, provide, operate, lease and maintain facilities for river shipping (except at seaports): river ports, terminal and loading facilities for private and public agencies serving or served by inland water transport, communications (except as handled by the Telecommunications Department) and navigation aids. To direct and control waterborne river traffic.

d. Railways

To plan, provide, operate and maintain railway transport and transport facilities to all communities and customers, domestic or foreign, the traffic with which or other value as public policy will economically support the investment and operating costs.

e. Highways

To plan, provide and maintain a competent network of highways and roads and their associated structures connecting all domestic and neighboring communities, from the serving of which the public benefit shall be found to warrant the capital and maintenance costs.

f. Airways

To plan, provide, operate and maintain airways, transport and transport facilities to all communities and customers, domestic or foreign, the traffic with which or other value as public policy will economically support the investment and operating costs.

Whenever joint facilities or connecting schedules are found desirable by any or several means of transport, it should be the obligation of any means of transport so requested to participate in such facilities or to provide such services by joint plan, any expenses not directly carried by the traffic being contributed by the requesting transport agency.

C. OPERATING REQUIREMENTS

1. COMPARISON OF PROBLEMS

(a) In the sphere of procedures, correlation and coordination are required particularly between the activities of the Department of Communications and each of the transport agencies. Subject to the approval of the Ministry of Transport and Communications only in case of dispute, the Department of Communications should decide the extent to which it can provide communications and communications equipment services requested by the transport agencies. While controlling the allocation of communications facilities, the Department should be liberal in affording independent nets and facilities needed by the transport agencies. Coordination will also be required between highways and the other transport agencies in providing feeder roads to rail, water and air terminals; and between seaports and inland waterways in providing joint use facilities and operating procedures at seaports. Combined passenger booking offices would also be advantageous in some communities and at major rail, air and water terminals. Periodic conferences should be held between operating counterparts of the several transport agencies for comparison of methods of dispatching, booking, communications, freight and passenger handling, administration, equipment, supplies, maintenance, finance and procurement.

(b) In the sphere of supplies, fuel, equipment, maintenance and purchasing, pooling of activities will probably be found advantageous in such matters as:

(1) Communications equipment—purchase and installation by Department of Telecommunications.

(2) Diesel fuel—purchase by Ministry and storage and distribution by Railways.

(3) Maintenance organization—common regional or divisional patterns may be found useful. Maintenance is too easily neglected, must be serviced by strong organization adequatcly equipped, and must be continuous.

(4) Crushed stone and other aggregates—quarrying and production by Highways, transport and use by other agencies.

(c) In the sphere of administration, each has the common requirement for sufficient autonomy to properly order its own affairs, to expediently expend funds allocated, and to utilize equipment and supplies which should be at its own disposal. Each has a training problem and should be encouraged to establish and conduct instruction, both full time and on-the-job, at whatever level required. Training assistance and training aids should be furnished by an adjunct of the university or other central agency as required.

(d) In the sphere of basic data, research and development, each agency requires the stimulus of continuing analysis, study, collection of data, and technical research. Each should be concerned with the collection and comparison of operating facts, with the trial of improved procedures and the development and trial of improved equipment and materials. Scientific research and experimentation should be brought to bear on transport problems with the collaboration and assistance of the transport agencies. Official and technical personnel of the transport agencies should be sent abroad for observation and study of overseas practices, and funds should be made available for subscription to a wide variety of technical publications.

2. TRANSPORTATION RATES

Reasonable transportation costs are necessary for the economic development of any country or area. The rates for carrying goods and passengers required for new development or normal governmental, cultural and commercial activities in any section of the country should support the cost of the services, but should not be so high as to discourage enterprise and limit traffic.

Transportation costs depend upon the volume of traffic available to the transporting agency. If the hauling facility can be operated at a relatively high percentage of its capacity, assuming that the investment in the plant and equipment has been reasonable, the rates that can be charged for service are certain to be reasonablc. Whcn it is necessary to extend new transportation service into an area for the purpose of development it will be necessary for Government to (1) subsidize the facility until sufficient traffic develops to support it or (2) increase rates on othcr scctions of the system until a volume of traffic adequate to support the investment and operating costs of the facility has been attained.

Where Government is the owner of essentially all means of transport except highway vehicles, the regulation of rates to provide equitablc costs to all communities served is not difficult. The records necessary to provide the basis for the establishment of equitable transportation rates arc rcadily available to it. It is necessary to establish an independent staff of administrators, accountants and engineers to review and analyze the records of the governmcnt-owned transportation systems. This analysis should set up: first, an accurate appraisal of the physical value of the plant and equipment of the transportation facility; second, a statement of the annual operating, maintenance and other variable costs entailed in carrying goods and passengers and rendering other transportation service; and third, a study of the amount of traffic, passengers, goods and other services handled, giving consideration to the type of commodity, its origin and destination, special equipment required for handling and other factors affecting its cost of transportation. From these data, rate schedules can be derived for all services rendered by the transportation agencies that will be equitable for all commodities and between all communities, and that will support the transportation service.

Existing rates are, in general, not set up to foster nation-wide development. While it has not been possible to make a comprehensive analysis of the rate structure of the principal transportation agencies, some spot checks have been made. These are presented in Table X–1 (*see next page*).

The present rate for the movement of cement from Thayetmyo to Rangoon is K38.92 per ton or K0·147 per ton mile. A careful estimate of providing suitable equipment for this service and including all operation and administration costs indicates that the transportation should be provided for about K0.04 per ton mile. The present charge for transporting coal from Kalewa to Rangoon is given as K110.50 per ton or K0·166 per ton mile. The estimated cost of providing this service when the mine is in operation and large quantitics are being moved is K35.75 per ton or K0·0537 per ton mile. The cost of transporting a bulldozer in 1953 from Rangoon to Kalewa for exploration and development purposes was nearly K10.00 per ton mile, a rate which no development program could support. The total transport costs for this equipment

TABLE X – 1

COMPARISON OF RAILWAYS AND IWTB RATES

(kyats/ton)

Commodity	Agency	Rangoon to		
		Myingyan	*Mandalay*	*Monywa*
Cement	BR	40.44	42.78	51.33
	IWTB	57.17	64.56	62.22
Rice	BR	40.44	42.78	51.33
	IWTB	66.89	76.22	73.11
Grains, Pulses	BR	40.44	42.78	51.33
	IWTB	38.11	43.17	41.61
Sugar	BR	57.56	58.69	72.33
	IWTB	66.89	76.22	73.11
Salt	BR	40.44	42.78	51.33
	IWTB	57.17	64.56	62.22

IWTB Miscellaneous Transport Cost per ton mile	
IWTB Kalewa Coal K110.50/T	K0·166/ton mile
IWTB Thayetmyo Cement K38.92/T	K0·147/ton mile
Estimated Costs (Project Reports)	
Kalewa Coal to Rangoon	K0·0537/ton mile
Chauk Oil to Rangoon	K0·0267/ton mile
Transportation—Bulldozer from Mandalay to Kalewa	K55,500
20 Tons at 280 miles = 5,600 ton miles	
$K\frac{55,500}{5,600}$	K9.91/ton mile.

from Rangoon to Kalewa amounted to approximately K70,000 or nearly 85% of the first investment cost. These representative examples certainly indicate that a consistent rate structure must be adopted.

The existing rates by rail are more reasonable than water rates, an anomaly that is difficult to understand since throughout the world water rates are consistently lower than rail rates. However, it is understood that government-owned and operated riverine transport realizes a substantial annual profit while Railways operates at an annual loss.

The average goods rates for commodities moved by rail since the close of World War II are as follows:

1946–47	K0·1057 per ton mile
1947–48	K0·0845 " " "
1948–49	K0·1042 " " "
1949–50	K0·1925 " " "
1950–51	K0·1590 " " "
1951–52	K0·1432 " " "

The average comparable prewar rate was K0.04 per ton mile. If the prewar rate is converted by the rise-in-cost indices (about 3·5), the 1951–52 rate should amount to K0.14 which approximates the actual rate of K0·1432.

The present high rates are influenced to a major extent by limited traffic movements and by the necessity of confining operations to the daylight hours since dacoity and insurgency will not permit operations during the night.

Expensive transportation costs and inadequate service will be a major deterrent to the development and normal commerce of the country unless steps are taken by Government to provide an effective and independent regulatory agency for the several modes of transport.

3. TRANSPORT COMMISSION

To encourage fair and healthy competition between the several transport agencies, to control their standards of service, to insure coordinated services and economic use of joint facilities, and to control rates in the interest of the public, there must be a regulating commission, free of operating responsibilities and pressures, and staffed and equipped to analyze the social, economic and technical aspects of the national transport problems. The specific needs for such a body are pointed out in the succeeding chapters. It is therefore recommended that the necessary legislative and administrative action be undertaken to create, in the Ministry of Transport and Communications, a Transport Commission having organization, functions and responsibilities similar to those described below.

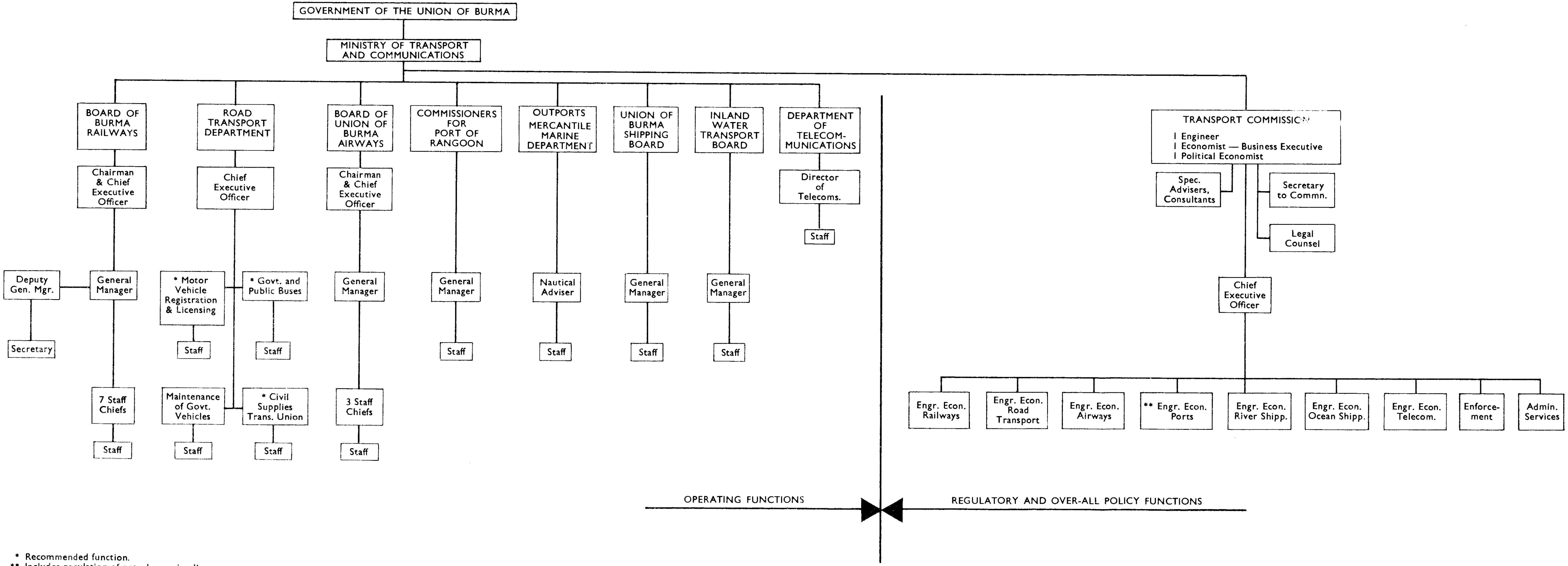
a. Organization. It is proposed that the Commission be composed of three men, all experienced in the field of transportation, and if possible contributing between them experience in social, economic and technological areas. They should devote full time to their work and should be supported by an adequate staff and by authority to engage specialists for advice on particular problems. A suggested organization chart is presented in Plate 1.

b. It is suggested that the duties and responsibilities of the Commission be formulated in terms similar to the following:

(1) To develop, propose, effect and administer the regulatory aspects of a national transport policy.

(2) To control the extent and variety of common carrier transport or public supported services and facilities in or subject to the jurisdiction of the Government by review and approval or rejection of proposals for the extension or abandonment of common carrier and publicly supported transport services and facilities.

(3) To develop, establish and maintain an economic



* Recommended function.
** Includes regulation of petroleum pipe lines.

ORGANIZATION CHART

Ministry of Transport and Communications and Transport Commission

NO. M—15

CHAPTER X, PLATE I

and non-discriminatory rate structure designed to serve the best interests of the Union of Burma as a whole, with due regard to the establishment of through rates and incentive rates for the encouragement of particular areas of traffic, and with due regard to the proper distribution, publication and enforcement of the rate regulations.

(4) To regulate and administer common contract carriers by:

(*a*) Prescribing licensing procedures for and licensing common carriers.

(*b*) Establishing common accounting forms, bills of lading and other administrative forms for common purposes.

(*c*) Developing and administering the establishing of safety rules, requirements for safety appliances and equipment, and (upon the recommendation of the interested transport service) limiting loads and other physical and operating criteria.

(*d*) Supervising, investigating and fixing responsibility for serious accidents.

(*e*) Compiling, analyzing and publishing pertinent statistics, including traffic records.

c. It is suggested that in performing the foregoing functions the Transport Commission follow procedures of somewhat the following nature:

(1) The rate structure, operating regulations, safety regulations and administrative procedures applicable to transport in the Union of Burma should be compiled, published and distributed in one or more conveniently bound volumes.

(2) Initial and continuing studies required for the development and compilation of rates and regulations should be based primarily on statistical data to be furnished by the transportation agencies, at first on the basis of initial requests, and subsequently on a periodic basis.

(3) In applying for extension, modification, or abandonment of services and facilities, the several transport agencies should file such information and supporting data as may be prescribed by the Transport Commission.

(4) With respect to the investigation of serious accidents, the transport agencies should file a "flash" report with the Transport Commission by the most expeditious communication means available. Representatives of the Transport Commission should visit the scene of the accident by the most urgent transport means available, should immediately initiate inquiry and should outline and initiate any further investigation required.

D. REVIEW OF RECOMMENDATIONS

The detailed recommendations relating to each of the modes of transport are contained in the pertinent succeeding chapters. With respect to transportation problems as a whole, the dominant need is for a Transport Commission, and it is recommended that early steps be taken to create and place in operation such a commission. It is further recommended that the Ministry of Transport and Communications support the several transport agencies in their efforts to obtain needed administrative autonomy, to develop adequate maintenance and maintenance organization, and to secure the needed extensions, improvements and training facilities.

CHAPTER XI

BURMA RAILWAYS

A. INTRODUCTION

1. IMPORTANCE OF RAILWAYS

Prior to the war, Burma Railways carried from 80 to 90% of the freight and practically all passengers except those destined for points not reached by rail. Although Burma's well-developed inland waterways provide the economical solution for certain types of freight and passenger movement, the speed and accessibility of railways for other types of movement are indispensable. The success of the present plans for the development of agriculture, industry and commerce will therefore depend in large part upon the efficient operation of an adequate railroad net fully coordinated with other means of transport, each handling the traffic in the sphere to which it is best adapted.

2. PURPOSE OF REPORT

The purpose of this report is to examine the existing situation of the railways, to review the current rehabilitation plans of Railways management, and to present recommendations for the further improvement and adaptation of Burma Railways to the integrated development of the country as a whole. In this connection plans are in preparation for the Chief Engineer and the Chief Mechanical Engineer of Burma Railways to spend two months in the United States for the study of American railroad practices, some of which form the basis for certain of the recommendations in this report.

B. HISTORY

1. PREWAR DEVELOPMENT

The first railway in Burma began service in 1877 (prior to the British annexation of upper Burma in 1886) with a 161-mile meter gauge line from Rangoon to Prome. By 1889, the 385-mile line between Rangoon and Mandalay was in operation. By 1903, the Myingyan, Myitkyina, Alon, Lashio and Bassein–Letpadan branches, aggregating 767 miles, were opened in the order named, bringing the total to 1,313 route miles. By 1930, the Martaban, Kyangin, Shwenyaung, Ye, Kyaukpadaung and Paleik-Myingyan branches, aggregating 582 miles, were opened in the order named. By World War II the total length of meter gauge line reached 2,058 route miles.

