MALAYSIA

REPORT ON THE DETAILED DESIGN OF THE SG. PRAI DRAINAGE AND RECLAMATION PROJECT

SEPTEMBER 19[illegible]

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

P R E F A C E

It gives me great pleasure to submit herewith the Report on the Detailed Design of the Sungai Prai Drainage and Reclamation Project to the Malaysian Government.

The present report has been compiled from the results of a survey conducted by a survey team the Overseas Technical Cooperation Agency (OTCA) dispatched in accordance with the request of the Malaysian Government to the Japanese Government. This survey team, headed by Mr. Kiyomitsu Yukawa, Senior Design Engineer, Agricultural Land Bureau, the Ministry of Agriculture and Forestry, and composed of nine experts from various fields, conducted on the spot, with the cooperation of the Malaysian Government, a soil engineering survey, topographic survey at the barrage and closure site, profile and cross-sectional leveling for the deviation road and the deviation canal, studies of construction plan and tender documents, and a preliminary study of the supply of industrial water, for one month from April 22 to May 21, 1968. Following these surveys and studies on the spot, the designs of structures, construction plan, and cost estimation, formulation of specifications, and a preliminary design of industrial water supply were worked out in Japan, and the present report and the tender documents were completed.

Before the recent surveys and studies on the spot, a feasibility study of this project was made by this Agency for about three months from September 4 to November 21, 1967, in accordance with the request of the Malaysian Government to the Japanese Government, and it became clear that this project was technically feasible and had a high economic value.

This is an important project for Malaysia , forming a part of her First Five-Year Plan, and it seems to be a matter of significance, for the welfare of the Malaysian people and for the friendships between the two countries, that Japan has taken care of the whole process from feasibility study by way of her agricultural cooperation with Malaysia and that a portion of the cost of construction of the project is to be financed by the Yen Loan agreed upon by the Government of the two countries in November 1966.

I wish to take this opportunity to thank all members of the survey team for the great efforts they exerted in the field and in Japan and to express my gratitude also to those people concerned of the Ministry of Foreign Affairs, the Ministry of Agriculture and Forestry, and the Sanyu Consultants International, Inc. for their cooperation.

Furthermore, I wish to keep on record here that the members of the Japanese Embassy in Malaysia generously extended their assistance to us and that the cooperation of the officials of the Malaysian Government, whose names are listed below, proved invaluable in carrying out the surveys and studies.

Enche Sulaiman Bin Abdullah, Principal Assistant Secretary,E.P.U.
Enche Saadullah Suhaimi, E.P.U.
Enche Ow Yang Hong Chiew, Director, D.I.D.
Enche Chan Weng Onn, Senior Design Engineer, D.I.D.
Tan Sri Wong Pow Nee, Chief Minister, Penang
Enche Tay Lang Seng, State Engineer D.I.D. Penang
Enche Joseph Yeoh Hoh Hoh, State Assistant Engineer D.I.D. Penang

September, 1968

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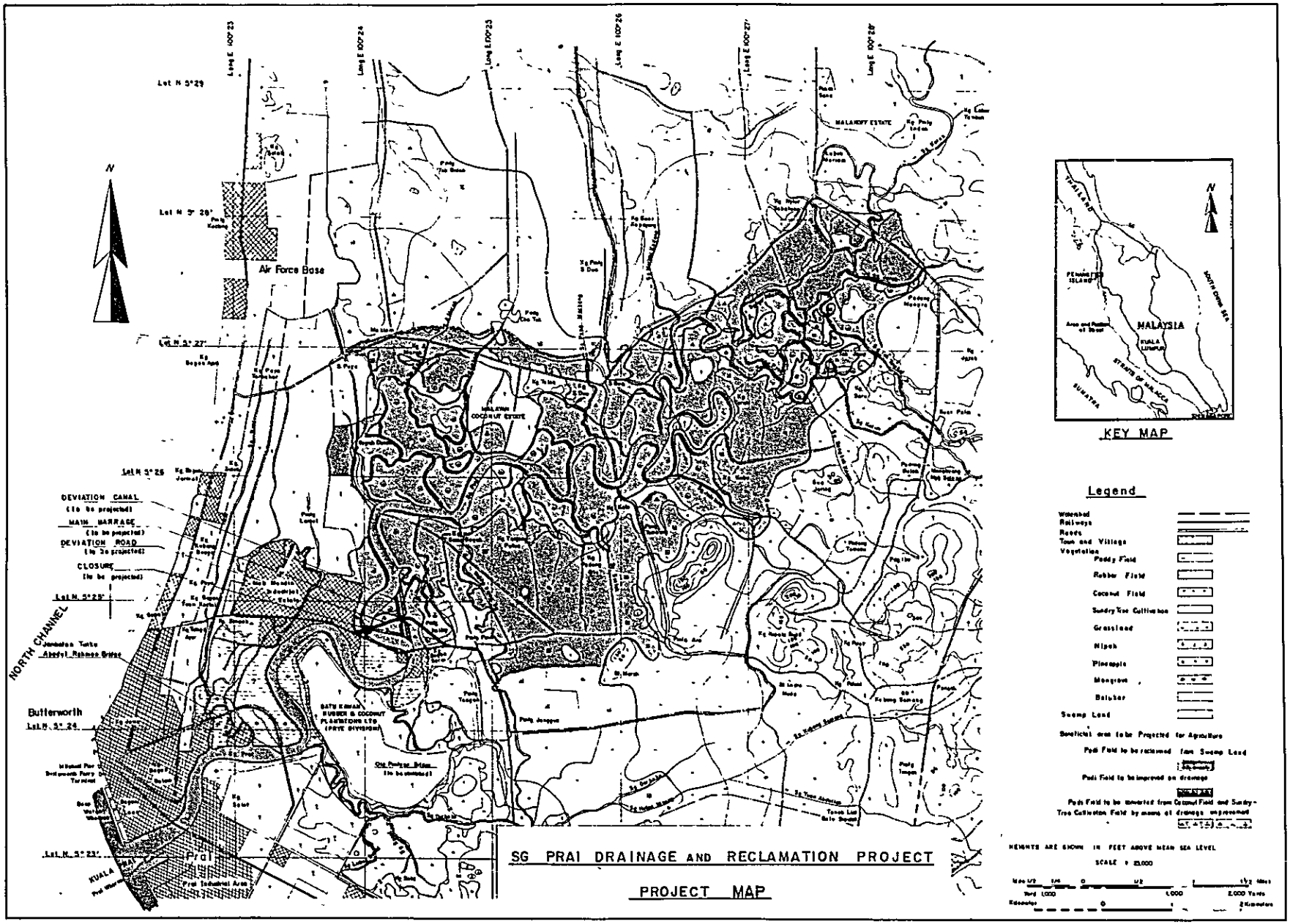

Air Force Base
DEVIATION CANAL
(to be projected)
MAIN BARRAGE
(to be projected)
DEVIATION ROAD
(to be projected)
CLOSURE
(to be projected)
NORTH CHANNEL
Butterworth
Prai
KUALA
MALAYSIA
KEY MAP
Legend
Waterbod
Railways
Roads
Town and Village
Vegetation
Paddy Field
Rubber Field
Coconut Field
Sundry Tree Cultivation
Grassland
Nipah
Pineapple
Mangrove
Belukar
Swamp Land
Beneficial area to be Projected for Agriculture
Padi Field to be reclaimed from Swamp Land
Padi Field to be improved on drainage
Padi Field to be converted from Coconut Field and Sundry Tree Cultivation Field by means of drainage improvement
HEIGHTS ARE SHOWN IN FEET ABOVE MEAN SEA LEVEL
SCALE 1:25,000
SG PRAI DRAINAGE AND RECLAMATION PROJECT
PROJECT MAP

LIST OF MEMBERS OF DETAILED DESIGN TEAM

Mr. Eiji Sugita	Team Leader	Chief Engineer, Irrigation & Drainage Section, Construction Division Agricultural Land Bureau, MAF
Mr. Kiyomitsu Yukawa	Deputy Leader Agricultural Civil Engineering	Senior Engineer, Design Section, Construction Division Agricultural Land Bureau, MAF
Mr. Shoji Kanatsu	Agricultural Civil Engineering	Senior Engineer, Agricultural Development Cooperation Office, OTCA
Mr. Atsushi Tanaka	Liaison and Accounting	Finance Section, General Affairs Division, OTCA
Mr. Hisatada Tanabe	Main Structure (Barrage & Industrial water supply)	Acting Chief Engineer, SCI
Mr. Kazunori Tamaki	Main Structure (Closure)	Senior Engineer, SCI
Mr. Hiroshige Tomiyama	Water Gate	Engineer, SCI
Mr. Isao Suzuki	Geology	Engineer, SCI
Mr. Hiroshi Moriyama	Small Structure	Assistant Engineer, SCI
Mr. Toshimasa Kobayashi	Land Survey	Assistant Engineer, SCI

MAF: Ministry of Agriculture and Forestry

OTCA: Overseas Technical Cooperation Agency

SCI: Sanyu Consultants International, Inc.

C O N T E N T S

List of Separate Volumes

SUNGAI PRAI
DRAINAGE AND RECLAMATION PROJECT

VOLUME I TENDER DOCUMENTS FOR CONTRACT

Instructions to Tenderers
Tender
Conditions of Contract
Specification
Bill of Quantities

VOLUME II TENDER DOCUMENTS FOR SUB-CONTRACT

Instructions to Tenderers
Tender
Conditions of Contract
Specification
Bill of Quantities

VOLUME III CONTRACT PLANS

LIST OF TABLES

LIST OF APPENDICES

LIST OR CONTRACT PLANS FOR DEVIATION ROAD

CHAPTER 1

SUMMARY

1-1. Purpose of the Development

1. The Sg. Prai basin, the object of this project, is situated in the central part of Province Wellesley in the north-west of west Malaysia.

2. In the development of the Sg. Prai basin, the only remaining undeveloped area is the tidal swamp of about 2,500 acres along the Sg. Prai. This tidal swamp is hindering the drainage of the adjoining paddy field. The population density in this basin is so high that increase of agricultural operation is desired.

3. The development of the Sg. Prai is possible only by the construction of the barrage. Its site, according to our study, should be immediate upstream from the Pontoon Bridge at Permatang Pauh. By maintaining a normal impounding water level of the barrage at R.L. +2.0 feet, 1,670 acres of swamp land will be reclaimed, and the drainage of the adjoining 4,700 acres of paddy field and 1,290 acres of coconut field below R.L. +6.0 feet will be improved.

Thus, sufficient irrigation water may be obtained, and consequently, double cropping will be made possible for the paddy cultivation. Benefits expected by this improvement in coconut field are less than that of paddy cultivation. Therefore, this project is to increase paddy production in the reclaimed area by converting coconut field to paddy field, and by improving the drainage conditions of existing paddy field. The area for reclamation is equal to 6 percent of the total paddy field in northern and central districts of Province Wellesley, or 25,800 acres and likewise for drainage improvement is equal to 23 percent. Moreover, the double-cropping system of paddy cultivation can be applied to all reclaimed paddy field. Hence, the agriculture return in this province area would be augmented considerably by this project.

Irrigation water required for the double-cropping system can be obtained by extending the Sg. Muda, Sg. Kulim, and Sg. Jarak irrigation schemes.