In 1896, the Irrawaddy State Railway which had initiated the development was succeeded by a private corporation, the Burma Railways Company, Ltd., of London, under a lease which expired at the end of 1928, when control was assumed by the Indian Railway Board. The monumental 3,760 ft. high-level Ava Bridge, constructed in 1934, closed the water gap between Rangoon and Myitkyina. The prewar freight and passenger services ranked high in physical performance among the meter gauge railways of the world. Financially, however, from 1938 to 1940, substantial deficits were accumulated until the added war traffic to China via Lashio and the Burma Road produced a profit.

2. WAR DAMAGE

Damage to Burma Railways during World War II was twofold. Initially both defensive operations and enemy attacks were concentrated on rail lines. Secondly, during four years of enemy occupation, Allied forces directed unremitting aerial attacks on all lines of communication. The re-conquest of Burma constituted a third phase of destruction. During the combat action the damage by both the attacking and defending forces was systematic and thorough.

No single section of Railways escaped heavy damage from one belligerent or the other. Table XI–1

TABLE XI – 1

WAR DAMAGE

Item	*Amount*	*Destruction*
Locomotive Works, Insein		Crippled
Carriage and Wagon Works, Myitnge		Crippled
Rails and Accessories	600 miles	Disappeared
Bridges		
9 Special Class	11,657 ft.	Great damage
6 Major	3,987 ft.	Destroyed
218 Important	31,286 ft.	Badly damaged
54 Other	5,361 ft.	Required repair
Major Stations, with Facilities and Equipment	44	Destroyed
Rolling Stock		
Locomotives	285 of 350	Destroyed
Goods Wagons	7,000 of 9,500	Destroyed
Coaching Service Vehicles	956 of 1,156	Destroyed

BURMA RAILWAYS ORGANIZATION CHART.

PLATE NO. 1

K. T. A. RANGOON. JUNE, 1953.

highlights, but cannot fully convey, the real extent of the losses to all features of the railway system. Table XI–2 summarizes the extent of the damage in monetary terms, and indicates a total wartime loss in plant, equipment and rolling stock of 48%. As described in the Edwards Evaluation Report, by the end of the war Burma Railways had "ceased to exist as a transportation system."

TABLE XI – 2

CAPITAL AT CHARGE AND POSTWAR EVALUATION

Accounts	1942–43 (*Rupees*)*	1945–46 (*Rupees*)*
1. Preliminary Expenses	41,95,955	41,95,955
2. Land	73,06,971	73,06,971
3. Structural Engineering Works	22,05,28,120	13,18,14,149
4. Equipment	1,93,28,170	6,66,320
5. Rolling Stock	5,94,63,190	55,13,600
6. General Charges	2,36,99,154	1,32,72,222
Minbu-Pakokku Construction†	56,52,039	—
Suspense Invoices and Stores	50,98,064	38,06,760
Total	34,52,71,663	16,65,75,977‡

* Rupees now designated kyats.
† Land only, construction abandoned.
‡ At 1936–37 prices.

3. POSTWAR CHANGES IN ADMINISTRATION

During the Japanese occupation of Burma, the Railways administration moved to India where it laid plans for postwar restoration of Railways properties. On January 4, 1948, Burma became an independent nation, and in 1951, under provisions of the "Union of Burma Railways Act," Burma Railways was transferred to the present Railway Board operating under the Ministry of Transport and Communications.

4. POSTWAR DISRUPTION AND RECOVERY

On re-occupation, Railways made astonishing progress in rehabilitation, following generally the plans laid in India. Rolling stock was obtained from the Allied Armies, and from India and the United Kingdom, and facilities were rebuilt or reconditioned to the extent that by the Burmese Independence Day, January 4, 1948, limited service had been restored on some 1,800 route miles of line. A period of wild insurgency ensued, during which the disaffected elements have persistently damaged and disrupted the system, at one time controlling early in 1944 all but some 20 miles of line in the vicinity of Rangoon. The continued destruction has been particularly vicious. Major bridges have again been destroyed. Night train services are entirely suspended, and armed escorts are still required in some areas. Table XI–3 indicates a two-year measure of the postwar destruction and shows why the execution of the rehabilitation program of Burma Railways has been seriously delayed.

TABLE XI – 3

INSURGENT SABOTAGE

Incidents	*1950–51**	*1951–52**
Incidents		
Track sabotage	198	187
Trains fired on from ambush	32	23
Railway buildings burned	59	17
Bridges blown up	204	176
Trains mined	49	48
Total	542	451
Casualties		
Passengers killed	29	32
Railway staff killed	9	15
Passengers injured	55	71
Railway staff injured	50	33
Total	143	151

* Fiscal years postwar end September 30.

Notwithstanding the disturbed postwar conditions, Burma Railways expended K2,651 lakhs for additions to September 30, 1952. Capital at charge, on the basis of prewar books, was K3,452 lakhs on October 1, 1945. After writing off K1,787 lakhs in 1948–49 for war damage, the capital at charge stood at K3,679 lakhs and subsequently steadily increased to approximately K4,316 lakhs as of September 30, 1952, as shown in more detail in Table XI–21 (*see p. 265*). The record of capital additions is extremely creditable considering the difficult conditions under which the work has been carried out.

C. EXISTING SYSTEM

1. ORGANIZATION

Burma Railways is a government monopoly operating under the direction of the Union of Burma Railway Board. The staff organization of Railways is shown on Plate 1. Subject to the control of the President of Burma, the Board has the power to "regulate, construct, maintain, and operate the railways in the Union of Burma"; to "undertake other activities necessary or expedient for the proper carrying out of its functions under this Act"; and "shall act on business principles with due regard to the interests of agriculture, industry, commerce and the general public." The general form of organization is consistent with customary railroad practices except that train operations, rates and fares, and commercial activities are under the direction of the Traffic Manager.

2. RAILROAD NET

The various lines and branches of the railway system are shown on the map, Plate 2. Table XI–4 shows the present and past total mileage and the effects of the various forms of damage.

TABLE XI – 4

ROUTE MILEAGE

	Miles
Prewar route mileage	2,058
Mileage in operation March, 1953	1,570
Difference	488
War damage restored but now in insurgent hands	139
War damage restored but more work required to restore damage by insurrection and work halted, being in unsafe areas	78
War damage not yet restored, line in insurgent hands	215
Abandoned (47) and low priority (9)	56
Total	488

There are five major gaps in the line:

(*a*) The Ava Bridge over the Irrawaddy River near Mandalay, destroyed by combat action in 1942. Steel was ordered in 1948, and the bridge is expected to be reopened for rail and highway traffic by late 1954.

(*b*) The Sittang River Bridge on the Moulmein branch 30 miles east of Pegu, also destroyed by war action, will be replaced at a site about nine miles up river and should be ready for traffic by about 1958.

(*c*) The Daga River Bridge on the Henzada–Bassein line, destroyed by air attack, should be ready for the resumption of traffic in 1954.

(*d*) The Irrawaddy River between Tharrawaw and Henzada has never been bridged and transfers are made by ferry.

(*e*) The Salween River between Martaban and Moulmein has never been bridged. The goods were formerly transferred on barges, and rolling stock by special barge, but destruction of barges has virtually stopped such traffic.

3. TRACK AND BRIDGES

Grades and curvatures are generally minor in degree and extent. Four per cent grades and switchbacks, or ghats, occur on the Lashio and Shwenyaung branches. The Prome–Rangoon–Mandalay main lines are suitable for high speed, heavy tonnage operation. A summary of gradients and curvatures is given in Table XI–5.

TABLE XI – 5

GRADIENTS AND CURVATURE

Road District	*Distance (miles)*	*Ruling Grade (%)*	*Longest Stretch (miles)*
Main Line			
Rangoon–Prome	161	0·33	1·00
Rangoon–Toungoo	166	0·33	1·00
Toungoo–Mandalay	219	0·50	1·40
Branches			
Myohaung–Myitkyina	328	1·66	0·35
Naba–Katha	15	2·00	0·35
Myohaung–Maymyo	40	4·00	1·95
Maymyo–Lashio	138	2·50	2·55
Thazi–Myingyan	70	1·00	1·25
Thazi–Lebyin	38	2·50	1·70
Lebyin–Shwenyaung	60	4·00	3·00
Pyinmana–Taungdwingyi	67	0·80	1·45
Pegu–Martaban	122	0·33	2·00
All other	—	1·00	1·60

EXTENT OF GRADIENTS ON 1,787 ROUTE MILES

Rate of Grade	*Miles of Grade*
Maximum 4%	26·50
Less than 4% to 2%	76·90
,, ,, 2% to 1%	88·46
,, ,, 1% to 0·5%	150·45

CURVATURE CHARACTERISTICS

Main line curves do not exceed 4 degrees.
Minimum radius 337·1 ft. or 17 degrees.
Ratio of curved to total line 15·39%.*
Average central angle per mile 37·22 degrees.*

* Largely due to Myitkyina, Lashio and Shwenyaung Branches.

Station and rights-of-way fencing and pedestrian crossings need repair and maintenance at nearly all major stations. The tracks are meter gauge, laid with 50-lb., 60-lb. and 75-lb. rail of conventional tee section. Rails are well anchored and track well ballasted. Sleepers, or cross-ties, will be creosoted in the new treating plant now being erected at Myohaung near Mandalay. Bridges are designed for adequate loadings, but clearances on some of the older structures are restricted.

4. COMMUNICATIONS

The prewar signaling systems are being restored in accordance with the rehabilitation plans prepared in India. Interlocking signals and power-operated

MINISTRY OF NATIONAL PLANNING

BURMA RAILWAYS

KNAPPEN TIPPETTS ABBETT ENGINEERING CO,
NEWYORK. RANGOON

DR BY. CK BY.	DATE MAY 53.	PLATE NO. 2

switches are in use at Rangoon, and automatic block signals are employed on the Rangoon–Prome line between Rangoon and Kemmendine, about 3½ miles. Yard interlocking plants are located also at seven other stations.

Land-line telegraph communications are installed and maintained by the Telecommunications Department of the Ministry of Transport and Communications. The disruption of land-line operations by insurgents has been partially overcome by radio links between Rangoon and Toungoo, Pyinmana, Yamethin, Thazi, Mandalay and Katha. Forty additional radio stations are being installed at important traffic centers for routine telegraphic business and future emergencies. Traffic cannot be moved efficiently until the communications problem has been solved.

5. YARDS

A marshaling yard is provided at Malagon, in the vicinity of Rangoon, and another is planned for development at Myohaung, the junction of the Lashio, Myitkyina and Ye-U branches. Station yards and belt lines serve Rangoon, and an extensive yard layout serves Mandalay. Yard layouts exist at other stations as well, and are generally adequate.

6. BUILDINGS AND UTILITIES

Both service buildings and housing are being provided by Burma Railways under the present development program. Family housing and facilities for medical attention for about 57,000 persons will eventually be required. The housing program constitutes a large factor in the Railways capital and expense budget. Progress on the rehabilitation or reconstruction of stations at 44 major locations is good.

The water-supply systems were badly damaged by the war and subsequent fighting, but good progress has been made in their restoration and improvement. Electric power requirements, obtained from both public sources and Railways' own plants, in the fiscal year 1951–52 were as follows:

Purchased	2,062,991 kWh	68%
Generated	989,030 kWh	32%
Total	3,052,021 kWh	100%

TABLE XI – 6

LOCOMOTIVE SUPPLY

Class	*Wheel Arrangement*	*Type*	*Weight in Working Order (tons*)*	*Tractive Effort (lbs.)*	*Number on Line*	*Year Built*	*Total Tractive Effort (lbs.)*
GB	2–8/8–2	Garratt	103	41,890	10	1946	418,900
GC	2–8–2/2–8–2	,,	117	41,890	12	1946	502,680
YD	2–8–2	IRS Goods	96	22,108	20	1950	442,160
D	2–8–2	USA ,,	95	20,128	57	1946	1,147,296
YC	4–6–2	IRS Passgr.	98	19,729	10	1948	197,290
ST	2–8–4	Tank-shunt	56	17,613	28	1948–49	493,164
YB	4–6–2	IRS Passgr.	94	16,492	50	1947–48	824,600
					187	(Postwar)	4,026,090
YD	2–8–2	IRS Goods	92	22,108	13	1928–30	287,404
YC	4–6–2	IRS Passgr.	96	19,729	1	1932	19,729
K	4–6–0	Goods	63	17,952	14	1920–25	251,328
KS	4–6–0	,,	61	15,778	21	1905–14	331,338
Jap	2–6–0	Mixed	66	15,300	13	1944	198,900
JS	4–6–0	,,	65	14,187	7	1905–08	99,309
A	4–6–4	Tank-subn.	57	17,952	1	1931	17,952
AS	4–6–4	,, ,,	51	15,778	2	1916	31,556
E	2–6–4	,, shunt	54	15,541	11	1929–30	170,951
M	2–6–2	,, ,,	47	15,541	15	1909–28	233,115
FS	0–6–0	,, ,,	44	11,623	17	1901–03	197,591
F	0–6–0	,, ,,	39	9,685	5	—	48,425
				Grand Total	307		5,913,688

* Tons of 2,240 lbs. IRS: Indian Railways Standard. USA: USA Army Type.

A new, modern generating plant for Railways purposes has just been completed at Mandalay. Although the current needs are being met, there is a probable requirement totaling 850 kilowatts in the Mandalay area to meet the heavy traffic increases that would be expected to develop by 1957 as a result of the industrial projects proposed for that region. This aspect of the power requirement is further treated in Part VI, Electric Power.

7. SHOPS

There are three principal workshops for construction, repair and maintenance of rolling stock, and for the requirements of the Civil Engineering Department. The main locomotive shop (Plate 3) at Insein, nine miles north of Rangoon on the line to Prome, is a busy and efficiently run facility well adapted to the needs of Burma Railways. The layout of the restored carriage and wagon shop at Myitnge, eight miles south of Mandalay, is shown on Plate 4. The carriage shop is served by a new power plant and has modern woodworking equipment, but needs additional portable power tools. The rebuilt civil engineering workshop in Rangoon needs an additional quota of tools of specialized types for the bridge and rail work required. The new timber-treating plant at Myohaung will serve all wood-treating purposes and will effect considerable long-range economies.

8. ROLLING STOCK

The characteristics of the present complement of 307 locomotives are shown in Table XI–6 (*see p. 259*).

Sixty-eight per cent of the total available tractive effort was built after 1945. The locomotives are well maintained although cannibalization has been necessary to support some of the older types.

TABLE XI – 7

PASSENGER-TRAIN VEHICLES

1941 Units	*1941* Seats	*Class*	*1953* Seats	*1953* Units
—	1,422	I*	906	—
—	2,734	II*	—	—
—	36,800	III	27,673	—
766	40,956	—	28,579	534
380	—	Miscellaneous	—	171
1,146	—	Total	—	705

* Classes I and II now combined as "Upper" and Class III called "Lower." Some carriages accommodate two classes of traffic.

Passenger vehicles are in drastically short supply as may be seen from Table XI–7.

The 200 new carriages under construction in Rangoon, though equipped with toilets, water, lights and fans, make no provision for passing from carriage to carriage, a serious deficiency from the viewpoint of preventing ticketless travel. Early consideration should be given to remodification of these vehicles to provide this added feature, particularly for the vehicles now under construction. Also, an additional 350 passenger vehicles are urgently needed to alleviate the present unsanitary and indecent crowding.

The supply of goods-train vehicles, even under present depressed traffic levels, is inadequate. Present stocks of such vehicles are listed in Table XI–8.

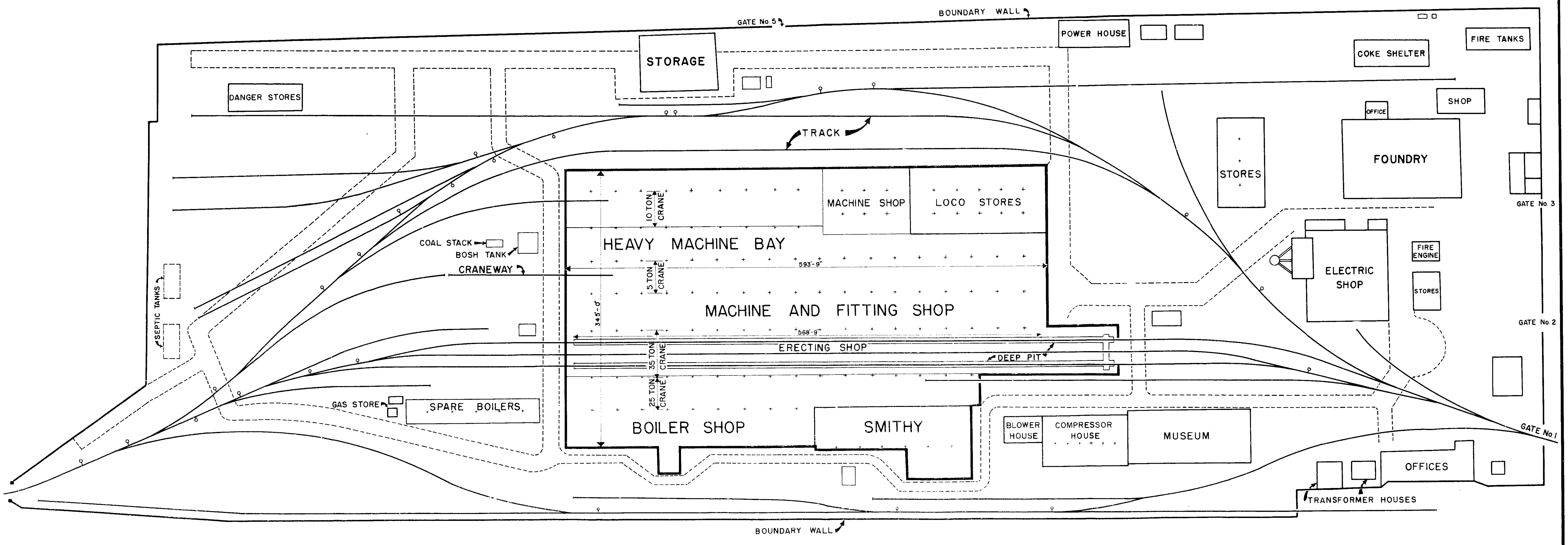
TABLE XI – 8

GOODS-TRAIN VEHICLES

Type of Vehicle	*Average Tare (tons*)*	*Short 4-wheel*	*Bogie 8-wheel*	*Type Total*
A. Goods Wagons				
Covered Goods Wagons	5·45	3,466	—	—
	12·03	—	390	3,856
Open Goods Wagons—High Side	5·01	468	—	—
	9·95	—	152	620
Open Goods Wagons—Low Side	5·31	382	—	—
	10·19	—	66	448
Group Total A		4,316	608	4,924
B. Special Service Vehicles				
Timber or Rail Wagons	4·18	112	—	—
	10·50	—	321	433
Departmental Wagons—Various	5·69	82	—	—
	15·31	—	64	146
Miscellaneous Type Wagons	4·65	76	—	—
	11·29	—	35	111
Tank Wagons—not Petrol	6·53	6	—	—
	15·13	—	15	21
Tank Wagons—Petrol	14·83	—	31	31
Live-stock Wagons	5·32	90	—	90
Brake Vans	11·71	134	—	—
	27·50	—	2	136
All other units, cranes, etc.	—	58	7	65
Group Total B		558	475	1,033
GRAND TOTAL—A, B		4,874	1,083	5,957

* Tons of 2,240 lbs.

The shortage of vacuum brakes on freight vehicles is a serious handicap to efficient operation. The possible requirement for refrigerator cars merits further study. A very rough estimate of total goods service vehicle



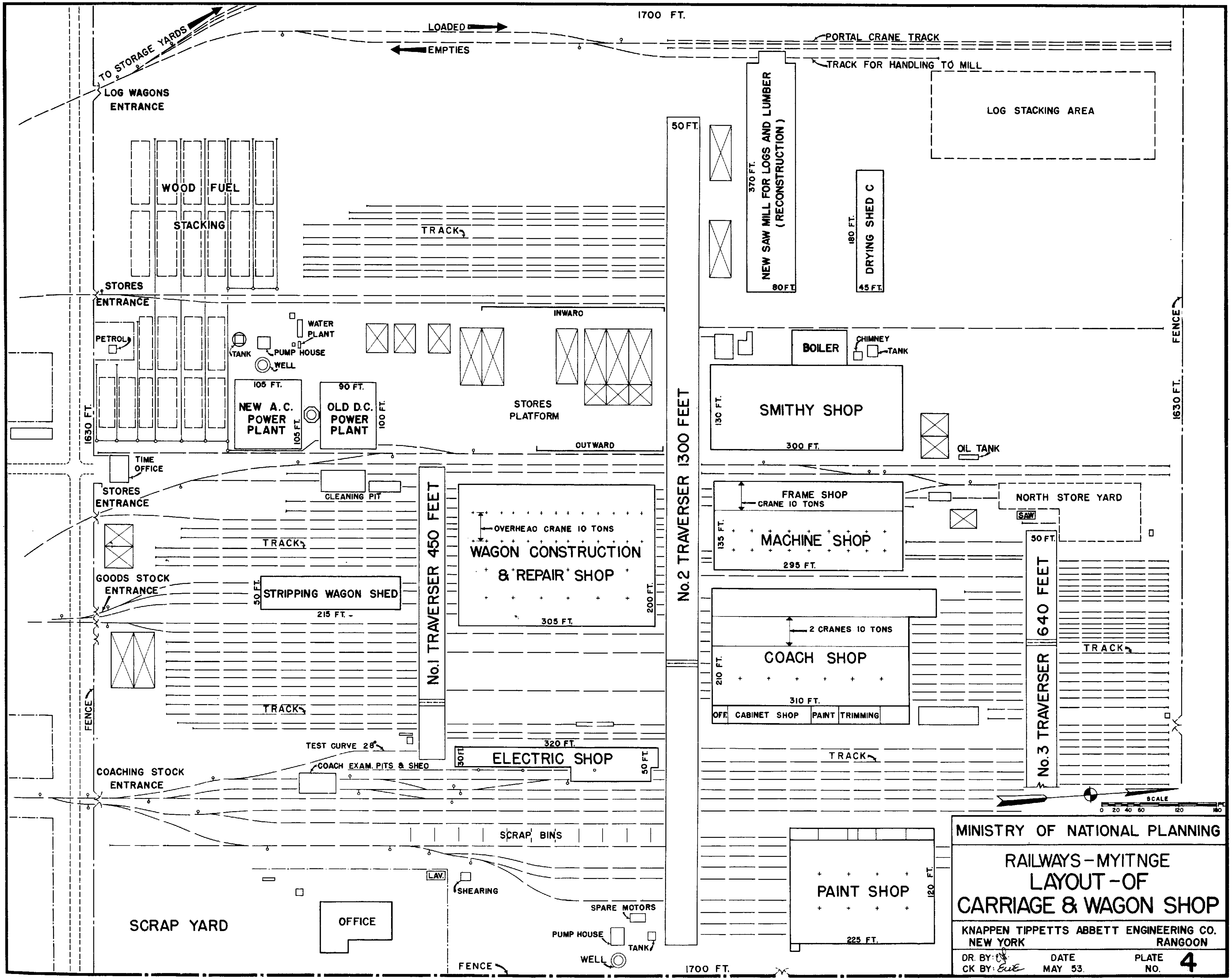
MINISTRY OF NATIONAL PLANNING

RAILWAYS – INSEIN

LOCOMOTIVE SHOPS

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON

DR BY: CK BY: DATE MAY 53 PLATE NO 3


1700 FT.
TO STORAGE YARDS
LOADED
EMPTIES
PORTAL CRANE TRACK
TRACK FOR HANDLING TO MILL
LOG WAGONS ENTRANCE
LOG STACKING AREA
50 FT.
370 FT.
NEW SAW MILL FOR LOGS AND LUMBER (RECONSTRUCTION)
80 FT.
180 FT.
DRYING SHED C
45 FT.
WOOD FUEL STACKING
TRACK
STORES ENTRANCE
INWARD
PETROL
WATER PLANT
TANK
PUMP HOUSE
WELL
BOILER
CHIMNEY
TANK
FENCE
105 FT.
NEW A.C. POWER PLANT
105 FT.
90 FT.
OLD D.C. POWER PLANT
100 FT.
STORES PLATFORM
OUTWARD
No.2 TRAVERSER 1300 FEET
130 FT.
SMITHY SHOP
300 FT.
OIL TANK
1630 FT.
1630 FT.
TIME OFFICE
STORES ENTRANCE
CLEANING PIT
No.1 TRAVERSER 450 FEET
OVERHEAD CRANE 10 TONS
WAGON CONSTRUCTION & REPAIR SHOP
200 FT.
305 FT.
FRAME SHOP
CRANE 10 TONS
MACHINE SHOP
135 FT.
295 FT.
NORTH STORE YARD
SAW
50 FT.
TRACK
GOODS STOCK ENTRANCE
50 FT.
STRIPPING WAGON SHED
215 FT.
2 CRANES 10 TONS
COACH SHOP
210 FT.
310 FT.
OFF. CABINET SHOP PAINT TRIMMING
No.3 TRAVERSER 640 FEET
TRACK
FENCE
TRACK
TEST CURVE 2°
320 FT.
30 FT.
ELECTRIC SHOP
50 FT.
COACH EXAM. PITS & SHED
TRACK
COACHING STOCK ENTRANCE
SCALE
0 20 40 60 120 180
SCRAP BINS
LAV.
SHEARING
120 FT.
PAINT SHOP
225 FT.
SCRAP YARD
OFFICE
SPARE MOTORS
PUMP HOUSE
TANK
WELL
FENCE
1700 FT.
MINISTRY OF NATIONAL PLANNING
RAILWAYS - MYITNGE
LAYOUT - OF
CARRIAGE & WAGON SHOP
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
DR. BY:
CK BY:
DATE
MAY 53.
PLATE NO.
4

requirements is given in the accompanying Table XI–9.

TABLE XI – 9

GOODS VEHICLE REQUIREMENTS

Type	*1955–56*	*1957–58*	*1959–60*
Covered Goods Wagons	5,900	6,200	6,400
Open Goods Wagons	1,700	2,030	2,200
Timber Wagons	560	630	700
Live Stock	600	700	750
Miscellaneous, Tanks, etc.	510	540	820
Total	9,270	10,100	10,870

D. CURRENT OPERATIONS

1. TRAIN MOVEMENTS

Trains are moved by several variants of the basic English system of absolute station-to-station block. Each station master passes the train to the next block after communicating with the station ahead to assure that no opposing train will be forwarded. With the failure of communications, emergency measures are frequently required. The trains are normally moved close to schedule, but passengers are sometimes returned to their starting points to await the repair of sabotaged lines. Extra trains are originated by the Traffic Department, but after leaving the terminal are moved by the various station masters. At stations without interlocking plant, from one to four jemadars on the station master's staff clear trains over the switching point switches. Train crews normally consist of three men, the engine driver, the fireman and the guard. These crews are on the staff of the chief mechanical engineer, but take their operating directions from the local Traffic Department. The guard is a traffic department employee.

Maintenance and construction are supervised by the chief engineer with the advice of the consulting engineers in London. Rehabilitation and maintenance of rolling stock, floating equipment and mechanical goods are supervised by the chief mechanical engineer.

2. PERSONNEL

A retirement system limits the turnover of employees. With the loss of trained specialists when Burma became independent, it became necessary to establish training courses to provide technical replacements. Selected employees are sent to the United States, Great Britain and Canada under foreign aid programs for advanced technical training. It should be noted that reductions in force achieved by the introduction of efficient methods and equipment can only be realized at the rate consistent with normal attrition or the absorption of personnel in expanded services. Medical services are provided to 19,000 employees and their families under the direction of a chief medical officer. Preventive measures are effective and outbreaks of contagious diseases are met with prompt and vigorous measures. The extent of medical treatment is summarized in Table XI–10.

TABLE XI – 10

MEDICAL TREATMENT CASES

Group	*1951–52*		
	Males	*Females*	*Total*
Railway Employees	77,761	573	78,334
Families of Employees	48,713	55,337	104,050
Non-railway Patients	4,856	3,216	8,072
Total	131,330	59,126	190,456

3. TRAFFIC AND EARNINGS

The distribution of traffic, the sources of goods traffic, earnings, and rates charged for selected com-

TABLE XI – 11

DISTRIBUTION OF TRAIN MILES

(Prewar and Postwar)

Class of Trains	*Train Miles and Per cent of Total*	
	1940–41	*1951–52*
1. Passenger Trains*	1,442,000— 19%	551,200— 25%
2. Mixed Trains†	3,988,000— 53%	1,043,400— 47%
3. Passenger and Mixed Total	5,430,000— 72%	1,594,600— 72%
4. Goods Trains—Main Line	1,407,000— 19%	525,900— 24%
5. Goods Trains—Branch Line	707,000— 9%	97,700— 4%
6. Goods Trains—Total‡	2,114,000— 28%	623,600— 28%
7. Total Commercial Traffic	7,544,000—100%	2,218,200—100%
8. Departmental Trains	386,000	474,900

* 99% of total passenger-train vehicle miles in 1951–52 were run on main line, Prome–Rangoon–Mandalay, including 22% run in Rangoon suburban service.

† Approximately two thirds of mixed-train vehicle miles accumulated on branch lines. Mixed trains averaged 88% carriages, 1951–52.

‡ Goods-train vehicle miles accumulated in 1951–52 were 97% on main line.

modities are shown in Tables XI–11 through XI–15. Any conclusions that might be drawn from an examination of the trends disclosed by these tables should take into account the following factors:

(*a*) The higher passenger earnings of the past four years are due to increases in rates rather than volume of traffic.

TABLE XI – 12

PASSENGER TRAFFIC

Year	*Passengers Carried*			*Earnings*		*Average Haul (miles)*
	Upper Class (000)	*Lower Class (000)*	*Total (000)*	*Passenger Total (K lakhs)*	*Passenger Mile (pyas)*	
1929–30	671	32,543	33,214	NA	NA	NA
1930–31	591	28,271	28,862	128·31	2·03	22·0
1931–32	417	22,431	22,848	97·55	1·87	22·8
1932–33	330	20,879	21,209	93·20	1·88	23·4
1933–34	269	20,061	20,330	86·50	1·90	22·4
1934–35	279	20,457	20,736	88·36	1·87	22·7
1935–36	288	20,271	20,559	95·91	1·98	23·0
1936–37	281	19,992	20,273	95·99	1·97	23·9
1937–38	247	19,156	19,403	90·89	1·96	23·9
1938–39	250	18,670	18,920	83·68	1·91	23·1
1939–40	233	18,557	18,810	88·58	1·97	23·9
1940–41	235	19,523	19,758	98·79	1·97	25·2
1941–45	WAR PERIOD					
1945–46	NA	NA	NA	NA	NA	NA
1946–47	21	8,214	8,235	138·82	5·40	31·2
1947–48	32	10,117	10,149	134·41	4·48	29·6
1948–49	6	4,413	4,419	32·53	4·38	16·8
1949–50	5	6,592	6,597	50·18	4·72	16·1
1950–51	15	9,805	9,820	95·23	4·61	21·1
1951–52	17	11,789	11,806	115·07	4·56	21·2

Source: Railways Annual Reports or other records.

Notes: 1 Kyat is of same value as former Rupee.
1 Pya is 1/100th Kyat.
1 Lakh equals 100,000.
NA: records not available.

(*b*) The restoration of normal train service, faster schedules, and improved facilities would undoubtedly attract to railways much of the passenger traffic lost during the disruption of service.

(*c*) The proposed agricultural and industrial developments with expected improvements in the standard of living will further increase the potential passenger traffic.

(*d*) Correction of the abuses of ticketless travel should result in a substantial increase in revenues.

(*e*) With inclusion of departmental traffic, which is handled at commercial rates, the figures for gross earnings unduly distort the goods revenue totals as an index of profits.

TABLE XI – 13

SOURCES OF GOODS TRAFFIC

Group	*Percentage of Total Tonnage*			
	1948–49	*1949–50*	*1950–51*	*1951–52*
Agriculture	44·2	45·6	44·0	43·2
Mines	7·2	6·6	12·8	8·8
Forest	8·0	9·8	12·3	13·0
	59·4	62·0	69·1	65·0
Railways Departmental	27·6	28·4	21·3	23·5
All Others	13·0	9·6	9·6	11·5
	100·0	100·0	100·0	100·0

TABLE XI – 14

GOODS TRAFFIC

(Including Railways Departmental)

Year	*Tons Carried (000)*	*Earnings*		*Average Haul (miles)*
		Total (K lakhs)	*Ton-mile (pyas)*	
1929–30	NA	317·32	NA	NA
1930–31	4,945	280·00	3·98	142·3
1931–32	3,975	251·26	4·20	150·5
1932–33	3,449	217·41	4·08	154·6
1933–34	4,021	252·18	4·05	155·4
1934–35	4,175	265·50	3·92	162·1
1935–36	3,983	249·59	3·88	161·5
1936–37	3,857	254·35	3·92	167·6
1937–38	3,970	253·48	3·80	167·9
1938–39	4,057	263·89	3·78	171·9
1939–40	4,001	276·59	4·04	171·4
1940–41	4,031	309·31	4·37	175·6
1941–45	WAR PERIOD			
1945–46	NA	NA	NA	NA
1946–47	1,863	336·69	10·57	171·2
1947–48	2,108	315·20	8·45	181·5
1948–49	784	103·91	10·42	127·4
1949–50	833	110·66	19·25	67·2
1950–51	1,362	194·72	15·90	89·9
1951–52	1,651	257·21	14·32	108·6

Source: Railways Annual Reports and other records or computed.