The acreage to be benefited and its yield increment by this project are estimated as follows.

Item	Existing Land	Acreage (Acres)	Increased Yield per acre/season (Gantangs)	Increment of Production (Gantangs)
Reclamation	Swamp land	1,670	500	1,670,000
Drainage Improvement	Paddy field	4,700	60	564,000
	Coconut field	1,290	500	1,290,000
Total		7,660		3,524,000

4. The location of this swamp, which is close to the industrial development areas, such as Penang, Butterworth and Mak Mandin, bespeaks the high economy of production after reclamation. Industrialization is apt to increase the income gap between urban and farming areas. Agricultural development under this reclamation project aims, for the present, at two crops of paddy field rice, but in future it will be advanced to the cultivation of vegetable and fruit trees in order to cope with the increase and diversification of consumption following the increase of population which will accompany industrial development. This project is uniquely distinguished for its characteristics of not being formulated only for agricultural development as seen in other developing countries.

This project, included in the First Five-Year Malaysia Plan, is one of the important projects for the attainment of the target of the Plan, and will also satisfy the urgent requirement of the State of Penang. We have also reached the conclusion that this project is feasible, technically and economically.

5. The industrial development depends upon development of an industrial water supply and traffic.

With regard to the supply of industrial water, water impounded by the barrage will naturally be desalinized in a comparatively short time following the construction of the barrage. The daily supply of 6 million gallons water as required by the Public Works Department will be available.

6. With regard to the traffic, the top of the barrage, to be constructed near the existing Pontoon Bridge, should be made into a permanent bridge with two carriage lanes, thus replaceing the Pontoon Bridge.

7. For the above reasons, it is believed most advantageous to construct a barrage in the coconut field on the left bank just upstream from the Pontoon Bridge and to close the Sg. Prai and dig a canal. With the construction of this barrage, the following four objectives should be attained;

(1) Development of new paddy fields by reclaiming the swamps;
(2) Prevention of inundation of the agricultural land adjacent of the Sg. Prai caused by the tide;
(3) Ensuring the supply of industrial water;
(4) Construction of a permanent bridge over the Sg. Prai to replace the Pontoon Bridge.

1-2. Plan Formulation

Existing Conditions

8. The proposed project area is located at 5°22' - 5°29' N. lat. and 100°22' - 100°29'E. long. and has approximately 20,000 acres, spreading over both sides of Sg. Prai, which runs through the middle part of Province Wellseley. The topography of the area is generally flat, and lowers westward from the foot of the mountains of the State of Kedah in the east of the area, with mean gradient of about 1 : 4000.

This area is composed of alluvial soil derived from granite, while soil is mostly clayey with poor drainage.

9. This area has a tropical climate, and the mean temperature is about 80°F. throughout the year. The annual mean rainfall is about 100 inches, slightly more in September - November and March - May, and slightly less in December - February and July - August. Humidity ranges from 60 to 80 percent. There is no record of strong winds causing serious damages.

10. The Sg. Prai starts from the confluence of three tributaries, Sg. Kulim, Sg. Jarak and Sg. Kerah, which originate in the mountains in the east of the project area, meanders southwestward and flows into the Strait of Malacca. The river is about 11 miles long. The estimated discharge at the Pontoon Bridge is the maximum flood of 20,000 cusec, the mean discharge of 500 cusec, and the droughty discharge of 200 cusec.

But the tidal flow at the mid-and downstream is bigger than the discharge of fresh water influx, and there is a flow, upstream or downstream, of about 20,000 cusec at the spring tide and about 7,000 cusec at the neap tide, in addition to the above-mentioned discharge.

The area on either side of the river, is inundated by seawater at flood tide and becomes a swamps, and remains unutilized with a thick growth of nipahes and mangroves. As for the utilization of river water, the upstream tributaries, receiving no tidal effect, are used for irrigation and municipal water supply. Apart from that, the river functions as a main drainage canal in the area, although it is insufficient.

Agricultural Development

11. With regard to land utilization in the Sg. Prai basin, there is agricultural land, mainly paddy fields, in the upstream and midstream areas, while in the lower reaches there are rubber and coconut estates around the industrial and residential areas. Generally, unutilized land resources do not exist except the swamp area.

12. According to the Agricultural Census of 1960, the utilization of agricultural land in the State of Penang in terms of the ratio in areas is: 43 percent for paddy fields, 1 percent for vegetables, 32 percent for rubber, 11 percent for coconuts, 12 percent for fruits, and 1 percent for others, namely, paddy fields are at the top.

Moreover, rubber and coconut estates have partly been converted into paddy fields. It is reported that the rice growing area in the northern and central districts of Province Wellesley, including the Sg. Prai basin, is 25,800 acres (9,972 farming houses).

13. The tidal swamps in the southern part of Sg. Prai basin have gradually been made into agricultural land by several drainage schemes. On the right bank of the mid-and lower reaches of Sg. Prai, swamps are being filled up to be used as industrial and residential land. Under these circumstances, there is a growing desire to develop the remaining tidal swamps along the river

14. These swamps, situated in the mid-and upper reaches of the Sg. Prai, should not be utilized for industrial and housing purposes, but for agricultural development. Adjacent to these swamps there is an ex-

panse of rice growing land, in which drainage is insufficient owing to the tidal flooding of the Sg. Prai. The tidal swamps can be reclaimed by eliminating the tidal movement in the river channel, and thus improving the drainage of the adjacent land. Therefore the reclamation of these swamps will lead to the improvement of the adjacent paddy fields.

15. By constructing the barrage at Permatang Pauh, 1,670 acres of tidal swamps are converted into paddy field out of the total existing tidal swamps of 1,850 acres, after lowering the impounding water level and desalinizing the salt soil, and the yield increase of 500 gtgs per acre per season is expected on the double-cropping system by its reclamation.

The existing paddy fields below R.L. +6.0 feet have poor drainage, as the high water level of the Sg. Prai always reaches R.L. +5.0 feet during the spring tide. But, such a situation is improved by the completion of the main and lateral drainage canals in addition to the fact that the impounding water level is expected to be lowered more than 3 feet. This drainage improvement will benefit 4,700 acres and about 15 percent of the current total yield is expected to be augmented after a completion of this project.

In order to facilitate a mechanization of farming patterns, following works should be carried out to lower the ground-water level to 1-2 feet under the surface:

(1) Digging of main drainage canals;
(2) Extension of the existing main irrigation canals;
(3) Construction of new lateral drainage and irrigation ditches;
(4) Construction of new farm roads;
(5) Desalinization and cultivation of land.

16. About 1,290 acres out of the coconut field below R.L. +6 feet excluding the residential area will be converted into paddy fields. To that end, new drainage and irrigation canals and farm roads will be constructed.

Industrial and Traffic Development

17. The tidal swamps may be reclaimed only by the barrage construction and the impounding water level lowered and fresh water obtained by preventing the tidal movement.

18. On the other hand, the rapid growth of industrialization requires an abundant water supply, for this there is no perpetual method but to supply fresh water.

19. The urgent demand of water for current industrial development is 1.7 mgd. Total demand for the industrial water is assumed at about 6.0 mgd after 5 years. This figure may be exceeded and also the period accelerated in accordance with the State's industrialization programme.

This project is proposed to supply 6.0 mgd of fresh water for industries when the barrage is completed.

20. The crest of the barrage and the closure will be so constructed that it can be used as a road, to replace the existing Pontoon Bridge.

After completion the barrage will have the same traffic capacity as the Jambatan Tunku Abdul Rahman namely several times as much as that of the existing Pontoon Bridge, and will also contribute greatly to economize the cost of operation and maintenance of the bridge, and the running cost of vehicles. Consequently, it is expected to make a rapid progress in this area centering around the Mak Mandin Industrial area.

Outline of Main Structures

21. Main structures for the project are the barrage, canal, closure, and their appurtenant works and the deviation road.

22. The barrage will have the most important function in this project. It should be constructed at a point about 5 miles from the estuary, on the left bank upstream of the Pontoon Bridge. Its function is to stem the influx of sea water on the tidal side and to keep water at a controlled level, by the manipulation of the gate.

According to the order of construction, the barrage body should be constructed in dry work and should then be connected with the Sg. Prai upstream and downstream by the deviation canal of about 2,550 feet long.

Since the main stream of the Sg. Prai can thus be diverted to a new course through the deviation canal and barrage, the old course of the river channel should be dammed by a closure of 450 feet long at a point about 5 miles from the mouth of the river.

The crest of the barrage should serve as a road bridge. This road bridge should have a width of 44 feet and a length of 200 feet.

23. The crest of the closure should be used for traffic in conjunction with the existing main road. The site of the closure will have the maximum depth of about 20.0 feet, and even after completion, most part of the closure will be under the water which is sea water for the outside and fresh water for the inside.

24. The deviation road should be used as a by-pass road of about 1.5 miles long from the Mak Mandin Industrial area on the right bank of the Sg. Prai to Bukit Tengah via the closure and the barrage. In order to cope with the increasing traffic load between Mak Mandin and Bagan Serai, the deveation road of about 1.26 miles should be constructed.

25. Appurtenant works should be to construct the dike at the left-bank, downstream of the closure, for a length of about 1,350 feet to prevent the intrusion of the upflow tide, and sheet pile breakwater should be carried out at the right bank, upstream of the Pontoon Bridge, for a length of about 400 feet.

CHAPTER 2

DETAILED DESIGN

2-1. Result of Investigation

26. In order to clarify the existing topography and the mechanical characteristics of the soil as required in designing the main structures, and to increase the accuracy of the related data used in the feasibility report, a survey was performed at the field for a month from April 1968, with the cooperation of the S.D.I.D., Penang.

Surveying

27. Surveying of the project area was conducted as follows; The leveling of the swamps and coconut fields lying along the bank of the St. Prai, the triangulation connecting the either bank of the river the adjoining portion of the main road, the traverse survey were performed. An investigation was also made into the houses to be compensated, since their number exceeds that shown on the existing map.

28. In designing of the main structures, the datum line was fixed at the canal line No.7 to No.26 + 60, as shown in Contract Plan No.2.

This survey center is set at 135 ft toward the right bank from the center of the deviation canal, in consideration of the existing houses and coconut trees.

The line perpendicular from No.18 on the datum line is the center of the barrage.

Soil Investigations

29. These investigation aimed at clarifying the condition of the foundation of the main structures and to obtain the data for their designs.

The substance of investigations is as follows;

i) Preliminary investigations

Boring	6 holes total depth 438 ft
Sounding	41 points
Laboratory tests	many samples

ii) Detailed investigations

Boring	4 holes total depth 245 ft
Sounding	25 points
Laboratory tests	10 samples

From the results of these investigations, as shown in the Contract Plan No.33 and the Appendix 1, it is seen that the basis of the project area consists of the alternations of alluvial sand and clay layers, and those layers lie almost horizontary, but the thickness of each layer varies from one bore-hole to others.

30. Distribution and characteristics of each layer

Clay layer I (Top soil)

This layer consists of the decayed vegetables and very soft sandy clay, and is distributed with a thickness of about 7 ft in the whole area, but does not exist in the bed of the Sg. Prai.

Sand layer I

This layer consists of comparatively loose fine sand, and is very permeable. The grain become larger gradually as nearer to the bottom. Its thickness is about 10 ft at the closure site and 17 ft at the barrage and canal sites.

The bottom of layer is about R.L. - 15 ft, about the same height as the basis of the barrage and the downstream part of the canal.

From the result of sounding, it is considered that the upper part of this layer is very loose, but the middle and lower parts are comparatively dense.

Clay layer II and III

Those two layers consist of yellowish white stiff clay and sandy clay, and therefore is considered to have undergone a slight preconsolidation.

Clay layer II has a thickness of about 5 ft at the barrage and canal sites, but it is vanished on the left bank of the closure and reappears on the right bank.

Clay layer III has a thickness of about 17 ft at the barrage site and becomes a little thinner as it comes nearer to the closure site, but the bottom mostly lies at about R.L. - 42 ft.

The characteristics of these two layers are very similar to each other, but layer III has lower LL. and PL. values, greater layer stiffness, and smaller deviation of qu values than layer II. Therefore it can be said that layer II has a larger variations of thickness and characteristics, but layer III has a uniform distribution and characteristics.

Sand layer III and IV

These two layers consist of very dense coarse sand and fine gravels, and are the so called granitic sand layers with the sand particles are mostly

angular quartz and feldspar crystals, and belong to the SP. or GP. group of the unified classification system.

At the barrage site, there is a thin clay layer (clay layer IV) between the sand layers III and IV with an average thickness of 4 ft, but it vanishes at the closure site and the two sand layers directly contact with each other.

Clay layer IV

This layer consists of stiff sandy clay and interbeds between the sand III and IV. The thickness is 4 ft and all characteristics are very similar to the clay layer III.

31. Foundation of the main structures

Barrage

As the base of the barrage is R.L. - 20 ft, it is in line with the uppermost of the clay layer II.

Since the qu values of this clay layer is 7.1 lb/in^2 on the average and the load of the barrage at the base of the pier is 13.0 lb/in^2, the raft foundation is impractical, and the pile foundation must be used.

The bearing layer of the pile foundation should be sand layer IV. Since the underground water table is about R.L. $\pm$ 0, and sand layer I of 17 ft thick which will outcrop in the excavated slope for the barrage is extremely permeable, it is necessary to ensure dry work and to take into consideration the boring and piping action of the slope when the construction work is executed.

Deviation canal

Since the canal bed is R.L. - 10.5 ft upstream of the barrage, sand layer I outcrops in the slope and the base.

On the downstream side, the base will be clay layer II and the slope will be sand layer I. The material put out by the excavation of the canal will be mostly fine - medium sand.

Closure

The base of closure, from R.L. + 3 ft to R.L. - 10 ft of the river bed, is on the soft clay layer I. In this part, it is necessary to use the stage embankment to allow a consolidation of the underlying soft clay and gain a sufficient shear strength during construction. From R.L. - 10 ft to R.L. - 25 ft of the river bed, fine sand of sand layer I outcrops, and below R.L. - 20 ft of the river bed, the stiff clay layer II outcrops. In the lowest part of the river bed, densive sand II layer slightly outcrops.

2-2. Barrage

Introduction

32. The route of the deviation canal is determined as indicated in Contract Plan No.1 after careful study of the topographical condition and checking whether or not the flood flow causes a harmful effect upon the upstream and downstream banks.

33. The barrage site is determined at about mid-point of the deviation canal as indicated in Contract Plan No.2. The length of the barrage is determined to be 96 feet long, considering the stability of structures against piping action, the width of the road bridge, and the width of the gate pier.

34. The up and downstream river bed near the barrage should be protected by placing concrete blocks and ripraps for the purpose of preventing scouring caused by the flood flow and tidal flow that pass through the barrage during the construction of the closure.

35. The transition sect-on of the barrage along the banks will be made of steel sheet pile walls because of their economic advantage.

36. It is decided that there should be four gate spans, each of which is 45 ft long, considering the cost of the gate itself to the total cost of the structures and the convenience of operating the gate in the normal draining condition.

Design

37. The seepage flow running along the barrage foundation is caused by the difference of upstream and downstream water levels. Therefore, if the hydraulic gradient is high, piping action will occur owing to the high velocity of water. In order to prevent the base failure caused by piping action, the required path of seepage should be furnished by the cutoff walls formed by the steel sheet piling. In this design, the maximum difference of the up-and downstream water levels is determined at 6.1 ft, considering the flood flow at 40 years return period.

The required length of the steel sheet pile is calculated by Bligh's formula and Lane's weighted-creep theory.

Giving some margin to the calculated length, steel sheet piles of 20.0 ft long each will be driven into the clay layer at the upstream edge of the barrage body and at the downstream edge, steel sheet piles of 10.0 ft each will be driven for a supplemental purpose, in order to check the seepage flow completely.

38. Although there is no rational formula to calculate the required length for the protections of the upstream river bed at the time of flood and drain, a cast-in-place concrete block of 50.0 ft long and riprap works of 90.0 ft long are carried out on the upstream side in order to keep the stability of the structures, because the flood flow scouring and the washing away of the soil grains by the tidal water are anticipated during the construction of the closure.

39. The downstream river bed requires proper protection to prevent its degradation by the excess energy at the time of flood. The required length for the protection of the downstream river bed is determined by a calculation using Bligh's formula.

As a result of the calculation, the cast-in-place concrete block of 100.0 ft long and riprap works of 120.0 ft long should be carried out as indicated in Contract Plan No.3.

40. Steel sheet piling should be executed at the edges of the upstream and downstream concrete blocks for additional protection against scouring, and gabion filling should be carried out at the edges of the riprap works.

41. Since the barrage foundation is comparatively weak, and hindrance to a gate operation and leakage owing to ununiform settlement are anticipated, a pile foundation should be provided for the barrage foundation. This pile foundation should be made by 12" x 12" x 58'-0" long precast R.C. pile driven to R.L. - 70.0 feet where there is a coarse sand layer, as indicated in Contract Plan No.8.

These piles are designed to give ultimately a safe load of 20 tons per pile by calculating the ultimate bearing capacity by using Dörr's formula and by taking the safety factor as 3. Since piles require a length of 58 feet, a glued joint should be privided for each pile in order to make handling, pitching and driving easy.

42. Where the gate is installed, the pier is 7.0 feet in width, and where the prestressed concrete beam bridge is supported, it is 4.0 feet in width. The both edges of the intermediate piers are given a shape of two arcs combined in order to make the flow of water smooth. The height of the piers is determined as indicated in Contract Plan No.5, considering gate installation and the height of lifting. The barrage floor is designed as a unit structure with construction joint only and without a contraction and expansion joint, to prevent the ununiform settlement. Typical thickness of the barrage floor is 4 feet and thickness of the blinding layer is determined as 6 inches, considering construction works.

43. The reinforcement of the barrage floor is calculated as a continuous beam supported by the piers with uniform load composed of the weight of the pier, gate and backfilled earth etc. immediately after completion of the barrage. As to the abutment and wall, they are calculated as a cantilever fixed on the barrage floor, and the reinforcement of piers is determined as indicated in the Contract Plan No.11 - No.15 to prevent cracks.

Tidal gates

44. The function of the barrage is to intercept an intrusion of sea water to the upstream and regulate the level of water on the upstream side by means of the gates. The desalinization of the impounding water will take place repidly. The comparison, in terms of usefulness and economy, of a roller gate and a mitre gate, which are commonly used in barrages, is as follows;

i) A mitre gate is suitable for a short span but not for a long span.
ii) The cost for a roller gate and a mitre gate is approximately same.
iii) The type of hoist for a mitre gate is almostly limited hydraulic oil cylinder.
iv) The water tightness of a mitre gate is inferior to that of a roller gate.
v) Where sedimentation at the gate sill is anticipated, a mitre gate has difficulties in operation.

Thus, the mitre gate is suitable for simpler uses, but will not serve the purpose of installing the gate in this project. Therefore, the roller gate is adopted.

45. There are two types of the roller gates, the single stage roller gate and the double stage roller gate. The latter is adopted for the following reasons:

i) This gate is divided into two parts. Since the two parts are rolled up one by one, the height of the pier can be made lower, and the cost can be reduced.
ii) It can be operated by one motor and is economical.
iii) Because the piers are made low, the surrounding landscape will not be spoiled.

46. The gate span is determined by considering the relation of the cost of the gate itself to the total cost of structures and the convenience of operating the gate in the normal draining condition. Generally speaking,

a gate span of about 50 feet is considered economical. For the convenience of operation, however, a shorter gate span is preferable. From an overall point of view, it is decided to erect 4 spans, with a length of 45 feet each.

47. Accompanied by the rise in the outside tide at the time of the high tide, the density current will be occured by the contact between the sea water and the fresh water, therefore the wedge of the sea water will penetrate into the lower part of the fresh water, according to the effect by the back water of tidal flow, it is considered that the sea water and mixed water will intrude into the fresh water due to the stagnation and tidal flow of the river.

Drainage of the upstream flow should be usually done by over flow of the upper stage gate, and at the time of flood it should be flowed out by opening the gate.

Purpose of the lower stage gate is to prevent the intrusion of the wedge of the sea water due to the difference of density.

The intrusion into the fresh water at the gate opening time is prevented by shutting the gate just before the stagnation of the flow occurs or when the impounding water level is kept high owing to the difference of density between the sea water and the fresh water.

The tidal gates should be the water tight structures against the outside tide.

48. Therefore, the system of operating the gates should be as follws;

When the upstream water level has risen to a certain height above the downstream water level, the gate begins to open, and should start closing quickly when the both water levels have reached the state of balance.

When gate is opening, its movement is intermittent, namely, there are repetitions of stops and starts.

When it is closing, its movement is quick and continuous.

49. The operation of the gate in the normal draining condition is done automatically by the automatic water level regulator installed in the remote control house. An outline of this equipments is as follows.

50. The pressures caused by the upstream and downstream water levels are given to the two ends of diaphram, according to the direction of the

pressuse difference, a variation is caused to the iron core in the differential transformer and that variation is changed into electricity, and this quantity of electricity is amplified and acts upon the motor of the gate hoists. Immediately before back current occurs, owing to the rise of the downstream water level, the gate should be shut. When the upstream water level rises up to the balance depth, the gate begins to open. In this project, the normal impounding water level should be kept at R.L. +2.0 feet after the completion of the barrage. Therefore, this equipment is designed to stop the gate automatically when the regulated water level of R.L. +2.0 feet is reached, irrespective of the direction of the water levels difference. Accordingly, how much the downstream water level may come down thereafter, the impounded water will not run out. When the impounded water level rises above the regulated level again, the gate starts to operate automatically as mentioned above.

51. If an electric current fails while the gate is operating automatically, the gate stops instantly, and a back current of tidal water occurs. Therefore, the generator must be installed as a supplemental source of power. And the generator must start automatically when the electricity fails, and must stop as soon as the power failure is over. The capacity of this generator should be sufficient for indoor and outdoor lighting and the operation of one gate.

Control house

52. In order to operate the tidal gate of the barrage, this control house is placed on the left side of the downstream near the D.I.D. office.

The equipments in the control house are follows:

1. Control Panel
2. Automatic water-level control device
3. Diesel engin alternater
4. Switch Board
5. Office desk and furniture for reception etc.

Therefore the size of the control house is decided to be 40 feet x 20 feet.