Notes: 1 Kyat is of same value as former Rupee.
1 Pya is 1/100th Kyat.
1 Lakh equals 100,000.
NA: records not available.

(*f*) The decline in goods traffic shown in Table XI–14 is attributable to the effects of insurgency and lowered production.

The traffic rates are set by the Traffic Department subject to the approval of the Ministry of Transport and Communications and of the President. Since about 70% of the traffic originates with government agencies, and since competition in transport service is limited to the Government Inland Waterways and the Union of Burma Airways, together with a minor volume of privately owned highway transport, the rate structure is relatively free of the pressure of competition.

Passenger and goods rates were increased in October 1945, in April 1946, in October 1946, by surcharges of 25%, 50% and 100% respectively. In August 1949 basic rates for both goods and passengers were also increased. Further increases are being sought. Nevertheless, on many important commodities, the present rates, including their 100% surcharge, are less than rates charged by Inland Water Transport. As the almost universal experience elsewhere is that water rates may be lower than rail rates, the condition in Burma suggests either that the rail rates are below the standard level or that the water rates are unnecessarily high. It should also be noted from

TABLE XI – 15

COMPARISON OF RATES
SELECTED COMMODITIES VIA RAILWAYS AND INLAND WATER TRANSPORT

(kyats/100 viss)

Commodity	*Agency*	*Rangoon to*		
		Myingyan	*Mandalay*	*Monywa*
Cement	BR	6·500	6·687	8·250
	IWT	9·187	10·375	10·000
Rice	BR	6·500	6·687	8·250
	IWT	10·750	12·250	11·750
Grains, Pulses	BR	6·500	6·687	8·250
	IWT	6·125	6·937	6·687
Sugar	BR	9·250	9·437	11·625
	IWT	10·750	12·250	11·687
Salt	BR	6·500	6·687	8·250
	IWT	9·250	10·500	10·000
Distance by Rail–miles		376	385	457

Source: Resolution of Railway Board, July 5, 1949.

Table XI–15 that the tariffs on widely different commodities are equal, a practice not normally followed in other countries. These two conspicuous incongruities in the rate structure serve to emphasize the requirement for a thoroughly competent and experienced transport commission that can be charged with the analyzing and establishing of rates consistent with potential traffic and with the costs of operation. Further reference to this subject is made in Chapter X, Transportation System. For a rough approximation of the adequacy of the present rates, it may be noted from Table XI–16 that in the year 1951–52 an

TABLE XI – 16

EARNINGS, EXPENSES, DEPRECIATION, INTEREST, PROFIT OR LOSS

Fiscal Years 1929–30 to 1951–52
(In lakhs)

Year	*Gross Earnings (K)*	*Direct Working Expenses (K)*	*Depreciation (K)*	*Railway Net Earnings (K)*	*Interest on Debt (K)*	*Profit or Loss (—) (K)*
1929–30	492.39	259.60	48.28	184.51	158.80	25.71
1930–31	428.79	263.67	51.72	113.40	158.96	– 45.56
1931–32	380.90	233.45	52.64	94.81	160.96	– 66.16
1932–33	355.74	222.11	53.44	80.19	150.58	– 70.39
1933–34	376.70	227.84	55.28	93.58	154.53	– 60.95
1934–35	389.29	233.89	53.36	102.04	150.22	– 48.18
1935–36	373.39	227.27	58.38	87.74	146.72	– 58.99
1936–37	383.07	208.72	58.19	116.16	141.90	– 25.74
1937–38	374.48	206.86†	57.82	109.80	120.12	– 15.55
1938–39	374.82	208.50†	57.65	108.67	122.39	– 13.72
1939–40	392.11	211.11†	57.57	123.43	120.89	2.54
1940–41	438.63	215.40†	57.19	166.04	120.54	45.50
1941–45			WAR PERIOD			
1945–46	300.19	213.08†	57.53	29.57	121.32	– 91.74
1946–47	509.34	348.82†	58.50	102.01	83.17	18.84
1947–48	486.46	430.24†	69.08	– 12.86	156.84	– 169.69
1948–49	140.93	390.19†	85.63	– 334.90	122.34	– 457.23
*1949–50	204.31	373.13†	61.29	– 230.71	39.04	– 269.75*
*1950–51	337.21	409.00†	64.93	– 136.72	81.88	– 218.60*
*1951–52	526.70	454.07†	68.60	4.03	116.36	– 112.33*

Source: Railways Annual Reports prewar years.

Notes: Postwar figures furnished March 1953 by controller.
1 Lakh equals 100,000.
* Last three years provisional subject to revision.
† Includes net effect certain minor interest items not strictly working expenses.

increase of about 20% of the gross earnings would have been required to eliminate the recorded loss.

4. EARNINGS, EXPENSES AND INCOME

The financial record given in Table XI–16 reflects the influence of the depression of 1930–31, the Burma Road traffic of 1940–41, the war, and postwar insurgent conditions.

The high ratio of expense to revenue shown for 1947–51 includes the cost of repairing damages resulting from insurgent depredations. The postwar depreciation charges through 1948–49 and interest charges through 1947–48 result from the insistence of the pre-independence Government upon basing the depreciation on the prewar capital at charge, notwithstanding that half the physical assets had been destroyed during hostilities. A reduction in capital at charge to cover war losses was finally booked in 1948–49 after Independence.

Personnel costs (Table XI–17) will probably continue to increase. Material costs (Table XI–18) are rising faster than personnel costs.

New sources of fuel are needed, and tests have been made with Kalewa coal which may have to be processed into briquettes before it can be used in locomotives. Tests are also under way as to the feasibility of using fuel oil in locomotives. Various fuel statistics are given in Table XI–19.

TABLE XI – 17

PERSONNEL AND WAGE COSTS

Year	*Route Miles of Road**	*Average Number of Employees*	*Wages (K lakhs)*	*Cost Living Allow. (K lakhs)*	*Total (K lakhs)*	*Average per Employee (K)*	*Per cent Working Expenses (†)*
1937–38	2,060	22,162	131·77	None	131·77	595	63
1938–39	2,059	21,906	129·42	,,	129·42	590	62
1939–40	2,059	21,851	128·41	,,	128·41	588	61
1940–41	2,058	21,901	129·00	,,	129·00	589	60
1941–45			WAR PERIOD				
1945–46	NA	NA	NA	NA	NA	NA	NA
1946–47	1,777	24,362	132·00	120·00	252·00	1,035	72
1947–48	1,777	22,905	156·00	97·00	253·00	1,105	59
1948–49	1,771	21,232	153·00	114·00	267·00	1,255	68
1949–50	1,771	19,131	110·00	131·00	241·00	1,260	64
1950–51	1,787	18,750	148·00	112·00	260·00	1,386	64
1951–52	1,787	19,121	152·00	115·00	267·00	1,395	54

Source: Railways Annual Reports and other records or computed.

* Postwar route miles shown not all in operation in years shown.

† Based on working expenses excluding depreciation.

TABLE XI – 18

COSTS OF SELECTED MATERIALS

Item		*1941 (K)*	*1947 (K)*	*1952 (K)*
Rail, Rangoon	ton	143	290	949
Structural Steel	,,	221	325	848
Bridge Girders	,,	400	516	727
Indian Coal	,,	21	60	96
Lumber Squared	,,	300	500	1,000
Bricks	100	25	80	58
Cement	ton	50	71	168
Ballast at Quarry	100 cu. ft.	8	38	40
Sleepers Average	each	2½	7	7
Sleepers Switch	ton	85	245	270
G.I. Sheets	,,	440	383	1,453

Source: Railways.

Notes: All tons 2,240 lbs. Duty included on imported items.

TABLE XI – 19

LOCOMOTIVE FUEL

Year	*Coal Used*	*Wood on Coal Basis (tons)**	*Total on Coal Basis (tons)**	*Engine Miles Run (000)*	*Lbs. Coal per Engine Mile*	*Gross Ton-miles Run* (millions)*	*Lbs. Coal per 1,000 GTM**	*Cost Ton Indian Coal Rangoon (K)*
1937–38	176,946	4,112	181,058	9,282	44	2,510	162	17.4
1938–39	180,391	4,342	184,733	9,525	43	2,569	161	18.7
1939–40	184,859	14,249	190,558	9,643	44	2,621	163	18.6
1940–41	191,614	15,648	197,872	9,973	44	2,672	166	21.1
1941–45			WAR PERIOD					
1946–47	76,166	11,889	88,055	3,165	62	1,078	183	60
1947–48	94,540	20,517	115,057	4,076	63	1,252	206	68
1948–49	34,841	8,671	43,511	1,625	60	NA	NA	70
1949–50	26,770	19,923	46,693	1,803	58	328	319	69
1950–51	52,313	45,689	98,002	3,214	68	661	332	75
1951–52	83,140	30,751	113,891	3,731	68	827	308	90

Source: Railways Annual Reports.

Notes: Gross ton-miles includes weights of locomotives, trailing loads in freight and passenger service and departmental trains.
Wood conversion basis 187·5 cubic feet piled wood equivalent to 1 ton of coal.

* All tons and ton-miles based on long ton of 2,240 lbs.

Reports and accounting practices will require basic changes if Management and Government are to be accurately advised as to Railways' fiscal affairs. The recently published Annual Reports are completely silent as to departmental expenditures, depreciation, interest and other vital information. Corrections in figures are not carried statistically through to derived totals and tables. Changes are still being made in old accounts. Table XI–20 illustrates the inconsistencies in various reports.

5. CAPITAL AT CHARGE AND DEBT

Table XI–21 shows the record of postwar additions to capital at charge, adjustment for war losses, and the investment in railway plant or capital at charge through 1951–52.

TABLE XI – 20

VARIATIONS IN RAILWAYS RECORDED EARNINGS, EXPENSES, INTEREST AND INCOME

Account and Source	*1946–47* (*K*)	*1947–48* (*K*)	*1948–49* (*K*)	*1949–50* (*K*)	*1950–51* (*K*)	*1951–52* (*K*)
Gross Earnings (in lakhs)						
Annual Report—original issues	494.19P (Table X – 7)	466.59 (Table X – 8)	158.3 (Table X – 8)	194.1P (Table X – 8)	336.69P (Table X – 8)	497.35P
Annual Report—subsequent issues	494.19 (1947–48)	466.59 (1948–49)	160.6 (1949–50)	202.1 (1950–51)	336.7P (1951–52)	—
Genl. Mgr.'s Rate Study 1952	504.00	483.00	138.00	155.00	337.00	—
Controller June 12, 1952	504.29	483.14	138.39	155.29P	337.21P	—
Budget 1952–53 marked "Actual"	—	—	—	164.39	326.06	—
Controller March 23, 1953	509.34	486.46	140.93	204.31P	337.21P	526.70P
Working Expenses (in lakhs) (excluding depreciation)						
Annual Reports	498.90	—	—	—	—	—
Genl. Mgr.'s Rate Study 1952	347.00	428.00	388.00	292.00P	414.00P	—
Controller March 23, 1953	348.83	430.23	390.19	373.72P	409.01P	454.07P
Interest (in lakhs)						
Annual Reports—No information	—	—	—	—	—	—
Controller June 12, 1952	86.41	159.59	125.09	112.31P	114.63P	—
Controller March 23, 1953	83.17	156.84	122.34	39.04P	81.88P	116.36P
Profit and Loss (in lakhs)						
Annual Reports	43.12	—	—	—	—	—
Genl. Mgr.'s Rate Study 1952	17.00	– 156.00	– 455.00	– 317.00	– 262.00	—
Controller June 12, 1952	18.84	– 169.69	– 457.23	– 312.69P	– 270.86P	—
Controller March 23, 1953	18.84	– 169.69	– 457.23	– 269.74P	– 218.60P	– 112.33P

P indicates Provisional subject to change at time issued. 1 lakh equals 100,000.

TABLE XI – 21

ADDITIONS TO AND CAPITAL AT CHARGE

Period	*Net Additions during Year* (*K*)	*Capital at Charge End of Year* (*K*)	*Basis of Capital at Charge*
As of October 1, 1945	—	34,51,72,637	Prewar
Additions during 1945–46	58,08,177	35,09,80,814	,,
Additions during 1946–47	6,35,22,522	41,45,03,336	,,
Additions during 1947–48	9,92,73,951	51,37,77,287	,,
Deductions war damage	– 17,86,95,686	—	
Additions during 1948–1949	3,26,84,640	36,77,66,241	Postwar
Additions for 1949–50	2,18,11,757*	38,95,78,998*	,,
,, ,, 1950–51	2,20,00,000*	41,15,78,998*	,,
,, ,, 1951–52	2,00,00,000†	43,15,78,998†	,,

Source: Controller Railways Accounts.

* Provisional subject to adjustment. † Estimated.

Interest is accrued on the full capital at charge, on ways and means advances made by Government to cover deficits, and on other debts. All monies received from any source by the Board are required to be credited to the "Railway Board Fund." However, an extraordinary stipulation that Railways must pay back therefrom all accumulated advances for the four years preceding October 1, 1952, has made Railways dependent upon ways and means advances. Since Railways is running continual deficits, the final effect is to make it again dependent upon the general government budget.

6. REHABILITATION

Despite the many difficulties confronting Railways, great progress has already been made in rehabilitating works damaged by the war and by insurgents. The Management's present program for further restorations and improvement is condensed in Table XI–22 (*see p. 266*). The estimated costs shown are the Management's and would in some cases be insufficient. Some of the work covered has been accomplished.

TABLE XI – 22

PROGRAM OF RESTORATION AND IMPROVEMENTS

	Estimated costs (in K lakhs)	
Civil Engineering Works—Part 1		
1. *Bridges*, including Sittang, Daga, Waw Mu Valley, Mogaung and completion of Ava Bridge	376·94	376·94
2. *Permanent Way*, rail renewals, track restorations, track improvements as shown in detail in Table XI–22a	947·87*	
3. *Station Buildings*, Prome, Shwebo, complete Rangoon, and 120 wayside stations	47·00	
4. *Staff Quarters* to complete one unit per man	187·58	
5. *Signals and Interlocking*, including through service by radio and restoration of station to station train operating wires	23·10	
6. *Fencing at Stations* and between	91·75	
7. *Watering Facilities*, locomotives and trains	33·00	
8. *Station Machinery*, miscellaneous	8·00	
9. *Locomotive Running Sheds*, Carriage and Wagon Sheds	11·00	
10. *Insein and Myitnge Shops*, completion of restoration and improvements	16·10	
11. *Service Buildings*, miscellaneous	32·17	1,397·57
Total Civil Engineering Works		1,774·51*
Mechanical Works and Rolling Stock—Part 2		
12. *Passenger Rolling Stock*		
(*a*) 50 Upper Class Bogie Coaches	68·00	
(*b*) 85 Lower Class ,, ,,	29·50	
(*c*) 5 Upper Class ,, ,, —rebuilds	2·58	
(*d*) 27 Lower Class Bogie Coaches—rebuilds	8·26	
(*e*) 86 New Coaches from India—completion	7·50	
(*f*) 24 Inspection Coaches—rebuilds	6·00	
(*g*) Electric Equipment for carriages	62·00†	183·84
13. *Goods, Timber and Cattle Wagons*		
(*a*) 200 Timber Wagons—New Bogies	84·00	
(*b*) 100 ,, ,, —New 4-wheel	20·00	
(*c*) 2,000 Goods Wagons—New Covered 4-wheel	270·00	
(*d*) 500 Cattle Wagons—New 4-wheel	20·00	
(*e*) 100 ,, ,, —rebuilds	4·00	
(*f*) 6,300 Rolled-steel Wheels	15·00†	413·00
14. *Locomotives*		
(*a*) Diesel-electric Locomotives (6)‡	42·00	
(*b*) Locomotive Boilers (20)—replacements	12·00†	54·00
Total Mechanical Works and Rolling Stock		650·84†
15. Grand Total of Program		2,425·35†

* Part of the cost of item 2 being contributed by US TCA to extent of K12·82 lakhs, reducing total of civil engineering works to K1,761·69 lakhs. May be modified if CTC signals installed.