As this faciltieis is a parmanent structure its construction should be executed by reinforced concrete, the plumbing, electric and septic tank equipment are provided at the control house. These details are shown in

Contract Plan No.18 - No.23.

Permanent Quarters

53. To control the tidal gate, the permanent quarters is designed based on the existing permanent quarters which was constructed in other project in Malaysia. These details are shown in Contract Plan No.24 - No.27.

Deviation Canal

54. The section for the deviation canal should be detarmined on the basis of hydraulics for the safe draining of the peak flow, under the designed probable rainfall at the barrage, in accordance with the tidal range. It is shown in Contract Plan No.30.

The dimensions for the deviation canal are as follows:

	Upstream	Downstream
Base width	300 feet	226 feet
Base depth	R.L. -10.5 feet	R.L. -15.0 feet

Generally speaking, the unlined earth section depends on earth material, but its side slope is 1 : 1.5 to 1 : 2. The side slope of the canal is determined at 1 : 2 considering stability of the material, which is mostly composed of fine sand.
This is proved by the laboratory tests.

55. The upstream side of the canal is normally in a steady condition. As mentioned before, in section 54, the depth of the downstream canal is greater than that of the upstream canal i.e. 22 feet deep. The downstream canal is affected by tidal action every now and then.

Due to these conditions, the side slope of the downstream canal should be protected by using the wooden pile filling works for keeping its stability.

56. As shown in the soil profile of the barrage site in Contract Plan No.32, the material obtained by an excavation of the deviation canal is mostly composed of fine sand, and it should be utilized for the closure embankment. The base of the deviation canal is almost embedded in the clay layer.

Appurtenant Works
Enclosure dike

57. The part of the left bank of the mainstream which is connected with the downstream side of the closure should be elevated at R.L. +7.0 feet for a length of about 1350 feet, because this part is used as a temporary work place and spoil bank and it is necessary to steam tidal water.

Sheet pile breakwater

58. Since the right bank in the vicinity of the existing Pontoon Bridge is affected by the stream of the deviation canal a pile revetment of reinforced concrete should be provided in order to prevent the river bank from a scouring. The downstream of the Pontoon Bridge is being used as a loading port, and the right bank of the river is protected by stone pitching. Therefore the sheet piles should be placed only in the upstream of the Pontoon Bridge for a length of about 400 feet. These details are shown in Contract Plan No.29.

Drain pipe works

59. The Sg. To'Togok is located on the left bank upstream of the deviation canal. This river will be closed by bank of the deviation canal. Therefore a drain pipe should be provided for the safe draining of the peak flow from this watershed the designed probable rainfall in relation to the impound water level. The diameter of this drain pipe is 3.0 feet as shown in Contract Plan No.30.

2-3. Closure

Typical section

60. To determine the typical closure section, the following matters should be taken into consideration.

The designed slope of embankment varies widely according to the character of the construction material, the conditions of the foundation, the height of the structure, and the construction method.

It is important that minimizing the cost the closure should be designed to make maximum utilization of the most economical available materials.

In this project, the material field by the excavation of the deviation canal is mostly composed of fine sand, which can be used as material for the embankment of the closure. In that construction of the closure, the sand

pump equipment should be used. For these reasons, the closure of the homogeneous type is suitable. A difference of the both water levels of up and downstream is so small that the cross section is planned about symmetrically.

61. Because of these weak foundation, additional fills for stability is required, and a beam should be provided at both toes of the closure at the elevation of R.L. -12.0 feet, and the width of the berm is 40 feet.

The slope of such a closure is from 1 : 2 to 1 : 10 for stability: usually it is 1 : 3 or 1 : 4. In this project, the slope is determined at 1 : 4, because of these weak foundation and embankment stability.

62. There should be a rubble mound works at both toes of the closure to prevent wave action and the wash away of the material while the closure is under construction.

And a stone pitching should be constructed from R.L. -4.0 feet to R.L. +3.0 feet on the rubble mound. Moreover, there should be asphalt facing from the road surface to a height of R.L. +3.0 feet against the tide, wave action and rainfall erosion.

The typical section of the closure is shown in Contract Plan No.28.

Stability Analyses

63. Various methods are suggested for analyzing the stability of these earth-fill structures. The slip-circle method, which takes the surface of rupture as a cylindrical surface, is a comparatively simple method of analyzing embankment stability. It is necessary to determine cohesion and angle of internal friction of the material, and magnitude of porewater pressure, for construction, steady-state, and draw-down conditions.

Various centers and radii should be used for repeated computations until the arc which gives the minimum safty factor is determined for whatever case that may occur to the closure.

Furthermore, the critical circle is established in the weak foundation consisting of clay.

But each case of the closure embankment has enough stability, and the worst case that is the both water levels at the up and downstreams are in the lowest condition, it has a safty factor of 1.41.

These design data for the foundation is determined by the laboratory tests. These data are show in the Appendix 1.

Foundation Settlement

64. The settlement of the foundation composed of fine-grain sand can be estimated from laboratory consolidation tests conducted in accordance with Terzaghi consolidation theory, which is commonly used for the prediction of the settlement of a closure on the clay foundation. It was estimated that a maximum settlement of approximately 3 feet at the middle of the closure site would occur, and about half of it occurs during construction.

The settlements of these material of closure consisting of sand which built in the wetted layers usually occur wholly during construction. Therefore, the settlement of the closure embankment body is considered to be so small as can be disregarded.

Asphalt Facing

65. Asphalt facing is required in order to protect the surface of the closure against the erosion by rainfall, the tide and wave action. Plain concrete should be used for the ending of the asphalt and for the adjoining portion between the end of asphalt facing at the shoulder of the closure and the stone pitching. It is shown in Contract Plan No.29.

Asphalt facing should be executed in the following orders.

First, the surface of the closure on which the asphalt facing is based should be made as flat as its foundation. Next, crusher run is placed on the leveled surface and then the asphalt requires to level the surface of the crusher run which is compacted. The asphalt facing should be executed in two layers of hot asphalt mix, each 1.5 inches thickness, and should be placed on the levelling surface of the crusher run.

The typical cross section of the asphalt facing is shown in Contract Plan No.28.

Other works

66. In order to use the crest of the closure for vehicle traffic, the closure top should have the same whidth as the road. Therefore, the width should be one chain for reserve.

On both sides of the crest, a guard rail and lighting posts should be installed. The lighting posts should be installed every 100 feet.

2 - 4. Deviation Road

67. Regarding the route of deviation road, the following two routes are considered. After having discussion in Malaysia between D.I.D. and Japanese Detailed Design Team, Plan-A is decided, however Plan-B is proposed by P.W.D. thereafter Plan-A. Therefore, Plan-B is not completed regarding the surveying and investigation.

68. The route of the deviation road from the closure to the barrage of Plan-B is the same as the route of Plan-A and the route of Plan-A at the left side of the barrage is planned to pass through the access reserve which was previously planned by P.W.D. in order to decrease the land compensation of the road.

69. The route of Plan-A is shown in Contract Plan R-1, and the route of Plan-B is shown in Contract Plan R-8.

The total length of Plan-A is 6,678 feet (≒ 1.26 miles), starting at the intersection of Vg. Permatang Pauh through the barrage and theclosure and terminating at the Mak Mandin Industrial area which is located at the right bank of the Sg. Prai. The route of the deviation road should be determined be determined by considering the location of the barrage and the closure, after having discussion with P.W.D. and D.I.D.

Design

70. Following matters are accounted in the stage of planning

(a) Designed speed -------- 60 M.P.H.
(b) Passing sight distance ---------- Min. 900 feet
(c) Non-passing sight distance ---------- 500 feet
(d) Min. radius of the horizontal curve ---------- 968 feet
(e) Increase in the width of the carriageway for curves with a radius less than 1,500 feet ---------- 2 feet
(f) Allowable gradient ---------- 3.33 %
(g) Superelevation ---------- Max. 1 in 10
(h) All curves with a radins less than 5,000 feet should have a cubic parabola transition.

But the radius of left bank of the barrage in Plan-A is decided at 600 feet, owing to the condition of the joining with the barrage. This radius is smaller than the minimum radius of the horizontal curve. Therefore, the speed should be slowed down near the barrage (installation of the road signs).

Typical cross section

71. The width, type of the base course and pavement of the road is designed in accordance with the P.W.D. drawings. The typical cross section of the road is shown in Contract Plan No. R-3, No. R-10. The principal dimensions are as follows;

(a) Width of road ---------- 24 feet

(b) Slow speed lane and side track -------- 5 x 2 = 10 feet

(c) Green belt ---------- (5 + 8) x 2 = 26 feet

(d) Min. road level is determined at R.L. +7.00 feet, considering up-and downstream water levels and the settlement.

(e) Transverse gradient of carriageway -------- parabolic curve in 2.5 %

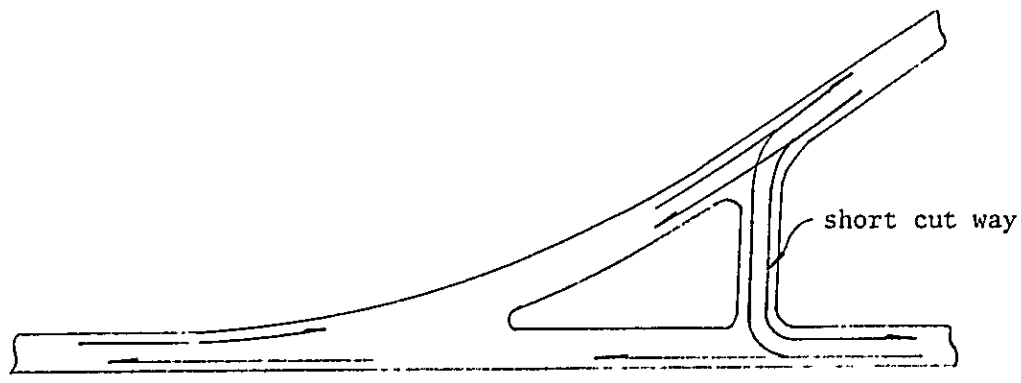
(f) Max.superelevation of curve ---------- 6 %

(g) Longitudinal curve will be ignored as the difference in level is small.

(h) Drain ditch is provided in the coconut field.

Junction with the main road

72. The intersection angle between the existing road and the deviation road is small. Therefore, a short cut way leading to the Pontoon Bridge is provided. After a completion of the deviation road, the traffic capacity via the Pontoon Bridge will be greately reduced. Therefore, the pattern of traffic via the Pontoon Bridge is designed as follows.



The width of the short cut way should be determined at 24 feet. There should not be a green belt between the carriageway and the side track near the juncture, to avoid congestion and to increase traffic capacity. The demarcation between the carrage way and side track should be white line. The existing bus stop at the junction of the Mak Mandin area should be relocated.

73. The deviation road is constructed by extending of the temporary road for construction work. The extent of the work to be executed for the construction of the deviation road is as follows;

(a) Land acquisition and compensation -------- Affiliated area is shown in Contract Plan No. R-7, No. R-14

(b) Excavation, banking, drain ditch, turfing -------- The site from E.C.C. (A.D. = 3,416.69) to No.114 (Plan A) and from No.110 to No.114 (Plan B) shall be carried out as the barrage construction, excluding the embankment of the closure.

(c) Pavement -------- Full pavement, including the road face surface over the closure and excluding the asphalt concrete pavement of bridge on the barrage.

2-5. Construction Plan

74. The construction of the structures of this project is executed separately according to the jurisdictions of D.I.D. and P.W.D. D.I.D. has jurisdiction over the barrage, deviation canal, closure and appurtenant works, which will be executed by a contract collectively. P.W.D. has jurisdiction over the deviation road and causeway, which will be executed separately.

75. Execution of works under D.I.D. jurisdiction.

Whole work

The construction of the barrage should be executed and completed under the dry condition by using the well point method. The deviation canal should be constructed in along with the barrage so as to be completed by the time of the change-over of the main stream to the barrage. The construction of the closure should be started after the change-over of the main stream, and embankment should be executed in a condition free from hindrance from flowing water, and then the old course of the river should

be closed. The barrage gate should be shut upon completion of the closure and the intrusion of the tidal flow will be stemmed, and the impound water will be desalinized.

76. The excavation depth of the barrage will be approximately 20 feet below the existing ground. Since the area lies besides the river and low and damp, the level of underground water is high, and the foundation will be a sand layer, spring water can be anticipated.

77. In order to conduct the works in dry condition the well point method is most suitable, because there is a formation of an impervious layer of the clay below the excavation bottom and the excavated portion is composed of sandy soil. Therefore, this draining method should be adopted. In addition to this method pumping drainage should be done. One step of the well point should be instalied as the depth of every 18 feet. The barrage site should be surrounded by such well points, and their operation will be continued until the installation of the gates is completed. The foundation work should be executed by reinforced concrete piles of the cast-in-placed, and the barrage, tidal gates, and sheet piling wall and should be constructed under the dry condition.

The deviation canal

78. The excavation material of the deviation canal is a little difference between the up and down stream of the barrage, and the upper layer has thin clay zone, the lower layer composed with mainly sandy soil.. The N value of the standard penetration test is comparatively small and there is no gravel and cobble stone. The underground water surface, affected directly by the Sg. Prai, is almost on the same level as the river. The excavation should be exectued under the water by the excavators. The spoil disposal should be done by dividing into the spoilbank No.1, No.2 & No.3.

Earth for the embankment of the closure is carried from the designate spoil bank No.1 and is composed of sandy soil. The excavation of the deviation canal is executed by the blocks which is divided into the up-and down-streams of the barrage. For the operation of the lorries carring spoil, a temporaly road for construction work should be constructed between the plan of excavation and the spoil-banks. The excavation to connect the up and downstreams of the Sg. Prai should be performed after the completion of the

barrage. The place of these spoil-banks are shown in Contract Plan No.1

Closure

79. In constructing the embankment of the closure, rubble mound works should be executed up-and downstream in order to prevent embankment material from being washed way by the river flow. Embankment should be executed between the up-and downstream rubble mound works after they are completed. The depth of the river at the site of the closure is somewhat large, being approx. 20 feet, and most of the work of embanking should be executed under water. The closure should be constructed step by step dividing into three stages at each elevation, in order to raise the whole construction surface of the embankment uniformly. The rubble mound works should be executed by carrying stones to the projected line of the closure by ship and dumping them into the river. Embankment should be done by the sand pump method for the following reasons;

(1) Material for embankment, being spoil from excavation, is loose and sandy and can be conveyed directly by pump;
(2) Since borrowing pit is close to the projected line of the closure, the distance of earth conveyance is short, and water for the sand pump is easily available from the main stream of the Sg. Prai;
(3) The equipment required is simple, the construction cost is low the work capacity is big, and embankment can be executed by a reliable method;
(4) Since most of the embankment work is executed underwater, this method is most suitable for the uniform raising of the whole length of the embankment.

80. A pond for the sand pump method should be dug near the borrowing pit to be designated on the left bank, and water should be led to the pond from the main stream of the Sg. Prai.

81. After the underwater part of the embankment has been raised to the vicinity of average water level, embanking should be executed up to R.L. +5 feet by working in the ebb tide hours, the width of the river should be closed half and half, then final closure embanking should be completed at a stretch using bulldozers in the low water period during the ebb tide. Asphalt facing for the protection of the closure surface should be executed, during the ebb tide hours or under dry condition and following the construction progress of embankment.

2-6. Time Schedule of Construction Works

82. The time schedule of construction work is shown in terms of the total number of days calculated from the day of the commencement of work. This time schedule is shown in Appendix 2. by a network of the Part formula, and the total number of days has been calculated by electric computer.

83. The time schedule of reclamation and drainage work is not shown, since this work will be executed by paddy farmers and land owner.

2-7. Cost Estimates

84. The extimated cost of this project comprises the cost of construction of the barrage, the deviation canal, the closure and the deviation road, and the cost of land acquisition and compensation, and the cost of reclamation and drainage improvement, and the cost of operation and maintenance.

But the cost of operation and maintenance is shown separately.

85. The unit cost of labour, prices of materials, method of calculation, etc. based on the figures obtained or derived by consulting with the state D.I.D. in May 1968. Since price hike is anticipated, the cost of construction may be increased at the stage of excuting the actual work.

For the estimate of the unit price of such materials and such works relating to the tidal gates as will be covered by the Japanese loan, the prices prevailing in Japan in September 1968 were adopted.

86. Total cost of construction is estimated M$ 8,700,000 as shown in Tab. 1, which comprise the cost of main structures, the deviation road, reclamation and drainage improvement after completion of the barrage, and in which include the separable costs of traffic, M$ 765,000 as shown in Appendix-7. Bill of quantities are shown in Appendix 3-6 excluding the cost of construction of the barrage.

87. It has been proposed that a portion of the construction cost should be financed by the Yen Loan, with a annual interest rate of 4.5% for period of 20 years, including a grace period of 5 years, as provided

for by the exchange of notes between the Governments of Japan and Malaysia, and that the remainder should be met by the funds of the Malaysian Government.

The Yen Loan, in the amount of M$ 2,145,000 as shown in Appendix 8, will cover the cost of construction of the barrage, which include the costs of construction material (steel bar and sheet pile), double stage roller gate, supervision by the consultant and contract work of construction.

88. The construction of the barrage will be completed in 2 years, and thereafter land reclamation in 3 years and drainage improvement in 2 years.

Tab. 1 Total Cost of Construction

(Monetary Unit: M$)

Item	Description	Cost M$	Remarks
1.	Land Acquisition and Compensation	75,000	App. 3
2.	Construction cost of barrage, canal, closure and gate etc.	4,089,000	
3.	Construction cost of deviation road		
	Plan of A	317,000	App. 4
	(Plan of B)	(526,000)	(App. 5)
4.	Engineering Fee	310,000	
	Sub Total	4,791,000 (5,000,000)	
5.	Reclamation and Drainage improvement	3,700,000	App. 6
	Total	8,491,000 (8,700,000)	

CHAPTER 3

MAINTENANCE AND OPERATION

3-1. Maintenance and Maintenance Cost Estimates

89. Since the barrage is a joint facility for industrial water, road and agriculture, it is necessary for its operation and maintenance that D.I.D. and P.W.D. should maintain close liaison and that coordination with the Port Commission should be considered in matters of the estuary.

The facilities constructed under this project should be maintained according to the jurisdictions of D.I.D. and P.W.D., namely, (1) D.I.D. maintains the barrage, closure and deviation canal, and (2) P.W.D. maintains the deviation road and causeway.

90. The annual cost of maintenance and operation of the joint facilities, such as the barrage, closure, etc., is estimated as below. With regard to the disbursement of this cost, it seems appropriate that each organ shares expenditure according to the joint cost allocation described in Chapter 4, subject to the overall administration of D.I.D., which is the principal organ in charge of construction work.

91. The maintenance of the facilities under the jurisdiction of D.I.D. should be carried out directly by the D.I.D. office at Bukit Mertajam, which is an organ of the Government of Penang. Therefore, the staff of that office should be increased by two, namely, a mechanical technician, who should be permanently stationed at the administration office at the barrage site. And 4 labourers should be assigned for the cleaning of the gates and channels and weeding. Accordingly, a house for the administration office and gate operating room and another house with two sets of quarters for the staff should be constructed at the barrage site.

92. The annual cost of maintenance is estimated as follows, including the office expenses, the cost of maintenance, repair and operation of machinery, and the cost of maintenance of the channels and embankment;

Table 2. Annual Operation and Maintenance Cost

Assessment for barrage	Cost	Monetary Unit M$
Technician	$250^{M\$} \times 12^{month} \times 2^{head}$	5,100
Labour	$5 \times 30^{day} \times 12^{month} \times 4^{head}$	7,200
	4×600	2,400
		14,700
Gate painting	$12,600^{sq.ft} \times 2.50 \div 5$	6,300
Repair of facility		2,000
Electric fee	$5.5^{kw} \times 4 \times 1^{H} \times 365^{day} = 8,030$	
	$5.0 \times 8^{H} \times 365 = 14,600$	
	$22,630 \times 0.08$	1,810
Body repair		2,000
		12,110
Closure	900×10	9,000
Canal	$2,000 \times 4$	8,320
Other		870
		18,190
Total		45,000
Assessment for road & causeway		
Surface	$1.2^{mile} \times 5,000$	6,000
Gurad rail	1.2×500	600
Maintenance	$1.2 \times 1,500$	1,800
Total		8,400

93. The cost of maintenance of the reclamation and drainage improvement area is the same as that of the irrigation facilities.

For the maintenance of the irrigation facilities in the paddy field area behind the swamp area, S.D.I.D. has prepared necessary personnel and organization. S.D.I.D. will take charge of it directly, and necessary arrangements have been completed. Therefore, it is believed possible to take care of drainage by reinforcing this organization and personnel. As in the case of the cost of maintenance of the irrigation facilities, the cost of maintenance of the drainage facilities is estimated hereunder, including the cost of main structures and main drainage canal:

Table 3. Annual Operation and Maintenance Cost Estimate for Reclamation and Estimate for Reclamation and Drainage Improvement

(Monetary Unit: M$)

(1) Reclamation

Item	Amount	Unit	Unit Cost	Cost
Main Drainage Canal	13,100	yd	0.45 $	5,895
Connecting Road	13,100	yd	0.43	5,633
Main Irrigation Canal	10,000	yd	0.18	1,800
Total				13,328

(2) Drainage Improvement

Item	Amount	Unit	Unit Cost	Cost
Main Drainage Canal	1,290	acre	1	1,290
Total				1,290

94. With regard to the anticipated blocking of the estuary of the Sg. Prai owing to the construction of the barrage, dredging by suction dredger is considered for the maintenance of the functions of the existing port.

Supposing that the existing port is maintained by removing about 130,000 cubic yards of sand every year, by using a 200 HP suction dredger to dump sand at a 0.3 mile point, a sum of M$195,000 will be needed a year, since the cost of dredging per 1 cubic yard is M$1.5, including the depreciation and operation of the dredger and all other expenses.

3-2. Control

95. The control of the equipment relates mainly to the barrage. The control of impounded water will have the most important bearing upon the effectiveness of the multiple purposes of this project.