† Part of the cost of these items contributed by US TCA, amounting to K18·62 lakhs for the mechanical items and aggregating for all program items K31·44 lakhs, reducing the total cost of the entire program to K2,393·91 lakhs.

‡ Initial order for test experience.

All estimated costs are Railways figures except TCA items noted.

TABLE XI – 22A

DETAIL OF ITEM 2 RESTORATION AND IMPROVEMENT PROGRAM

	Item 2 Permanent Way Work		*Estimated costs (K. lakhs)*
A.	Lay new 75-lb. rail and fastenings, switches, 10% sleeper renewals, Kanyutkwin–Mandalay and Insein–Prome, releasing 60-lb.	415 miles	543·80*
B.	Relay worn 50- and 60-lb. rail on Ywataung–Myitkyina line with relayer 60-lb. rail from Item 1, sleeper renewals 10%.	182 miles	10·00
C.	Track restorations, other branch line rail renewals in part, Danbi–Kyongin, Kalewthut–Ye, Lewe–Kyaukpadaung, Myingyan–Tada U, Meiktila–Myingyan, Ywataung–Ye U, Sittang deviation line, station-yard rail renewals	572 miles	200·35
D.	Ballast reinforcement all lines, (deferred maintenance arrears estimated 15 million cu. ft.)	—	75·00
E.	Sleepers, deferred maintenance arrears, 1,300,000 ordinary and 3,000 tons switch specials	—	100·00
F.	Rail anchors or anti-creepers, various lines to reduce maintenance costs (1,370,000)	—	18·72
G.	Grand Total, Item 2		947·87*

*Part of the cost of Item A being contributed by US TCA to extent of K12·82 lakhs, reducing the Item 2 total to K935·05 lakhs.

Four items of the Management's program contributed from the United States program for technical cooperation effectively reduce the total estimated cost of Management's program from K2,425·35 lakhs to K2,393·91 lakhs:

	Dollars	K lakhs
15 Track Miles 75-lb. rail and fastenings	270,000	12·82
1,178 Rolled-steel Wheels (delivered)	78,000	3·70
42 Sets Carriage Electrical Equipment 50 Locomotive Headlight Generators 75 Locomotive Headlights	208,000	9·88
3 Locomotive Boilers 2 Sets Valve Motion Gear	106,000	5·04
U.S. Aid Total	662,000	31·44

7. ESTIMATED INCOME

a. Traffic Earnings

A detailed study has been made of passenger and goods earnings, both prewar and postwar, and consideration has been given to the effect of increases expected to flow from restoration of law and order and execution of various plans for expanding agricultural and industrial production. Tables XI–23 and XI–24 show conservative estimates of passenger

TABLE XI – 23

BURMA RAILWAYS

ESTIMATE OF PASSENGER TRAFFIC FOR THREE TARGET YEARS

Based on Rehabilitation of Lines, Restoration of Normal Improved Services, Increased Haul and Increased National Income

	Total Passengers (in thous.)	*Haul per Passenger (miles)*	*Earnings at Present Rates (K lakhs)*	*Average Rate Passenger Mile*		
				Present Rates (pyas)*	*Prewar 6 Years (pyas)*	*Per cent Increase*
1955–56						
Main Line	9,310	30·0	150·00	5·37	2·340	130
Suburban	3,780	15·0	8·06	0·14	0·046	204
Total	13,090	25·7	158·06	4·71	1·970	139
1957–58						
Main Line	10,640	30·0	171·20	5·37	2·340	130
Suburban	4,158	15·0	8·73	0·14	0·046	240
Total	14,798	25·7	179·93	4·71	1·970	139
1959–60						
Main Line	11,970	30·0	193·10	5·37	2·340	130
Suburban	4,410	15·0	9·54	0·14	0·046	204
Total	16,380	25·7	202·64	4·71	1·970	139

Notes: 1 Lakh equals 100,000. 1 Pya equals 1/100 kyat.
If the 19,758,000 passengers carried in 1940–41 at an average rate of pyas 1·97 per passenger-mile, with earnings of K98·79 lakhs, had been carried at the average rate of pyas 4·71, the earnings would have been K235·00 lakhs.
* Including present surcharge of 100%.

traffic and goods traffic for three target years at existing rates. Chart 1 is a graphic comparison of past earnings with the estimated earnings for the three target years, 1956–58–60. The validity of the estimates is supported by a comparison with hypothetical earnings on the past volume of traffic if it had been handled at present rates (see Notes, Tables XI–23 and XI–24, *see pp. 270 and 271*).

Chart 2, average revenues per unit haul, shows how the rates have been increased in an effort to reduce Railways' deficits. These rates should be reducible when traffic volume is restored to or above prewar levels. Attainment of such traffic levels can be hastened by rapidly closing such gaps in the line as the Sittang River and Ava Bridge, but until Railways can operate normally 24 hours a day daily without fear of dacoity (armed robbery by gangs) and sabotage, the increases in traffic volume must be nominal.

b. Working expenses and profit

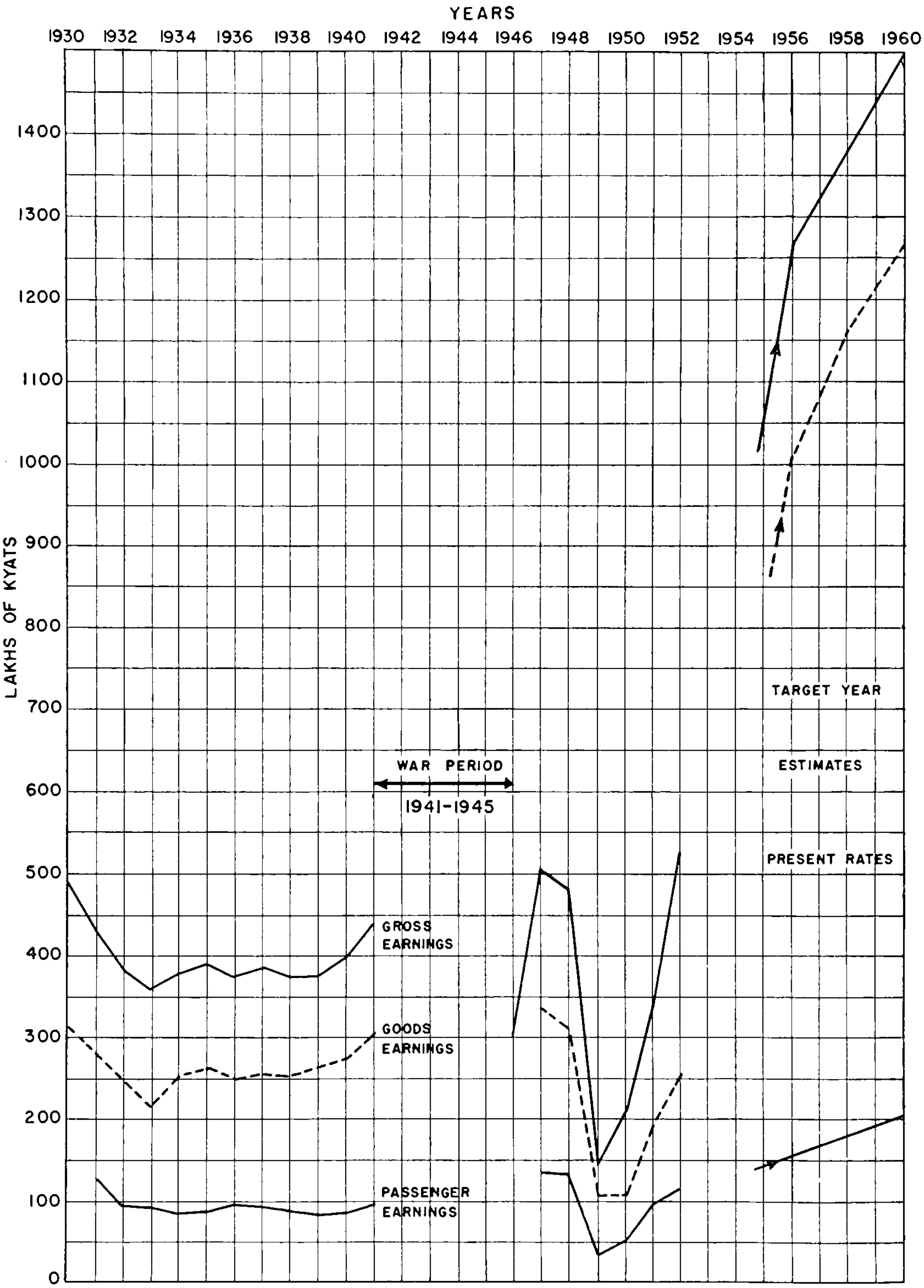
The estimate of direct working expenses has been made on the basis of existing pay scales, cost of living allowances now in effect and present costs of materials and supplies. It also includes revenue charges for the rehabilitation and improvement program for six years. Maintenance and train operation costs have been gradually reduced to reflect the use of new tools, methods and motive power as recommended in paragraphs E–5, 6 and 7 of this chapter.

For depreciation and interest factors, it has been necessary to estimate the growth of capital at charge which will result from the improvement program. If the estimated profits and rate of return shown in Table XI–25 are realized, there will be room to lower rates and encourage traffic (*see p. 271*).

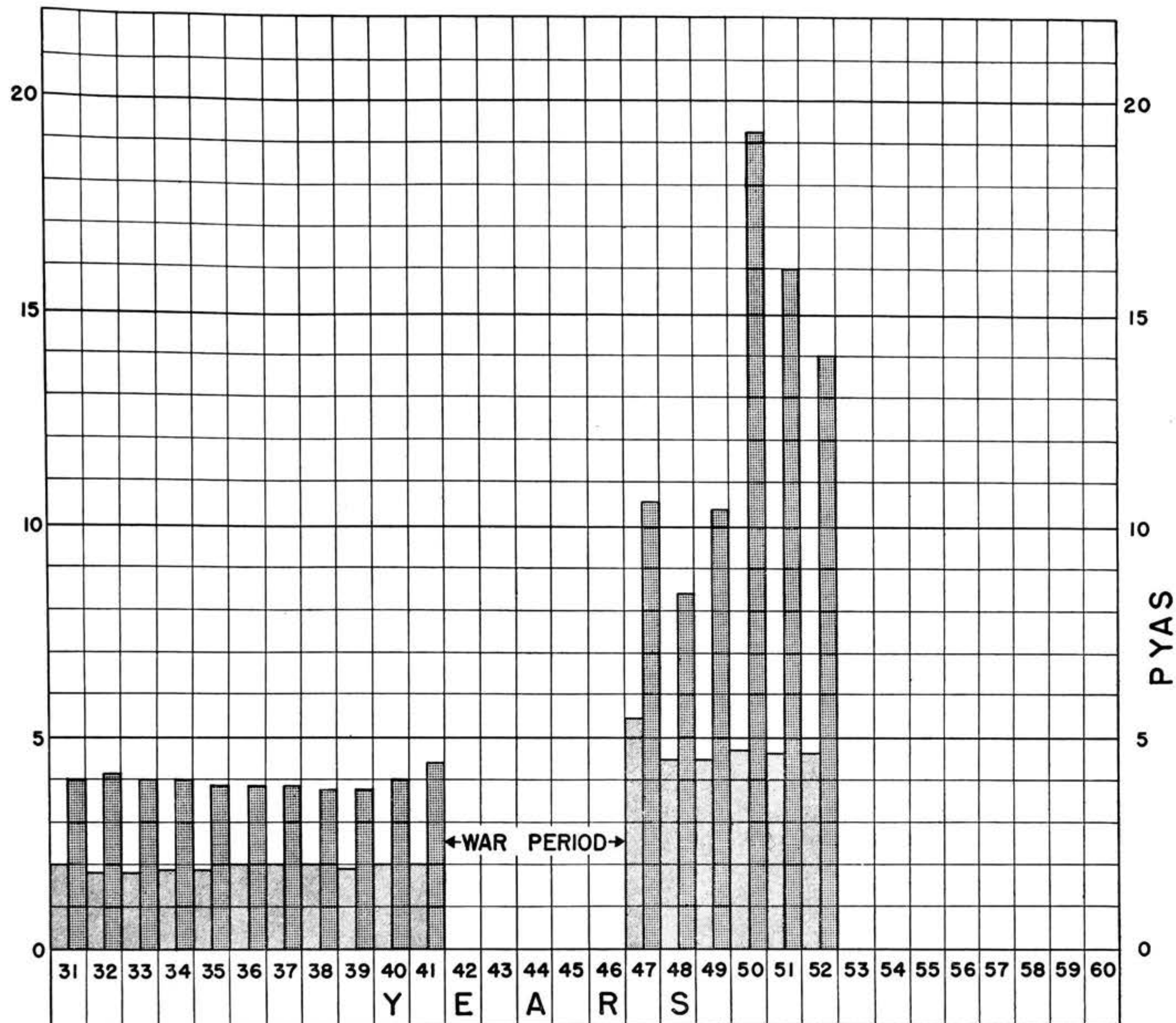
E. REQUIREMENTS FOR FURTHER IMPROVEMENT

1. SCOPE

The foregoing paragraphs have presented the background of Burma Railways and an analysis of the current workings and problems of the system. In this section, after a brief recapitulation of previously mentioned problems and current plans, specific suggestions for further improvements are discussed. Many



MINISTRY OF NATIONAL PLANNING		
RAILWAYS **TRAFFIC EARNINGS**		
KNAPPEN TIPPETTS ABBETT ENGINEERING CO NEW YORK. RANGOON		
DR BY. E.J.P. CK BY. EWE	DATE MAY. 53	CHART NO. 1



Year	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
GOODS	3.98	4.20	4.08	4.05	3.92	3.88	3.92	3.80	3.78	4.04	4.37					N.A.	10.57	8.45	10.42	19.25	15.90	14.32								
PASS'GR.	2.03	1.87	1.88	1.90	1.87	1.98	1.97	1.96	1.91	1.97	1.97					N.A.	5.4	4.48	4.38	4.72	4.61	4.56								

AVERAGE REVENUE PER PASSENGER-MILE

AVERAGE GOODS REVENUE PER NET TON-MILE

NOTE: 1 PYA EQUALS 1/100th. KYAT.

MINISTRY OF NATIONAL PLANNING

RAILWAYS

AVERAGE REVENUES PER UNIT HAUL

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK RANGOON.

DR. BY: E.J.P DATE CHART
CK. BY: EWE MAY 53. NO. 2

TABLE XI – 24

BURMA RAILWAYS

ESTIMATE OF GOODS TRAFFIC FOR THREE TARGET YEARS

Based on Rehabilitation of Rail Lines and Effect of Increases in Traffic expected to Result from Execution of Plans for Expanded Agricultural and Industrial Production

Period and Commodities	*Tons of Freight (in thous.)*	*Per cent of Traffic*	*Earnings at Present Rates* (K lakhs)*	*Per cent of Earnings*	*Average Rate Per Ton*		
					Present Rates (pyas)*	*Prewar (pyas)*	*Per cent Increase*
1955–56							
Agricultural Products	2,077	53·44	614·60	56·75	29·60	6·17	382
Minerals, excluding Coal	506	13·30	97·95	9·04	19·40	8·90	118
Forest Products	193	4·99	17·86	1·65	9·25	4·50	106
Miscellaneous and Live Stock	337	8·67	174·57	16·11	51·80	25·60	102
Coal, Railway Supplies, Military	773	19·60	178·44	16·45	23·08	11·54	100
Total	3,886	100·00	1,083·42	100·00	27·80	6·80	309
1957–58							
Agricultural Products	2,219	52·63	654 08	56·30	29·95	6·17	385
Minerals, excluding Coal	602	14·28	115 41	9·88	19·25	8·90	116
Forest Products	222	5·26	20·75	1·77	9·25	4·50	106
Miscellaneous and Live Stock	371	8·80	192·17	16·46	51·80	25·60	102
Coal, Railway Supplies, Military	801	19·03	184·91	15·59	23·08	11·59	100
Total	4,215	100·00	1,167·32	100·00	27·65	6·80	307
1959–60							
Agricultural Products	2,428	53·31	711·77	56·30	29·31	6·17	375
Minerals, excluding Coal	668	14·65	132·60	10·41	19·60	8·90	120
Forest Products	247	5·42	22·89	1·80	9·25	4·50	106
Miscellaneous and Live Stock	408	9·02	211·34	16·73	51·80	25·60	102
Coal, Railway Supplies, Military	804	17·60	185·59	14·76	23·08	11·54	100
Total	4,555	100·00	1,264·19	100·00	27·70	6·80	308

Notes: For the 5-year prewar period 1937–41, the average tons carried annually was 3,976,000 tons, with earnings of K271·59 lakhs, or an average of K6.80 per ton. The average lead of 173·2 miles resulting in earnings of K0·0399 per ton-mile.