96. The control of the impounded water should be effectively carried out according to the under-mentioned standards, by coordinating and adjusting the multiple purposes to bring about the improvement of the drainage of paddy-fields and the ground improvement of the reclaimed area by the stemming of salt water and the lowering of the level of impounded water, to desalinize and utilize impounded water as a source of industrial water, and

to prevent damage in case of flood by rapidly draining flood water along the river.

(a) Throughout the period of paddy-field cultivation, the level of impounded water should be kept at R.L.+2.0 ft.

(b) The intake of industrial water should not exceed the depth of 3.0 ft., and surface water should be taken.

(c) The inflow of salt water should be watched by constant observation to eliminate trouble at water intake.

(d) Excess of water over the controlled level of R.L. 2.0 ft. should be drained off at ebb-tide. Drainage should be effected by the overflow of the roller gates in case of small flood and normal condition, and by the full opening of the gates in case of big flood.

97. The general control of water should be carried out daily by establishing rules of gate operation. It is difficult to set forth these rules at the present time, since the inflow, intake, and level of flood water are not known accurately. It is desirable, therefore, that these rules be fixed after having analyzed and examined the actual records for several years upon completion of the barrage.

The necessary matters for handling the gates are as follows:

(a) Drawing of the water stage and impounding capacity curve;

(b) Determination of the observatory of basic discharge in the river basin and drawing of the stage discharge curve (QH Curve);

(c) Forecast of the inflow (flood discharge, ordinary water discharge, low water discharge) by correlative analysis of the data concerning the observed discharge in the river basin;

(d) Recording and analysis of variations of the inflow, the flood stage, flood hours, and drainage hours in case of flood (big flood, frequent floods), and the handling of the gates;

(e) Recording and analysis of variations of the inflow, in case of ordinary water level and the handling of the gates;

(f) Survey and analysis of the salinity of impounded water;

(g) Testing and analysis of the handling of the gates (measure of opening, number of the controled gates).

Drainage is effected by the overflow from the crest of the lower gate at the ordinary water level and by the full opening of the gate in case of flood.

CHAPTER 4

ECONOMIC APPRAISAL

4-1. Benefits

98. The economic appraisal for this project is made by the same procedure as used in the feasibility report. As for the computation of the annual benefits, the cost allocation and the annual cost, the interest rate is taken as 5 % based in consideration of the national economy, and the benefit-cost ratio is computed by taking the period of its economic analysis as 50 years. The payment capacity will be examined on basis of the interest rate applied in practice and the period of repayment.

Annual Benefits

99. As annual benefits for agriculture, industrial water supply, traffic, and indirect benefits were studied in full detail in the feasibility report, only the results are shown below:

(a)	Agriculture	
	(i) Reclamation	M$ 227,120
	(ii) Drainage improvement	356,184
	Total	M$ 583,304
(b)	Industrial water supply	M$ 788,400
(c)	Traffic	M$ 117,200

Cost allocation for the Barrage

100. The separable costs-remaining benefit method is adopted for cost allocation. Reference is to be made for the conception of this method to "Conception of cost allocation" in Para. 8-3-1 of the feasibility report. A basic year for analysis is taken as the year in which the barrage is completed. The interests during the construction period, lag in accrual of benefits and the cost for necessary replacements during the period of the analysis are considered in this allocation. The maintenance and operation costs are allocated at the same time.

(1) Cost allocation among Agriculture, Industrial Water Supply and Traffic

The combined cost for allocation are to be M$ 4,171,000 that deducts M$ 829,000 of the separable cost of the road from M$ 5,000,000 of the construction cost of the barrage. This combined cost has been allocated among agriculture, industrial water supply and traffic as below:

(A)	Agriculture	49.02 %
(B)	Industrial water supply	49.02 %
(C)	Traffic	1.96 %

(2) Cost allocation between reclamation and drainage improvement

The allocated for the combined cost to agriculture will be re-allocated between reclamation and drainage improvement. The basic year for this allocation is to be 2 years after the time that the barrage is completed, when the effects of the drainage improvement for the hinterland will appear, and cost allocation between reclamation and drainage improvement have been made as follows, taking into consideration the possibility that there may be a delay of one year in the appearance of the effects of reclamation.

(A)	Reclamation	38.39 %
(B)	Drainage improvement	61.61 %

Annual Cost

101. In calculating the annual cost, "Period of the analysis" and "Lag in accrual of benefits" are adopted as indicated in Para. 8-3-1 in feasibility report and the amortization for an installation costs is given by converting the total installation costs to an equivalent uniform annual amount over the period of analysis by the Capital Recovery Factor.

(1) Agriculture

In calculating the annual cost for the agriculture, the allocated joint cost to agriculture should be added with interest during the construction period and the maintenance and operation costs before effects is occured for the agriculture, and specific installation costs for agriculture should be calculated by adding interest during the construction period to the allocated costs between reclamation and drainage improvement.

	(A) Reclamation	(B) Drainage improvement
Maintenance and operation	M$ 17,289	M$ 19,388
Replacement of gates	M$ 2,378	M$ 3,615
Annual amortization of investment	M$ 169,675	M$ 185,717
Total	M$ 189,342	M$ 208,720

(2) Industrial Water Supply

The allocated combined cost to industrial water is calculated by the same method as in the case of "Agriculture", and, regarding the cost of the sole-purpose facility for industrial water supply, interest during the construction period, is taken into account.

Maintenance and operation	M$ 290,059
Replacement of electrical installations	M$ 2,331
Replacement of gates	M$ 6,193
Replacement of mechanical installation	M$ 10,253
Annual amortization of investment	M$ 307,346
Total annual cost	M$ 616,182

(3) Traffic

Annual cost for traffic is calculated by adding the allocated cost of the barrage to traffic and the separable cost

Maintenance and operation	M$ 9,282
Replacement of gates	M$ 211
Annual amortization of investment	M$ 52,386
Total annual cost	M$ 61,879

Benefit Cost Ratio

102. The benefit-cost ratio is computed by the annual costs and the annual benefits.

(A) Agriculture

Reclamation

Annual benefits	M$ 227,120
Annual costs	M$ 189,342
Ratio	1.20 to 1.00

Drainage improvement

Annual benefits	M$ 356,184
Annual costs	M$ 208,720
Ratio	1.71 to 1.00

Agriculture

Annual benefits	M$ 583,304
Annual costs	M$ 398,062
Overall ratio for agriculture	1.47 to 1.00

(B) Industrial water supply

Annual benefits	M$ 788,400
Annual costs	M$ 616,182
Ratio	1.28 to 1.00

(C) Traffic

Annual benefits	M$ 117,200
Annual costs	M$ 61,879
Ratio	1.89 to 1.00

(D) Overall benefit-cost ratio

Annual benefits	
Agriculture	M$ 583,304
Industrial water supply	M$ 788,400
Traffic	M$ 117,200
Total	M$ 1,488,904
Annual costs	
Agriculture	M$ 398,062
Industrial water supply	M$ 616,182
Traffic	M$ 61,879
Total	M$ 1,076,123

Overall benefit-cost ratio 1.38 to 1.00

103. According to these results, the benefit-cost ratio is to be maintained more than 1.0, therefore this project is economically feasible.

Moreover, the benefit-cost ratio of the traffic development and the ratio of the industrial water supply will be increased further in future because following the development of these area, the traffic capacity will be increased more than that of the prescribed traffic number, 140,000 vehicles/month, and the industrial water consumption will be more than that of the prescribed number, 6,000,000 gallons/day.

4-2. Repayment

104. The fund necessary for this project will be provided by the Malaysian Government and the Yen loan of the Japanese Government. The cost of construction of the barrage, which is a multipurpose facility, is allocated by each purpose to be served.

The cost of construction for each purpose can be worked out by adding the construction of facilities exclusively serving a particular purpose to the allocation amount. The sum so worked out, as divided into portions to be financed by the domestic fund and by the Japanese loan is given in App. 9.

The Malaysian currency necessary for this project, except the cost of the industrial water supply, will totally be furnished from the general account of the Government of Malaysia. The local currency of M$2,850,000, required for industrial water supply is expected to be raised by a domestic loan, with the annum interest of 5% for a repayment period is 20 years including the grace period of 2 years.

The schedule of the amortization of the Yen loan is described in Para. 106 and the payment capacity of each purpose is shown Paras. 107-116.

105. The repayment period of the Yen loan is 20 years, including the grace period of 5 years, from the date the Project Loan Agreement is signed. The interest rate is 4.5% per annum.

The preparation and computation on the repayment schedules for the Yen loan of M$2,145,000 are made in accordance with the applicable loan procedures, and they are as follows;

Schedule of Repayment of Yen Loan for this Project interest payment during construction

Loan in 1st yr of construction:	
(refer to App. 8)	M$1,287,000
(M$2,145,000 x 60%)	
Interest payment in 1st yr of construction:	
(1,287,000 x 1/2 x 0.045)	M$ 28,958
Loan in 2nd yr of construction:	
(M$2,145,000 - M$1,287,000)	M$ 858,000
Interest payment in 2nd yr of construction:	
(M$1,287,000 x 0.045 + 858,000 x 1/2 x 0.045)	M$ 77,220
Annual interest payment during 3 yrs of grace period:	
(M$2,145,000 x 0.045)	M$ 96,525
Annual repayment of principal and interest:	
(M$2,145,000 x 0.04464 x 2)	M$ 191,506

Repayment for Agriculture

106. The local currency of M$2,130,421 will be appropriated from the budget of the Government of Malaysia. According to past examples, S.D.I.D. collected from the farmers water rates amounting to about 70% of the annual maintenance and operation cost. Theoretically, it is a matter for study whether the farmers can afford to reimburse the money invested in agriculture. From this point of view, a study will be made on the possibility of repayment of the investment made in local currency at 5% annual interest rate and for a 20 year repayment period with the grace period of 5 years. The calculations relating to the Yen loan are made in accordance with the terms of the loan, and the fund required for the payment of the interest for the period of the loan and for the non-effective period will be supplemented from a domestic source.

107. Repayment of local currency for reclamation

Construction cost:	M$ 978,339
(refer to App. 9)	
Initial investment including interest prior to amortization of local currency:	
[M$537,311 x (1+1/2x2yrsx0.05) x $(1+0.05)^3$ + M$441,028 x (1+1/2x2yrsx0.05) x (1+0.05)]	M$1,078,618
Interest payment for Yen loan:	
[M$28,958 x 0.165 x (1+0.05) + M$77,220 x 0.165 x (1+0.05) + M$96,525 x 0.165 x [1+(1+0.05) + $(1+0.05)^2$]]	M$ 67,768
O & M costs prior to amortizaton:	
(refer to Tab. 3)	
[(M$8,477 x [(1+0.05) + $(1+0.05)^2$+$(1+0.05)^3$]	M$ 28,059
Total initial investment:	M$1,174,445
Amortization, at 20 yrs 5%:	
(M$1,174,445 x 0.0824)	M$ 96,774
O & M costs:	
(M$8,477 + M$8,821)	M$ 17,298
Total annual cost expected to be borne by farmers:	M$ 114,072 ... (1)

108. Repayment of local currency for drainage improvement

Construction cost:	M$1,152,082
(refer to App. 9)	
Initial investment including interest prior to amortization of local currency:	
M$862,210 x (1+1/2x2x0.05) x (1+0.05) + 289,872 x (1+1/2x2x0.05) x (1+0.05)	M$1,270,171
Interest payment for Yen loan:	
(M$28,958 x 0.246 x (1+0.05) + M$77,220 x 0.246 x (1+0.05)) + M$96,525 x 0.246 x [1+(1+0.05)]	M$ 70,132
O & M costs prior to amortization	
(refer to App. 8)	
(M$13,584 x [(1+0.05) + $(1+0.05)^2$])	M$ 35,352
Total initial investment:	M$1,375,655
Amortization for 20 yrs at 5% interest	
(M$1,375,655 x 0.08024)	M$ 110,383
O & M costs:	
(M$13,584 + M$5,797)	M$ 19,381
Total annual cost expected to be borne by farmers:	M$ 129,764 ... (2)

109. Repayment of Yen Loan for reclamation

Construction cost:	M$ 403,689
(refer to App. 9)	
Amortization, at 15 yrs 4.5%	
(M$403,689 x 0.04464 x 2)	M$ 36,041 ... (3)

110. Repayment of Yen Loan for drainage improvement

Construction cost:	M$ 647,790
(refer to App. 9)	
Payment of interest in 5th yr:	
(M$88,695 x 0.246)	M$ 21,819
Amortization, at 15 yrs 4.5%	
(M$647,790 x 0.04464 x 2)	M$ 57,834 ... (4)

111. Total repayment for reclamation

Repayment		
Local currency from (1):	M$	114,072
Yen loan from (3):	M$	36,041
Total	M$	150,113

Repayment per acre (1,670 acres)		
Local currency	M$	69
Yen loan	M$	21
Total	M$	90

112. Total repayment for drainage improvement

Repayment		
Local currency from (2):	M$	129,764
Yen loan from (4):	M$	57,834
Total	M$	187,598

Repayment per acre (5,990 acres)		
Local currency:	M$	22
Yen loan	M$	10
Total	M$	32

113. The annual cost per acre borne by the farmers will be (1) M$90 in the reclamation acrea (2) M$32 in the drainage improvement area. On the other hand, the annual benefits per acre are (1) M$138 in the reclamation area, (2) M$59 in the drainage improvement area. Consequently, the share of the farmers in repayment will be 65% of the annual benefits in the reclamation area; (2) 54% of the annual benefits in the drainage improvement area.

In the culculation mentioned above, it was assumed that the costs of paddy field works, such as branch canals and lateral ditches, excluding, the cost for main canals executed by S.D.I.D., would be met by the farmers' own fund. If the fund for the above works is to be borrow by the farmers, the amount of its amortization should also be taken into account.

The amortization for Yen loan per acre per annum amounts to M$21 in the reclamation area and M$10 in the drainage improvement acrea, hence it is assumed that the repayment by the farmers within the limit of the annual increment of benefit will be possible. With regard to the method of collection of money, special consideration for obtaining the agreement and cooperation of the farmers is needed.

Repayment for industrial water supply

114. The local currency of M$4,249,521, a part of the cost of construction for the industrial water supply, will be provided by a domestic loan. The details of this loan are unknown, and the terms are supposed to be an annual interest of 5%, and a period of 20 years, including two year grace period. M$1,051,479 out of the Yen loan is calculated according to the prescribed terms. The amount needed for repayment will be collected from the users of water in the form of water rate.

The annual repayment is as follows:

(1) Repayment of local currency	
Construction cost:	M$4,249,521
(refer to App. 9)	
Initial investment including interest prior to amortization of local currency:	
(M$1,399,521 x (1+1/2x2yrs x 0.05) +M$2,850,000 x (1+1/2x2yrs x 0.05)	M$4,461,997
Interest payment for Yen loan:	
[M$28,958 x 0.411 x (1+0.05) + M$77,220 x 0.411]	M$ 44,234
Total initial investment:	M$4,506,231
Amortization, at 20 yrs 5%:	M$ 351,415
(M$4,379,550 x 0.08024)	
Replacement of mechanic installation in associated works at 10 yrs 5%:	M$ 4,827
(M$98,000 x 0.6139 x 0.08024)	
O & M costs:	
(M$19,208 + M$117,500)	M$ 136,708
Total annual costs	M$ 492,950
(2) Repayment of Yen loan	
Construction cost:	M$1,051,479
(refer to App. 9)	
Repayment of interest in 3rd, 4th and 5th yr:	
(M$96,525 x 0.4902)	M$ 47,316
Amortization, at 15 yrs 4.5%:	
(M$1,051,479 x 0.04464 x 2)	M$ 93,876

Total repayment	
((1) + (2) = M$492,950 + M$93,876	M$ 586,826

The water rate is estimated as follows:

M$586,826 ÷ 1,971,000,000 gallons = 30 cts per 1,000 gallons

A water rate lower than 30 cts per 1,000 gallons stated by P.W.D. to be economically feasible, is possible, and it is well within the payment capacity of the users.

Repayment for traffic

115. Out of the cost of construction of facilities for traffic, the local currency of M$55,958 is appropriated from the Government of Malaysia, and the remainder, M$42,042 is furnished by the Japanese Government from Yen loan. Beneficiaries of traffic improvement are unspecified large number of people and the share of cost by beneficiaries may be out of consideration. Accordingly, repayment will be made from the budget of P.W.D. which is the principal organ in charge.

The repayment of the Yen loan is scheduled as follows:

Interest payment in 1st yr: (M$28,958 x 0.0196)	M$	568
Interest payment in 2nd yr: (M$77,220 x 0.0196)	M$	1,514
Annual interest payment in 3rd, 4th and 5th yr: (M$96,525 x 0.0196)	M$	1,892
Annual repayment of principal including interest: (M$191,505 x 0.0196)	M$	3,753

Revenues and outlays of the Yen loan

116. The results of studies made in the above clauses 4-1, 4-2 are shown for each by year in App. 10. The figures shown are for the Yen loan only, because with regard to the revenues and outlays of the local currency, the kind of fund its terms and the amount of repayment by the farmers are not known.

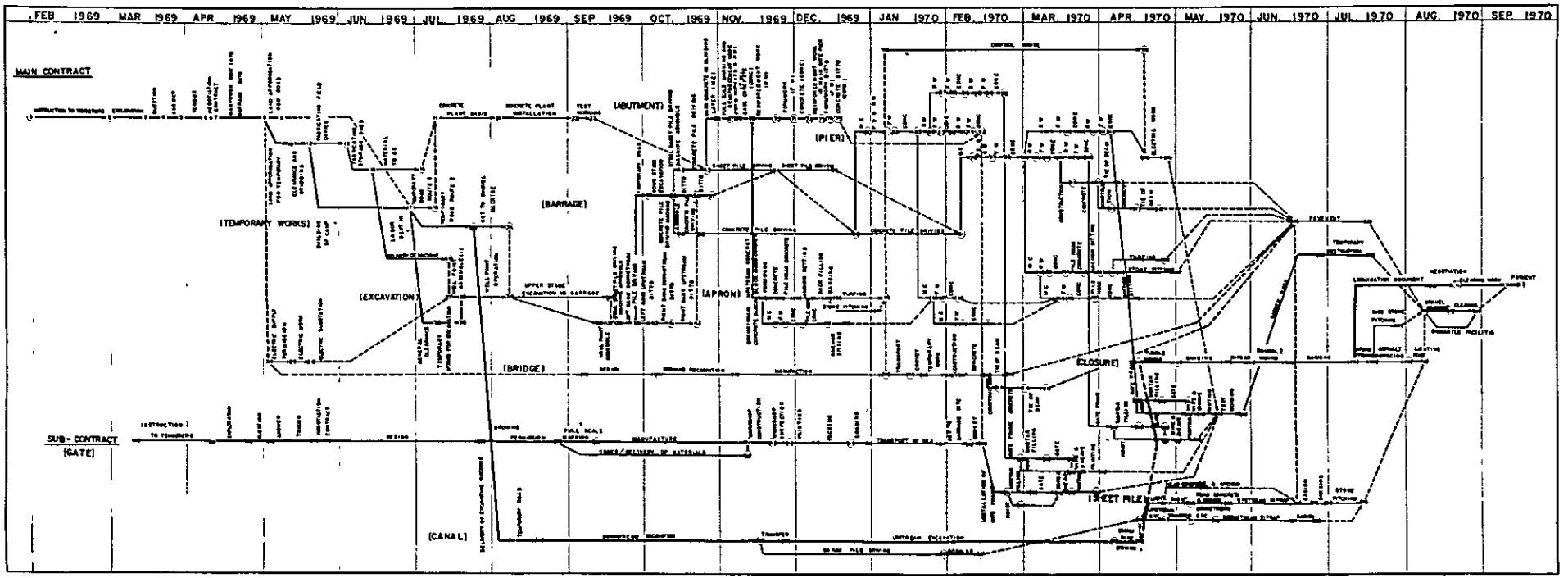
The principal organ in charge of the barrage which is a multi-purpose facility, will be D.I.D.. The principal organ in charge of industrial water supply and traffic will be P.W.D.. Therefore the allocated share of the repayment of the Yen loan will be paid in by P.W.D. to D.I.D..

117. The revenues and outlays of the Yen loan as shown in Tab. are based on the following assumptions. For reclamation and drainage improvement, which are under the jurisdiction of D.I.D., funds other than the Yen loan are appropriated from the budget of the Government of Malaysia, and the repayment of the Yen loan in made wholly by the farmers. For industrial water supply, which is under the jurisdiction of P.W.D., the fund other than the Yen loan will be raised by a domestic loan, and will be rapid together with the Yen loan is by water users. Traffic is under the jurisdiction of P.W.D., and the fund other than the Yen loan will be furnished by the budget of the Government of Malaysia, and the repayment of the Yen loan is will also by the budget of the Government of Malaysia.