If the same traffic had been handled at the 1951–52 average rate of K0·1435 per ton-mile, the average 1937–41 annual earnings would have been increased to K976·94 lakhs, or an increase of 260%.

1 Lakh equals 100,000. 1 Pya equals 1/100 kyat.

* Including present surcharge of 100%.

of these suggestions entail adoption of mechanized methods, some of which have heretofore been discounted as inapplicable or unsuited to labor and economic conditions of tropical Asia. These recommendations are, however, made advisedly and after careful study, with the firm conviction that if the methods and equipment proposed are introduced judiciously and gradually they will result in accelerated progress, higher standards of progress and reduced costs.

2. RECAPITULATION OF OPERATING PROBLEMS

The following paragraphs summarize, in the approximate order of urgency, some of the operating requirements already discussed:

(*a*) Restoration of law and order. This is necessary to efficient and expeditious execution of improvements, night running of trains, speed-up of services, and other normal railroad procedures. Without this, time for completion of work now planned cannot be satisfactorily forecast.

(*b*) Closing of gaps in line at Ava Bridge, Sittang River and Daga River to restore traffic.

(*c*) Acquisition of additional goods wagons and passenger carriages, ballast cars, and heavy construction equipment for bridge building and restoration work.

(*d*) Restoration of damaged bridges, destroyed housing, impaired sleepers and ballast.

(*e*) Permanent restoration of branch lines or release of rights of way for highway use.

(*f*) Rail renewals with heavier rail on balance of Rangoon–Mandalay line and later on Rangoon–Prome line,

TABLE XI - 25

BURMA RAILWAYS

ESTIMATED EARNINGS, EXPENSES AND INCOME FOR THREE TARGET YEARS

	1955–56 (*K lakhs*)	*1957–58* (*K lakhs*)	*1959–60* (*K lakhs*)
Revenues			
Goods and Live Stock	1,083	1,167	1,264
Passenger	158	180	203
Other Coaching	25	40	45
Total Earnings	1,266	1,387	1,512
Working Expenses			
Structural Works	190	160	150
Locomotive Supply, Carriage and Wagons, Ferry and Workings, Traffic and Trains	612	575	590
General	25	30	30
Miscellaneous	20	20	20
Total Direct Expenses	847	785	790
Depreciation	82	89	93
Total Working Expenses	929	874	883
Railways Net Earnings	337	513	629
Less Interest	122	133	138
Profit	215	380	491
Return			
Estimated Capital at Charge	5,115	5,415	5,615
Rate of Return	4·2%	7·0%	8·7%

Notes: Based on details of Passenger and Goods earnings shown on Tables XI–23 and XI–24.
Depreciation of 1/60th of capital at charge and of previous year.
Interest assumed at 2·5% on same basis
1 Lakh equals 100,000.

releasing 60-lb. rail for branches now laid with 50-lb. or worn 60-lb. rails.

(*g*) General improvement of goods and passenger train services, increased speeds, and recapture of traffic lost to other transport.

(*h*) As a general proposition and commencing at once, a gradual reduction in working expenses, costs and time required for completion of rehabilitation and improvement works.

(*i*) Systematic study and adjustment of the rate structure.

3. CURRENT REHABILITATION PROGRAM

The Management program is generally well thought out and covers the physical work and acquisitions necessary to bring the railroad plant and rolling stock back to their normal position of prestige and efficiency among the transport agencies in Burma. After further critical study and the preparation of detailed estimates for various segments of the work, the program should be carefully scheduled over a practical period of not less than six years. Time allotments for work acquisitions should be guided by the considered judgement of Management after a review of all factors. Each year thereafter, the scheduling for the balance of the program should be adjusted to what has been accomplished, and estimated costs should be reviewed and reallocated in the light of experience and current conditions. For purposes of this Report, the program will be considered as requiring six years for its execution, with expenditures allotted at arbitrarily estimated rates.

4. SPEED OF PROGRAM EXECUTION

Under the conditions existing in Burma, only the most intensive detailed planning and aggressive prosecution of the work can result in attainment of the ambitious goals set for achievement in six years. If the railroad is to be restored in such a period, Railways must be authorized to place long-range orders for rails, bridge steel, rolling stock and other important items well in advance to insure that suppliers can and will make deliveries to fit the progress schedule. A wait of five years, as in the case of Ava Bridge steel, for example, should not be tolerated. Orders for such important works should be placed on a firm delivery or penalty basis, even if the cost be slightly more than that of the lowest bidder. Time saved will be translated into substantial earnings and lowered working expenses which will more than support the increased costs.

A complete, efficient and well-functioning railroad operation is essential to the success of government plans for increased agricultural production and industrial development, and for the consequent improvement of economic conditions in all Burma. If Railways is to accomplish quick results, it will need aid in short-circuiting administrative obstructions, indecision and delays of the kind that retarded designs for the new Sittang River Bridge for nearly six years. Such delays deprive Railways of earnings on substantial traffic which cannot be handled until the gaps are closed.

The Ministry of Transport and Communications should assist Railways in obtaining decisions of higher authorities, in expediting cooperation required from other government agencies, and in reconciling its needs and requirements with those of other agencies by prompt and aggressive action.

Railways Management also should press vigorously its case for implementation of the program, but it should insure that execution of work authorized does not lag. Both to improve Railways' earnings and to release labor for new enterprise, management should aggressively adopt applicable new methods, machines and practices found successful elsewhere, and must divorce itself from traditional wasteful uses of cheap human labor.

5. MAINTENANCE OF WAY

a. Rail Renewals

Renewals, with new 75-lb. and relayer 60-lb. rail, are programmed for nearly 600 track miles. The plan calls for an average laying of 30 miles of 60-lb. and 70 miles of 75-lb. or a total of 100 miles annually for six years. However, the work should be done more rapidly and in not more than four years. To eliminate the delays heretofore experienced, steel can be secured in world markets other than the customary India and United Kingdom sources.

Rail renewals should be made by a small, well integrated, and specially trained crew housed in mobile quarters provided with reasonable amenities. Equipment should include a complement of modern hand tools, a modern power crane for handling rails and portable power tools such as a power adz, sleeper borer, spike puller, spike driver, bolt tightener, hack saw and rail grinder. Adequate track motor cars and trailers should be provided for rapid gang transport from set-out point to the job so that time lost in walking can be eliminated. For renewing sleepers, follow-up lining, surfacing and dressing up, a gang should be equipped with a mobile power plant and with air or electric ballast tampers. Such gangs would require competent trained supervisors and assistants, and once organized should be kept regularly employed until the job is done. The equipment costs of about K4 lakhs would be saved many times in lowered costs.

b. Ballast Work

Ballast work under the current program will be performed largely as reinforcement work, and much ballast will be placed by regular local gangs. However, some districts will require the services of a specially trained ballast gang which should follow and be equipped with the same sort of mobile housing, tools and transport as the rail gang. The cost for such equipment need not exceed K2 lakhs. Ballast is now costing Railways about K40 per 100 cubic feet or five times the prewar quarry price, with labor cost for coolies increased in about the same proportion. Prewar ballast requirements were about $5\frac{1}{2}$ million cubic feet annually, obtained principally from private contractors. The Chief Engineer estimates the present backlog as 15 million cubic feet.

It is strongly recommended that Railways carefully investigate the results to be obtained by establishing a modern crushing plant of its own at a cost of about K5 lakhs, or that it enter into a long-term contract with the Department of Roads or a private enterprise under terms which would support production of ballast with modern high-capacity machinery. So-called "portable" rock-crusher plants are available with capacities conservatively estimated at 500 tons or 10,000 cubic feet daily. If set up at a suitable quarry face, one such plant, working two shifts for 300 days, could supply Railways with its annual ballast needs. Two plants would supply rock for all needs. These plants could be moved from year to year to the quarry nearest the major requirements to reduce costly haul, and surplus rock could be sold. With a trained ballast gang and reliable source of supply, ballast work could be effectively carried on almost continuously.

Existing ballast cars are constructed to dump only outside the rails, and all ballast needed between rails is shoveled or hoed in by hand, a costly practice. A quota of about 75 modern, 40-ton ballast cars with controlled dumping either center, side, center and one side, or center and both sides, could be obtained at a cost of about K30 lakhs. When not in use as ballast cars, they could be used commercially for hauling coal and similar materials.

c. Track Maintenance Gangs

These now average about $2\frac{1}{2}$ men per mile on sections of about four miles. Men walk to work carrying their meager allotment of tools. Much dressing up of ballast is done with bare hands. Railways should at once commence a program of providing gangs with motor cars, trailer cars, adequate hand tools and equipment, and should gradually eliminate two gangs out of three. Many men can be transferred to rehabilitation work for several years. Considering conditions in Burma, gangs of 12 men with proper equipment and transportation should very adequately maintain 12 miles of line, except on ghat sections where extreme grades and curvature are encountered. Surplus personnel can be absorbed in rehabilitation and extension of the system.

On the basis of equipping 1,700 miles of line, about 150 eight-man motor cars and 150 trailers would be required, costing K11 lakhs. A garage tool shed and additional hand tools for each gang would require another K6 lakhs. The eventual release of coolie forces to other work would be about 2,400 men, saving K22 lakhs annually, or in one year an amount equal to $1\frac{1}{3}$ times the first cost of the new equipment. Savings would also accrue from the release of living quarters, medical services, supervisors and accounting time. About 40 small motor inspection cars suitable for two to four men would cost about K2 lakhs, would save wages of peons now used to push engineers and supervisors slowly over the line on hand push trolleys, and would enable such officers to handle more territory.

d. Equipment for Heavy Construction and Maintenance Work

This is insufficient in quantity and character for rapid and efficient work on some of the large jobs such as, for example, the Sittang Bridge piers which must be sunk through 100 feet of river-bottom silt. It is recommended that a careful selection of mechanized construction equipment be acquired, and to include such items as the following:

Caterpillar tread shovel and two long-boom cranes of good capacity.
Supplemental orange-peel and clam-shell buckets.
One crane with heavy magnet equipment.
Drag-line excavator attachments.
Steam pile-drive unit.
Air compressors and reservoirs.
Pumps, self-powered units of various sizes, large and small.
Small electric plants for power and lighting.

Some of this equipment can be obtained in combination units. Such tools will reduce costs and save sorely needed time. The total cost of such long-lived plant need not exceed K30 lakhs.

e. Weed and Heavy Brush Control

Weed and heavy brush control in Burma is presently all hand work. Results which can be achieved by brush-killing chemicals and chemical weed control should be thoroughly investigated.

f. Salvage

Wreckage and scrap from the war and insurgent operations litter the railroad property, particularly on the Rangoon–Myitkyina line. Hundreds of bomb- and gun-shattered and wrecked wagons and carriages lie on every hand. Large collections of wrecked locomotives are gathered at Insein, Yamethin, Yawataung and other points, and many more are on line. Railways have in this wreckage hundreds of usable wheels, axles, couplers, draft springs, brake rigging and other materials, in addition to a substantial tonnage of scrap rail. It is recommended that a well organized special gang be equipped with a heavy crane, small tractor, wire ropes, cutting torches, and other suitable gear for retrieving and concentrating these materials at strategic points for inventory and classification. This will have to be done some time, and now is a good time to start. Existing tools and equipment could be diverted for this work.

It is further recommended that the Railway Board seek Government sanction to process all scrap suitable for shipment to rail mills as a partial substitute for cash on rail orders. Open-hearth steel mills are always in need of scrap. The customer with a substantial amount of it is able to trade advantageously as to price and delivery. The waste inherent in continuing to use full cash to buy new rails while neglecting to use this presently wholly unproductive but valuable scrap will be evident.

6. RAIL AND MECHANICAL EQUIPMENT

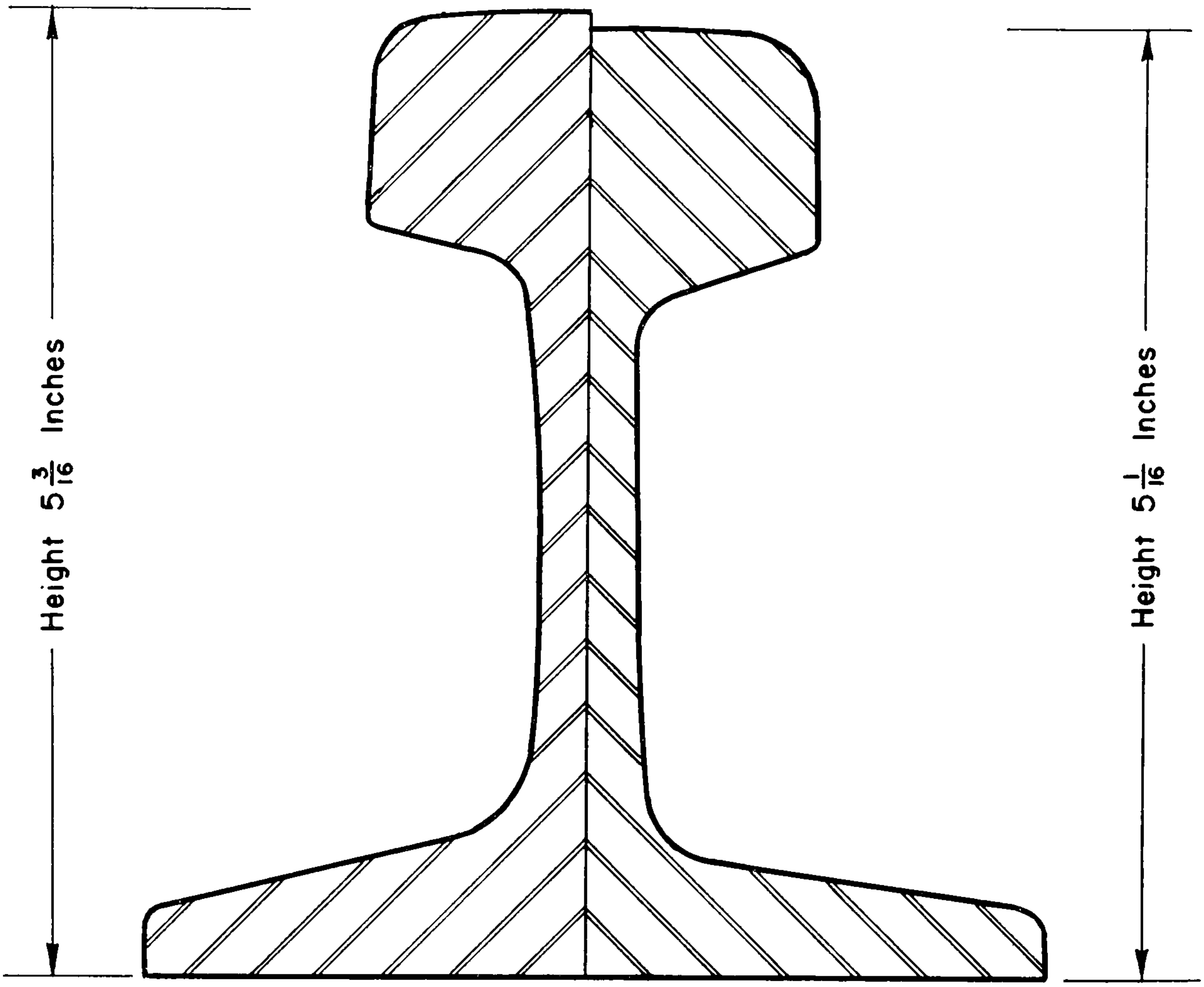
(*a*) The design of the 75-lb. rail section now standard on Burma Railways no longer represents what is considered to be the most efficient and effective use of the metal. In view of the large tonnage of this weight to be laid on the main line where higher speeds than ever before in Burma eventually will be commonplace, Railways should adopt a new cross-section with better girder strength and deeper fishing space for joint bars. The general proportions of a recent rail section are compared with the present standards of Railways on Plate 5. Railways should start study at once so that a better rail section can be obtained on current and future rail orders.

(*b*) Better track for high speeds will result if staggered rail joints are used. The effectiveness of this practice has been demonstrated by its use in United States, Canada and Mexico for more than 60 years on track bearing extremely heavy loads at very high speeds. As the new 75-lb. rail is laid, the joints should be rcspaced to the staggered standard now already followed by Railways on curves.

(*c*) When sleepers are pre-bored before creosoting at the Myohaung plant, eight holes should be bored. If this is done, as it should be, by two four-spindle drills simultaneously, no extra production cost will be involved. Penetration of treatment under the rail seat will be greatly improved and sleepers will be ready, without field boring, for double spiking on outside of curves where necessary.

(*d*) Speeds are bound to increase on the main line, and curves over 3° should be fitted with four-hole bearing plates so that the dogspikes, both inside and outside, will combine to resist thrust against the outer rail. The number of plates required to thus outfit the main line will be nominal.

(*e*) On the ghat sections and where curvature is sharp, gradual installation of fixed-position track oilers will be found profitable in saving rail wear and wheel-flange wear. These devices, actuated by the passing wheels, automatically feed a small amount of heavy oil onto the wheel flanges. This oil is carried



RECOMMENDED SECTION

AREAS	SQ.INCH	PERCENT
HEAD	2·81	38·2
WEB	1·66	22·6
BASE	2·88	39·2
TOTAL	7·35	100·0

STANDARD SECTION BURMA RAILWAYS

AREAS	SQ.INCH	PERCENT
HEAD	3·21	43·7
WEB	1·56	21·2
BASE	2·58	35·1
TOTAL	7·35	100·0

MINISTRY OF NATIONAL PLANNING

RAILWAYS

COMPARISON OF SECTIONS
75 Lb. RAIL

KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK. RANGOON.

DR. BY. E.J.P. DATE PLATE
CK. BY. EUE. MAY 53. NO. 5

around the curve without affecting traction on top of the rail. Rail life on curves is greatly extended in this way. One oiler often serves several curves.

(*f*) A gradual program of equipping additional goods vehicles with vacuum brakes should be initiated. Efficient operation will eventually require higher speeds on goods and mixed trains. Better control and shorter stoppings will be imperative from a safety standpoint. Higher speeds will reduce investment in wagons by increasing the utilization factor.

(*g*) Non-synchronizing snubber springs should be applied to bogies on American-type "box" cars on line to eliminate the "bounce" now detrimental to loadings and track. Data on these devices has been furnished Railways.

(*h*) Sandblasting should be employed at Myitnge shops for removal of rust on underframes and structures of the large number of wagons undergoing rehabilitation. This work is now being done ineffectually by slow and costly handwork. Sandblasting will do a much better job faster and cheaper. Data on suitable equipment has been furnished Railways.

(*i*) In general, new wagons should be of heavier capacities than standards now used. The added cost is nominal in comparison with the added strength, improved revenues per wagon, and increased operating efficiency.

7. DIESEL-ELECTRIC LOCOMOTIVE OPERATION

Utilization efficiency of locomotives on Railways is understandably low under present conditions. Out of 307 steam locomotives owned, 187 or 68% of the total tractive effort is comprised of locomotives built since 1946 as shown in Table XI–6. From a traffic-movement standpoint alone, it is unlikely that Railways will require any additional motive power for several years.

However, from a standpoint of economy through reduction of working expenses, after insurrection troubles have subsided, and when traffic density has improved to a point where some diesel-electrics can be kept in active heavy-duty service for 80% or more of the potential hours, a gradual change to diesel-electric power is recommended. When such conditions develop for any segment of train-service, a railroad can no longer afford to operate steam locomotives in that segment of service even though dieselization may involve laying some steam power aside in idleness, or as scrap, regardless of its age.

While diesel-electrics are high in initial cost, two will serve in place of three steam locomotives of approximately the same tractive power. This is because of the high degree of mechanical availability which approaches 90%. How then should Railways prepare to reap the substantial benefits of partial dieselization when density of traffic volume shall make the investment profitable?

(**a**) First, it is recommended that Railways promptly secure six diesel-electric combination road or shunting locomotives for service in the Rangoon area as shunting engines and for use during rush hours on Rangoon suburban trains. A representative American-built locomotive suitable for such use would be the following:

400 h.p.—43 metric ton—4 axles—meter gauge.
Combination Road and Shunting Locomotive.
Tractive Effort—Initial —29,700 lbs.
" " —Continuous Rating—12,100 lbs.
Speed up to 50 m.p.h.
All with suitable brakes, couplers, etc.
Approximate cost, Rangoon—K3,92,000.
International General Electric Company, Manufacturer.
Schenectady 5, New York, U.S.A.
Locomotive Specification No. 4359-E.

The locomotive described is powered by two 200-h.p. Caterpillar diesel engines, each directly connected to an electric generator. All four axles are individually motor-driven through enclosed gear trains. This specific recommendation is made for the following reasons:

(1) The locomotive is a unit of highest quality and has been long proven by numbers in use, both in standard and meter gauge types.

(2) The Caterpillar diesel engines are known and serviced all over the world. Parts are readily obtainable.

(3) The locomotive can be used for shunting, passenger or road-freight service anywhere.

(4) If provided with multiple-unit control circuits, locomotives can be used in tandem with one set of controls, thus permitting use as a single locomotive.

(5) The axle load of 12½ metric tons is within Railways bridge limits for non-reciprocating locomotives.

This initial installation is urgently recommended in the Rangoon areas because it would provide improved service, would afford much needed information, and would create a training ground for diesel and electrical maintenance personnel at headquarters under close supervision. With the technical and working experience thus gained, Railways would be prepared for gradual extension of diesel-electric operations on main-line districts when the economies become favorable.

(**b**) Second, if traffic in Burma improves materially in the next few years, as planned for and expected, the time for use of diesel-electric locomotives for the principal volume of main-line traffic may not be far distant. When that time comes, some of the steam power can be sold, stored or scrapped. The ideal operation would be to keep the diesels fully busy on the constant "backbone" of traffic and to handle seasonal peaks, short runs and low-density branch lines with existing steam power. The relatively higher cost of diesel-electric locomotives demands that the investment be kept almost constantly productive.

Although two 400-h.p. locomotives can be used in road service as an 800-h.p. locomotive, main-line operations would be better handled by more powerful unit types of about 1,000 h.p. to 1,500 h.p. After detailed studies of train tonnages and speeds, a combination type suitable for freight or passenger work should be selected, with an initial tractive effort between 30,000 and 45,000 lbs. and suitable wheel arrangement for Railways' axle-load limits.

(c) Third, it is estimated that traffic requirements will be such by 1958 that about 25 road service passenger and freight diesels should be in use and about nine additional combination road-shunters, with the main line almost entirely dieselized and branch lines running with coal or oil-burning steam power. The investment for such additional equipment would be approximately:

	Lakhs
9 Additional Road-shunters at K3·90 lakhs	K35·1
25 Road Freight and Passengers at K8·3 lakhs	K207·5
Total	K242·6

(d) Overall economies to be expected from use of the foregoing diesel-electric locomotives are several. Their exact determination would require an analysis of specific conditions, presently not practical. The major economies would result from lower fuel and repair costs and better locomotive utilization. On the basis of 165 lbs. of coal and 1·5 imperial gallons of diesel oil per 1,000 gross ton miles, the coal cost would be K7.06 versus a diesel-oil cost of K1.80 with coal costing K96 per ton at dock and diesel oil K1.20 per imperial gallon. If the 1940–41 gross ton miles had been handled only one third by diesel-electric locomotives, the fuel purchase costs would have been reduced by K49 lakhs on the basis of today's prices. Equivalent mileage locomotive repairs would have been reduced by at least 50%.

(e) A final word of caution is that locomotives of different manufacture should be fully investigated as to first costs, performance, maintenance costs, reliability and other factors. The manufacturer, once selected, should be retained for future acquisitions unless some extraordinary defects develop. If four or five different types are used, the investment in different sets of spare parts and tools becomes a burden. The road-service type finally selected can and should be suitable for operation in either goods or passenger train service so that maximum utilization can be obtained.

8. COAL HANDLING

Coal handling on Railways should be mechanized to save both coal and handling expense. At present, coal on the dock is loaded in covered wagons, unloaded and stock-piled at destination, and finally loaded on locomotives by coolies with head-baskets. Waste from breakage and dust loss inevitably occurs at each handling. Proposed port improvements at dockside will reduce the cost of unloading from barge or ship. Railways will eventually substitute diesel-electric locomotives for much of its main-line traffic, but will continue to burn coal on branches. Consequently, mechanical coal storage and loading plants of moderate capacity should be installed at branch-line junction points. Such station would receive coal from center-dump hopper wagons and elevate it to storage and service "tanks" above. The elevated coal trestle and side bunkers should be considered obsolete because of their high first cost and high maintenance cost.

9. CENTRALIZED TRAFFIC CONTROL SIGNALS

A special project report has been prepared setting forth advantages of train control by means of outlying signal indications operated from a central point. The project report emphasizes the fallacy of replacing any part of the second main track, formerly existing from Togyaunggale 170 miles north of Kyungon, which was destroyed or carried away during the war.

The project report also shows that Centralized Traffic Control (CTC), should receive careful consideration on its own merits, without respect to the second track argument, as a method more speedy, economical and safe than methods heretofore used. CTC will endow a single track with train capacity

TABLE XI – 26

CENTRALIZED TRAFFIC CONTROL

Investment	*Kyats*
170 miles additional main track	3,05,00,000
CTC signals, switch machines, etc.	82,00,000
First Cost Savings in favor of CTC	2,23,00,000
Annual Costs and Amortization	
170 miles additional main track	23,08,455
CTC signals same distance	7,00,990
Savings in favor of CTC	16,07,465
Other operational savings due to CTC on single track	5,00,000
Total Annual Savings in favor of CTC	21,07,465

equal to 75% of that of double track and will effect large savings in working expenses. It may be installed in sections over a period of years to suit conditions and finances. Costs relating to the 170 miles analyzed in the project report are shown in Table XI–26.

If annual operational savings at K5 lakhs be capitalized at 5%, the investment warranted would be K100 lakhs compared with a first cost for CTC of K82 lakhs. Thorough study of the related project report should be made before proceeding too far with acquisition of the expensive hand-operated electric-type station signals now planned for the main-line replacements.

10. ADMINISTRATION

a. Working Expenses

Costs of railroad working expenses have increased greatly since the war, both for personnel and materials, but since costs of most materials are beyond control of Railways, it must look for economies largely in reduction and more efficient use of staff by employment of improved methods and labor-saving devices. This will involve much planning and may require a determination to break sharply with traditional practices.

Staff on Railways, although proportionately smaller than on some other Asian lines, is demonstrably much larger than required to successfully and profitably operate the railroad under normal conditions if mechanized practices are employed. The figures below provide a comparison of the manpower used at present in Burma with the manpower utilized by a typical US railroad operating in similar terrain, but with traffic aggregating about five times the prewar traffic in Burma:

Total Employees	*US Ry.*	*Burma Railways*
Employees per mile of road	4·3	10·7
Employees per mile all tracks	2·6	8·6

Generally speaking, Railways has also a very high percentage of supervisory staff with very small jurisdictions, considering the density of its traffic. Savings should be effected gradually as retirements occur by consolidating some districts and granting increased compensation for officers taking on increased responsibilities.

b. General Offices

General offices at Rangoon are inadequate for forces employed. In many cases clerks and others are working in quarters with inadequate light. Files and records are stored on open shelves or on floors where they become deplorably dusty and dog-eared. An increase in working space should be provided. All interiors should be painted with light-coloured lusterless paint of pleasing tint and provided with adequate non-glare shadowless lighting. A good quota of modern electric adding machines and electric calculators should be provided in the general office (and important outlying offices) to save time in compilation of accounts and statistics. Study should be made with the intent of adopting an enclosed vertical filing system suited to Burma conditions. Total cost of such changes need not exceed K4 lakhs and would result in greatly improved labor conditions and better efficiency.

c. Repair Costs for Sabotage

Repair costs for sabotage and expenses of armed escorts and armored trains should be credited to Railways by Government because such costs are not true working expenses of a normal railroad operation but are part of the general security costs of Government.

d. Accounting Records

From a reading of Table XI–20 and paragraph D–4 of this chapter, it would appear that decisive action should be taken to clear up uncertainties existing as to the earnings, expenses and income of Railways during the postwar period. Evidently books for past years are not yet closed, although prewar annual reports were completed and consistent from year to year on all counts.

It is recommended that a prewar model annual report be issued for 1952–53 not later than three months after the close of the fiscal year on September 30, complete with all traffic, operational and financing information. Unaudited items in any account should be estimated and included in Operating and Balance Sheet accounts and later adjusted and included in the same accounts in the following year's report, with appropriate explanation if the entry causes undue distortion. Delayed items and retroactive payments or adjustments should be handled in the current year, and, if desirable, pro-rated over several months to avoid distortion in any one month.

e. Accounting Organization

Accounting is now in charge of the Controller of Railways Accounts who has a dual responsibility to the General Manager of Railways and to the Auditor-General of the Union of Burma. The Statistical Officer reports to the General Manager and is responsible for preparation of the annual reports but has to obtain all money data from the Controller's office. Consequently, divided responsibility and confusion exist with respect to statistics and annual reports.

Interests of Railways and Government would best be served by having the Controller appointed by and responsible to the General Manager and responsible for the integration and correctness of all financial and statistical reports and compilations. Appropriate check by Government could be arranged for in a manner desired by the Auditor-General.

f. Ticketless Travel

This evil is much worse than detection figures indicate, as shown by recent surprise checks. It can be entirely suppressed by providing means for passing from one carriage to the next while the train is in motion, and placing ticket collectors on the train who pass from end to end of the train (or certain group of carriages assigned) after each stop. All of North and South America, Japan, China, North and South Africa, and all modern trains in Europe, provide end to end communications on trains in motion, and have no ticketless problem of any consequence. As soon as possible, passenger vehicles should be modified to provide through passage.

g. Interest

Under the government fiscal system, interest on Railways book record "Capital at Charge" cannot be reduced except by reduction of plant and consequent reduction of book record costs of road, equipment and rolling stock. Every addition to plant increases the capital at charge, and interest increases proportionately. Stated in another way, every addition is treated as if acquired 100% with borrowed money, with no provision for reduction of debt or interest.

A revision of this system is recommended so that Railways can make the normal run of substantial plant additions from earnings, when available, without increase of interest, leaving only the costs of important extensions or major additions to plant on the borrowed-money basis. This might be accomplished by issue of Railways bonds, guaranteed by Government and with sinking fund provisions for retirement at maturity.

h. Specifications and Standards

Railways should cease using specifications and standards entitled "Government of India" or "Indian Railways," and should adopt any available specification found suitable for Railways needs. Such specifications and drawings should be labelled "Burma Railways," with a note reference to origin, if desirable for manufacturers.

i. Technical Periodicals

Information on railroads everywhere and their practices is vital to progress. It is strongly advised that Railways subscribe to the following monthly American railroad publications, in addition to British and other publications now received:

	Two-Year Foreign Subscription
Railway Mechanical and Electrical Engineer	\$12.00
Railway Engineering Maintenance	\$12.00
Railway Signalling and Communications	\$12.00
	\$36.00

(Simons Boardman Publishing Company, New York 7, New York, U.S.A.)

These magazines, both text and advertisements, will be of great service to officers and technical personnel in their studies of railway practices.

j. Liaison Visits

Visits abroad to various countries will be more beneficial if made by senior staff officers who are in a position to take direct action on practices noted and considered desirable for adoption by Railways, whereas younger staff officers will sometimes have difficulty in convincing their superiors of the virtues of some method observed and considered by them as desirable.

k. The Association of American Railroads

The Association of American Railroads, Transportation Building, Washington, D.C., is a cooperative organization maintained for the purpose of standardizing materials, certain methods and practices, and for group aetion on various railroad matters. It also aids and embraces the various major railroad engineering associations, conducts railroad laboratory research and prepares analyses of problems important to the industry. Inquiries as to technical practices or where American products can be obtained, if addressed by Burma Railways to the Association, will always receive courteous attention. Railways is urged to avail itself freely of the opportunities offered for cooperation and assistance.

11. SUMMARY OF COSTS

Due to many obvious uncertaintics relating to Railways operations under conditions now existing, any year-by-year timing for expenditure proposed must be approximate. Table XI–27 shows a desirable allocation over six years which, if followed, would result in a speed-up of program execution and early realization of the economies attainable by more effieient operation and use of improved methods of works construction.

F. CONCLUSION

In common with the accomplishments of railway men in other war-torn countries, Burma railwaymen, from staff officers to coolies, have behind them a fine record of repairing war damage and restoring service. Considering the conditions of insurgency existing continuously since early 1949, and the remoteness

TABLE XI - 27

SUMMARY OF REHABILITATION AND OTHER IMPROVEMENTS

Excluding Costs Donated by US TCA

Work or Acquisition	*1953 (K lakhs)*	*1954 (K lakhs)*	*1955 (K lakhs)*	*1956 (K lakhs)*	*1957 (K lakhs)*	*1958 (K lakhs)*	*6 Years Total*
Management Program (Table XI–22)							
Civil Engineering Works	262·00	427·00	434·00	375·00	158·94	104·75	1,761·69*
Mechanical and Rolling Stock	46·96	192·00	170·00	120·00	90·00	13·26	632·22*
Total Program*	308·96	619·00	604·00	495·00	248·94	118·01	2,393·91*
Other Recommendations							
Equipment for Rail Gang	—	4·00	—	—	—	—	4·00
Equipment for Ballast Gang	—	2·00	—	—	—	—	2·00
Rock-crusher Plant	—	5·00	—	—	—	—	5·00
75 Ballast Cars	—	—	30·00	—	—	—	30·00
Heavy Construction Equipment	—	30·00	—	—	—	—	30·00
Track Maintenance Motors and Tools	—	9·00	8·00	—	—	—	17·00
Motor Inspection Cars	—	2·00	—	—	—	—	2·00
General Office Changes	—	2·00	2·00	—	—	—	4·00
Scrap Reclamation Program	—	—	—	—	—	—	—
9 Additional Diesel-electric Shunters	—	—	20·00	15·10	—	—	35·10
25 Diesel-electric Road Locomotives	—	—	50·00	75·00	82·50	—	207·50
Total Other Items—KTA	—	54·00	110·00	90·10	82·50	—	336·60
Total Program and KTA Items	308·96	673·00	714·00	585·10	331·44	118·01	2,730·51*

*Items reduced from Management's program by K31·44 lakhs, the amount of US TCA contributions.

from sources of equipment and materials supply, the results have been outstanding.

Opportunity now exists for Burma Railways to better its good prewar service record and to move forward to become the most progressive railway in East Asia. With adoption of new methods and a continuance of the fine courage, skill and tenacity of purpose heretofore shown by the entire staff in the face of extraordinary difficulties, consummation of such a result seems assured. The various measures that are proposed or discussed in the foregoing pages and that are recommended here as a means of materially facilitating and expediting this splendid objective are condensed and summarized in the following paragraphs.

1. The following modifications and improvements in present practices, equipment, and administration are recommended:

(*a*) That continuing improvement through increased mechanization, introduction of power handling, and procurement of high-production equipment be adopted as a positive policy.

(*b*) That the current improvement program be scheduled over a six-year period, reviewed and revised annually to accommodate changes in the situation.

(*c*) That immediate efforts be made to expedite the general rehabilitation measures, closing of gaps and improvements in services and efficiency as summarized in paragraph E–2 above.

(*d*) That new equipment and methods of operation for maintenance of way and improved rail and mechanical features be adopted and introduced gradually as experience is gained and as personnel can be absorbed on new work or curtailed through normal attrition (paragraphs E–5, E–6).

(*e*) That the use of diesel locomotives be introduced with a pilot purchase and familiarization program beginning with combination road and shunting engines for the Rangoon and suburban areas (paragraph E–7).

(*f*) That coal handling be mechanized and simplified (paragraph E–8).

(*g*) That centralized traffic control be instituted in stages beginning with 170 miles of main track (paragraph E–9).

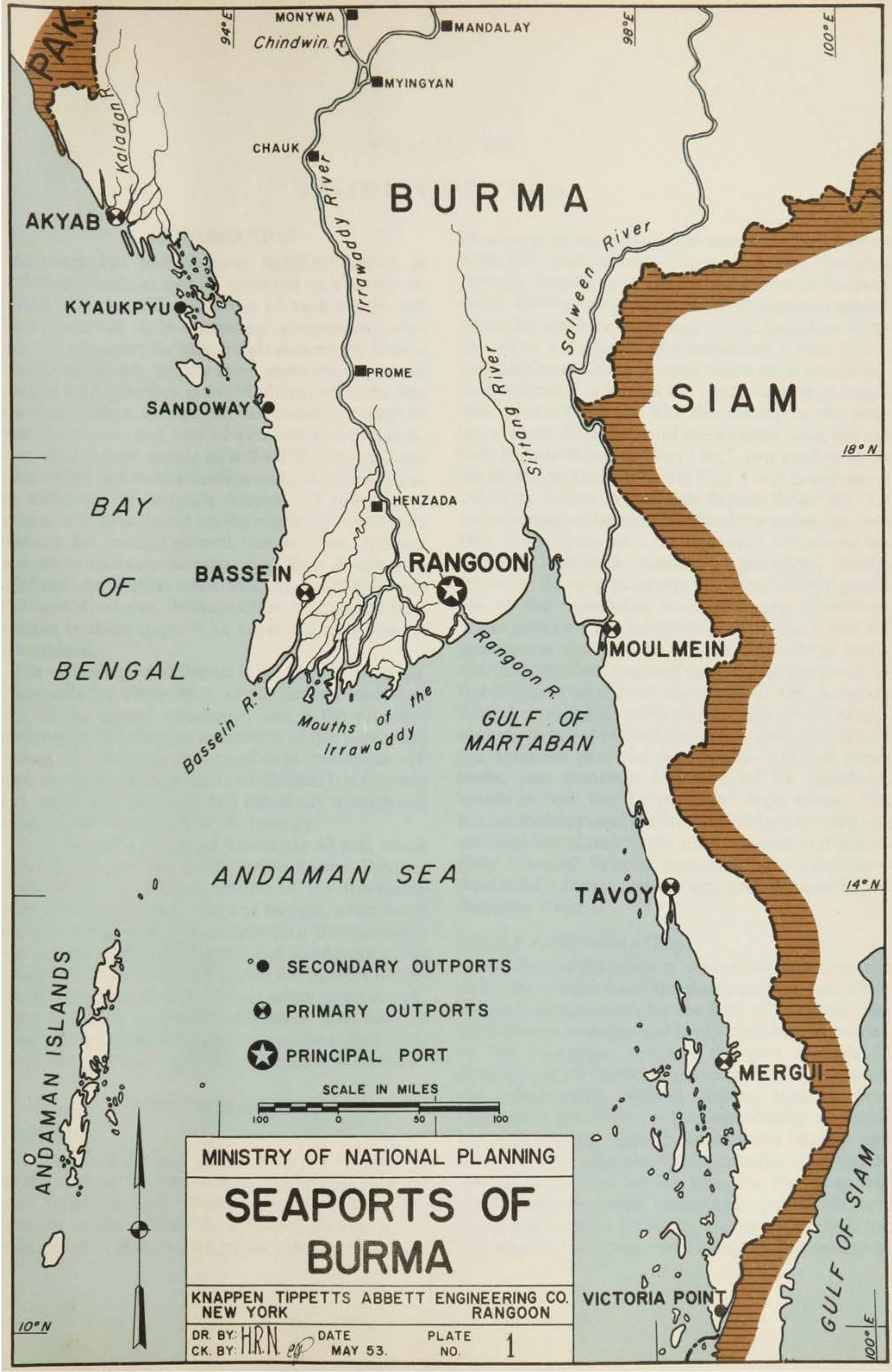
(*h*) That administrative practices be studied and revised to reduce labor costs, correct accounting weaknesses, provide adequate office space and in crease the availability of technical information (paragraph E–10).

2. To insure the expeditious and coordinated implementation of this or any program of improvement, it is further and urgently recommended:

(*a*) That the Ministry of Transport and Communications aggressively support Railways by granting prompt decisions, by expediting the services of other departments affecting Railways, and by exacting prompt coordination of interdepartmental actions.

(*b*) That Railways be authorized to undertake long-range purchasing under contracts fixing firm delivery dates.

(*c*) That Railways establish in its own organization a highly placed center of responsibility for rehabilitation and development headed by a broadly trained and widely experienced railway executive, serving in a capacity such as special deputy manager or special assistant to the Manager or as Consultant.


PAK.
MONYWA
MANDALAY
94°E
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100°E
Chindwin R.
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Irrawaddy River
BURMA
AKYAB
Salween River
KYAUKPYU
PROME
Sittang River
SIAM
SANDOWAY
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OF
BASSEIN
RANGOON
BENGAL
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Bassein R.
Mouths of the Irrawaddy
GULF OF
MARTABAN
ANDAMAN SEA
TAVOY
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SECONDARY OUTPORTS
PRIMARY OUTPORTS
PRINCIPAL PORT
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MINISTRY OF NATIONAL PLANNING
SEAPORTS OF
BURMA
KNAPPEN TIPPETTS ABBETT ENGINEERING CO.
NEW YORK
RANGOON
VICTORIA POINT
GULF OF SIAM
10° N
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CHAPTER XII

SEAPORTS OF BURMA

A. INTRODUCTION

Although rail and highway facilities leading to bordering countries can be extended and better exploited, the physical difficulties of such routes will always preclude their competing economically with seaborne transport for bulk freight movement. Burma must therefore rely largely upon seaborne commerce to maintain its position in world affairs and trade. The principal foreign income of the country is derived from the export and sale of rice and rice products. Even after a high degree of self-sufficiency has been attained through mechanization and industrialization, the well-being of Burma's citizens will continue to depend to a large extent on the exchange of Burma's products for foreign general merchandise. Without seaports to accommodate the cargo fleets of seagoing, coastwise and riverine commerce, this essential foreign trade would collapse. Without efficient cargo-handling facilities in these seaports an expanded trade cannot be sustained.

The main seaport of Burma is the Port of Rangoon. It accounts for about 85% of the foreign trade and 44% of the coastal commerce, and is the principal terminus for the riverine commerce of the waterways of the great Irrawaddy River and delta systems, as well as for the railways, highways and airlines. It is the only port capable of receiving and effectively distributing goods to the larger part of the country.

The principal outports of Burma are Akyab, which serves the Arakan region of western Burma; Bassein, which serves the western section of the Irrawaddy delta; and Moulmein, Tavoy and Mergui, which serve the Tenasserim section of southeastern Burma. Other minor ports include Kyaukpyu and Sandoway in the Arakan area and Victoria Point at the extreme southeastern tip of the country. These minor ports are engaged primarily in coastal commerce. The Port of Rangoon, the principal outports and the minor ports are shown on Plate 1 entitled, "Seaports of Burma."

B. PORT OF RANGOON

1. GENERAL

The city and the port of Rangoon are situated on the left bank of the Rangoon River about 21 nautical miles from the Gulf of Martaban, Andaman Sea. Rangoon is the capital and principal industrial and trade center of Burma. The public wharves and jetties (floating pontoon landings) all are along the left bank of the river, and extend for about seven miles upstream from the beginning of the harbor proper at Monkey Point. Private and government establishments extend along the south or right bank of the Rangoon River and along both banks of Pazundaung Creek. There are three main wharf sections where ships can be unloaded directly, a total of ten berths varying in length from 450 to 500 ft. and with channel depths alongside up to about 30 ft. Seven of these berths comprise the Sule Pagoda Wharves Nos. 1 to 7, two are known as the Brooking Street Wharves Nos. 1 and 2, and one is called the Ahlone Wharf. Sule Pagoda Wharf No. 5 is out of operation because of extensive war damage, and Nos. 6 and 7 are used for lighterage operations because of inadequate foundation conditions. Public jetties or floating pontoons are provided for public use at the Lanmadaw and Botataung foreshores. These jetties are for the use of coastal vessels and for government and private riverine craft; three jetties can accommodate seagoing vessels. There are over 20 free-swinging and fixed moorings in the Rangoon River for seagoing vessels where loading and unloading may be accomplished through lighterage. Anchorage areas are provided for country craft and cargo boats, and moorings are provided for petroleum vessels in both the Rangoon and Pegu Rivers. The Burma Railways and the Strand Road provide railway and highway access to the main wharves and jetties. Plate 2 entitled, "Port of Rangoon," shows the aforementioned features and the approach channel of the Rangoon River.

2. PORT ADMINISTRATION

The Port of Rangoon is maintained and operated under the provisions of the Rangoon Port Act, 1905, by the Commissioners for the Port of Rangoon. The Commission, consisting of ten Commissioners headed by the Chairman, operates the port through its Departments of Traffic, Engineering (Civil), Engineering (Mechanical), Marine, Stores, Medical, Port Health and Port Police. It is responsible for maintaining, marking and lighting the entrance channel and the harbor; for pilotage of ships entering or leaving or moving within the harbor area; for providing and maintaining moorings, anchorages, public wharves, jetties and facilities pertaining thereto. It controls the movement of shipping, the loading and unloading of cargo on public wharves, and storage in transit sheds and warehouses. The lighterage within the port is handled by the Inland Water Transport Board and by the Rangoon Cargo Boat Owners Association.

3. WAR DAMAGE AND REHABILITATION

The Port of the City of Rangoon suffered greatly during the past war, from denial measures during evacuation in March 1942 and from military bombing from 1942 to 1945. The entire wharf and jetty area was damaged badly, and the cranes, pontoons and jetties were sunk in the river; sunken vessels and other wreckage prevented acccss to what remained of the wharves and jetties. Important dockyards, shops and other facilities were destroyed along with all warehouses and transit sheds. The lower reaches of the Rangoon River entrance channel and sea approaches were mined extensively; however, a channel with a maximum width of 3,000 ft. was swept of mines as the initial clearance of the harbor.

The rehabilitation of the Port of Rangoon was started immediately after the liberation of Burma, but it will be many years before complete rehabilitation can be realized. Upon return of the British in May 1945 immcdiate steps were taken to elear the waterfront, raise or remove sunken pontoons, cranes and other wreckage, and replace warehouses, pontoon jetties and other facilities with materials available, such as Army Nissen huts, Bailey bridges, Navy-assembled pontoons, and other temporary facilities. The port was put in operating condition in a remarkably short time, and in fiscal year 1947–48 handled more than 40% of prewar tonnage. Since 1948, all major reconstruction and rehabilitation measures have been curtailed by lack of funds. In 1949 and 1950, the Commissioners adopted a five-year program estimated to cost K4,39,49,000 and later revised that to a seven-year program which was estimated at K14,12,00,000. As yet very little progress has been realized. However, through the assistance programs of the United States, $2,624,330 (K1,24,65,570) have been received for materials and equipment for several pontoons and bridges, for transit sheds at the public wharves, for plant and tool equipment, and for tractors and trailers for handling cargo. In addition to the rehabilitation of the fixed structures the seven-year program includes principally the replacement of the flotilla required for port operation.

4. ENTRANCE CHANNEL

The sailing distance from the Gulf of Martaban to Monkey Point in the Port of Rangoon is about 21 nautical miles. The width of the channel from Elephant Point to the Port of Rangoon varies from 1,500 to 3,000 ft. and depths vary from 22 to over 500 ft., Mean Low Water Springs datum. The bar extends about ten nautical miles outside the entrance in all directions, and depths over the bar are approximately as follows:

About 18 ft. at Mean Low Water Springs.
About 23·5 ft. at Mean Low Water Neap.
About 32 ft. at Mean High Water Neap.
About 37 ft. at Mean High Water Springs.

There are no particular navigational hazards, and the channel is well lighted and marked; however, pilot service is required. The outer pilots take over the vessel about six miles out from the channel entrance, and bring the ship up the Rangoon River to about Middle Point. From there the vessel is brought to the berth by berthing pilots. At present there are 13 outer pilots and seven berthing pilots; and the quality of pilotage is good.

5. HARBOR AREA

The Port of Rangoon extends along part of the Rangoon and Pegu Rivers and Pazundaung Creek. The southern limit of the harbor is located about seven miles below Rangoon; the northern limit is about four nautical miles up Pazundaung Creek above its junction with the Rangoon River; the eastern limit is about 1·5 miles up the Pegu River; and the western limit is located where the Panhlaing and Hlaing Rivers join to form the Rangoon River, about seven miles upstream of the junction of the Rangoon and Pegu Rivers and Pazundaung Creek.

a. Hydrographic Conditions

From the western port and harbor limit to the entrance of the Twante Canal the depth of the channel is from 40 to 100 ft.; from the Twante Canal downstream for the next two miles the depth of the channel along the right bank or Dalla side varies from 25 to 30 ft. below low tide, and along the left bank or Rangoon side the depths in front of the wharves vary from 35 to 50 ft. As the river widens at its junction with the Pegu River and with Pazundaung Creek it gets progrcssively shallower, forming a bar opposite Monkey Point. Dredging is required in the Monkey Point Channel every day during thc dry season to maintain a channel about 700 ft. wide, with depth of from 14 to 16 ft. below MLWS for access to Rangoon Harbor. During the rainy season thc tidal flows maintain this channel by scouring action. The depths elsewhere in the harbor are generally ample at all stages of the tide for the movcment or mooring of ships of any draft which can pass through the Monkey Point Channel.

The Commissioners operate a suction dredge mainly at Monkey Point Channel or in the approaches thereto. The annual dredging there and in the approaches