Appendix 1. GENERAL CHARACTARISTICS OF SOIL LAYERS

LAYER		CLAY(I)	SAND(I)	CLAY(II)	SAND(II)	CLAY(III)	SAND(III)	CLAY(IV)	SAND(IV)
AVERAGE THICHNESS(ft)		7	13	5	6	16	9	4	
CLASSIFICATION		OH-CH	SM-SP	CH	SM-SP	CH	SP	CH	SP-GP
SPECIFIC GRAVITY		2.55	2.60	2.60	2.60	2.65	2.63	2.55	2.63
WATER CONTENT (%)		80-180	-	30-90	-	60-75	-	30-60	-
CONSISTENCY	LL(%)	100	-	90-120	-	75-130	-	-	-
	PL(%)	40	-	60-90	-	24-40	-	-	-
	PI(%)	60	-	30-60	-	50-99	-	-	-
UNIT WEIGHT (t/m^3)		1.4	1.4-1.9	1.5-1.9	1.4-1.9	1.6	1.6	1.9	1.6
VOID RATIO		1.2	-	1.1	-	1.7-2.0	-	0.78	-
PERMEABILITY (cm/sec)		IMPERMEABLE	5.5×10^{-2}	IMPERMEABLE	5.6×10^{-2}	IMPERMEABLE	7.5×10^{-2}	IMPERMEABLE	4.1×10^{-2} - 4.0×10^{-1}
UNCONFINED COMPRESSION TEST	$Qu(Lb/in^2)$	1.7-2.1	-	3.5-15.9	-	4.5-19.0	-	19.0	-
	St(%)	-	-	1.7-6.4	-	1.5-4.2	-	-	-
TRIAXIAL COMPRESSION TEST	ϕ (degree)	-	-	-	-	1°50'	-	-	-
	$C\ (t/m^2)$	-	-	-	-	2.7	-	-	-
CONSOLIDATION TEST	$P_o(t/m^3)$	-	-	-	-	5.0	-	-	-
	$Cv(cm^2/sec)$	-	-	-	-	0.95×10^{-4}	-	-	-
	$Mv(cm^2/g)$	-	-	-	-	1.49×10^{-4}	-	-	-
N - VALUE (blow/ft)		2-4	6 - 14	5 - 6	4	4	8	9	15 - 31

APPENDIX 2. TIME SCHEDULE FOR BARRAGE



Appendix 3. Land acquisition and compensation

Description	Quantity	Unit	Rate	Amount
1-1 Land acquisition, excluding reserved				
Swamp land	13.31	Acre	1,000	13,310
Coconut field	10.63	Acre	2,000	21,260
Sub total				34,570
1-2 Compensation for				
Removal of house	8	House	5,000	40,000
Total				74,570
			Round	75,000

Appendix 4. BILL OF QUANTITIES FOR DEVIATION ROAD ON PLAN A

Description	Quantity	Unit	Rate	Amount
Land acquisition, excluding reserved land				
Swamp land	2.31	Acre	1,000	2,310
Coconut field	5.31	"	2,500	13,275
Compensation for				
Removal of house	5	House	7,000	35,000
Coconut tree	200	No	20	4,000
Replacement of electric pole	1	Pole	300	300
Relocation of fences	133	Yard	2	266
Sub total				55,151
Cutting and uprooting of				
Swamp oand	5.79	Acre	300	1,737
Cutting and uprooting of				
Coconut field	5.00	"	300	1,500
Excavation	1,599	Cu-yd	2.50	3,997.5
Banking	44,418	"	1.70	75,510.6
Finish for drain ditch	1,710	Yard	2.40	4,104
Turfing (Spot turfing)	22,600	Sq-yd	0.50	11,300
Pavement for vehicle way				
including crushed rock base course	20.978	"	6.00	125,868
Repair the adjoining section				
of the existing main road pavement	224	"	3.50	784
Pavement of side track				
excluding the closure	5,673	"	4.00	22,692
Pavement of side track at closure	1,000	"	4.-	4,000
Sub total				251,493.1
Safe facilities for bus stop	2	Sum	2,000	4,000
Safe facilities for new road	1	"	2,000	2,000
Sub total				6,000
Miscellaneous work				
Overhead	1	Sum	4,000	4,355.0
Total				317,000

Appendix 5. BILL OF QUANTITIES FOR DEVIATION ROAD ON PLAN B

Description	Quantity	Unit	Rate	Amount
Land acquisition, excluding reserved land				
Swamp land	5.20	Acre	1,000	5,200
Coconut field	5.88	"	2,500	14,700
House lot	2.63	"	4,000	10,520
Compensation for				
Removal of house	20	House	8,000	160,000
Coconut tree	300	No	20	6,000
Replacement of electric pole	1	Pole	300	300
Relocation of fences	133	Yard	2	266
Sub total				196,986
Cutting and uprooting of swamp land				
Cutting and uprooting of				
Coconut field	5.88	"	300	1,764
Excavation	1,618	Cu-yd	2.50	4,045
Banking	56,654	"	1.70	96,311.8
Fish for drain ditch	1,700	Yard	2.40	4,080
(Spot)	26,924	Sq-yd	0.50	13,462
Pavement for carriageway				
Including crushed rock base course	26,924	"	6.00	161,544
Repair the adjoining section				
of the existing main road pavement	224	"	3.50	784
Pavement of side track				
excluding the closure	7,732	"	4.00	30,928
Pavement of side track at closure	1,000	"	4.00	4,000
Sub total				319,072.8
Safe facilities for bus stop	2	Sum	2,000	4,000
Safe facilities for new road	1	"	2,000	2,000
Sub total				6,000
Miscellaneous work				
Over head	1	"	4,000	3,941.2
Total				526,000

Appendix 6. Cost Estimate of Reclamation and Drainage Improvement

Description	Unit	Quantity	Rate	Amount
1. Reclamation				
Cutting and Uprooting	acre	1,670	300 M$	501,000 M$
First Plowing	"	1,670	100	167,000
Drainage ditches and Branch Irrigation Canals	"	1,670	486	811,620
Main Drainage Canals and Roads	yd	13,100	44	576,400
Main Irrigation Canals	"	10,000	9	90,000
Other Works				980
Sub Total				2,147,000
2. Drainage Improvement				
(1) Paddy Field converted from Coconut Field				
Main Irrigation Canals	acre	1,290	50	64,500
Branch Irrigation Canals	"	1,290	26	33,540
Drainage Ditches	"	1,290	242	312,180
Other Works				780
Sub Total				411,000
(2) Existing Paddy Field				
Drainage Ditches	acre	4,700	242	1,137,400
Other Works				4,600
Sub Total				1,142,000
Total				3,700,000

Appendix 7. Separable Cost Estimate of Traffic in Barrage

(Monetary Unit: M$)

Item	Description	Quantity	Unit	Rate	Amount	Remarks
Barrage	Reinforced Concrete class AA	1,459	Cu-yd	60	87,540	
	Mass Concrete class C	447	"	45	20,115	
	Mass Concrete class E	133	"	46.75	6,217.75	
	Concrete Pile Draiving	144	Pile	548.7	79,012.80	
	Steel sheet Pile Draiving	60	"	146.50	8,790	
	Bridge				113,264	Cost of Bridge floor x 30/46
	Fairfaced formwork	487	Sq-yd	13.-	6,331	
	Rough formwork	122	"	11.-	1,342	
	Steel bar	74,456	Lb	0.27	20,103.12	
	Closure					
	Banking by Cut Earth	25,700	Cu-yd	3.00	77,100	
	Steel Lights	5	Set	200	1,000	
	Guard Rails	350	Yd	20.00	7,000	
	Deviation Road	526,000 x 3/4			395,000	
	Sub total				765,005.67 ≒ 765,000	

Appendix 8. Yen Loan Estimate

(Monetary Unit: Japanese Yen)

Item	Description	Quantity	Unit	Rate	Amount	Remarks
(1) Material	Deformed Reinforcement Bars	178	t	44,000	7,832,000	
	Mild Steel Reinforcement Bars	398	t	42,000	16,716,000	
	Sheet Piles	209	Short ton	56,000	11,704,000	
	Gates				75,000,000	
	Handrail Lighting post, Guide rail etc.		Sum		1,200,000	
	Sub total				112,452,000	
(2) Construction Cost by Yen Loan		4,095,000 x 25% x 120			120,000,000	
(3) Supervise cost by Yen Loan					25,000,000	
	Total				257,452,000 ÷ 2,145,000 M$	

Appendix 9 Construction Cost to be Borne by Each Purpose

(Monetary Unit: M$)

Purpose	Barrage			Associated Works			Total		
	Local Currency	Yen Loan	Total	Local Currency	Yen Loan	Total	Local Currency	Yen Loan	Total
Agriculture									
Reclamation	537,311	403,689	941,000	1,921,628	0	1,921,628	2,458,939	403,689	2,862,628
	(0.1882)	(0.1882)	(0.1882)	(441,028)		(441,028)	(978,339)		(978,339)
Drainage Improvement	862,210	647,790	1,510,000	1,778,372	0	1,778,372	2,640,582	647,790	3,288,372
	(0.3020)	(0.3020)	(0.3020)	(289,872)		(289,872)	(1,152,082)		(1,152,082)
Sub Total	1,399,521	1,051,479	2,451,000	3,700,000	0	3,700,000	5,099,521	1,051,479	6,151,000
	(0.4902)	(0.4902)	(0.4902)	(730,900)		(730,900)	(2,130,421)		(2,130,421)
Industrial Water Supply	1,399,521	1,051,479	2,451,000	2,850,000	0	2,850,000	4,249,521	1,051,479	5,301,000
	(0.4902)	(0.4902)	(0.4902)						
Traffic	55,958	42,042	98,000	0	0	0	55,958	42,042	98,000
	(0.0196)	(0.0196)	(0.0196)						
Total	2,855,000	2,145,000	5,000,000	6,550,000	0	6,550,000	9,405,000	2,145,000	11,550,000
	(1.000)	(1.000)	(1.000)						

Notes: (1) The construction cost to be required for the construction of barrage is allocated among the purposes served with the ratio of cost allocation.

(2) The construction cost of associated works for the industrial water supply is indicated in (1) of paragraph (8-4-2).

(3) The values in the parenthesis of the column "Associated works" are the construction costs in the governmental budget by D.I.D., which consist of those of the main canals for drainage and irrigation, and the road. The residuals other than the above are financed by the agricultural beneficiaries.

Appendix 10 Repayment Table for Yen Loan

(Monetary Unit: M$)

Project Year	Agriculture (D.I.D.)						Industrial Water Supply (P.W.D.)				Traffic (P.W.D.)	
	Loan	Repayment	Loan	Repayment			Loan	Repayment			Loan	Repayment
	Construction of Barrage	Construction of Barrage		Budget	Farmers	Total		Local Loan	Collection of Water Rute	Total		Budget
1	1,278,000	28,958	630,887	14,195	-	14,195	630,887	14,195	-	14,195	25,226	568
2	858,000	77,220	420,592	37,853	-	37,853	420,592	37,853	-	37,853	16,816	1,514
3	-	96,525	-	47,316	-	47,316	-	-	47,316	47,316	-	1,892
4	-	96,525	-	18,926	-	47,316	-	-	47,316	47,316	-	1,892
5	-	96,525	-	-	28,390	47,316	-	-	47,316	47,316	-	1,892
6	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
7	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
8	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
9	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
10	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
11	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
12	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
13	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
14	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
15	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
16	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
17	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
18	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
19	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
20	-	191,506	-	-	93,876	93,876	-	-	93,876	93,876	-	3,753
Total	2,145,000	3,268,343	1,051,479	165,606	1,436,530	1,602,136	1,051,479	52,048	1,550,088	1,602,136	42,042	64,053

Notes: The repayment during 5 years of grace period is the interest excluding the amortization.

Appendix 11.

A B B R E V I A T I O N S

P.W.D.	Public Works Department
D.I.D.	Drainage and Irrigation Department
S.D.I.D.	State Drainage and Irrigation Department
B.S.	British Standard
C°	Centigrade degrees
cm	centimeter (s)
C.P.	B.S. Code of Practice
cu	Cubic
cusec	Cubic feet per second
Eq.	equation
Eqs.	equations
F°	fahrenheit degrees
Fig.	figure
Figs.	figures
ft	feet
g	gram
gtgs	gantangs
H.H.W.L.	higher high water level
hr	hour
in	inch(es)
J.I.S.	Japanese Industrial Standard
M.	million
m	meter(s)
Max.	maximum
M$	MALAYSIA dollar
M.H.W.S.	mean height of high water at spring tide
M.H.W.N.	mean height of high water at neap tide
M.S.L.	mean sea level
M.L.W.N.	mean height of low water at neap tide
M.L.W.S.	mean height of low water at spring tide
mb	millibar(s)
mgd	million gallons per day
mi	mile(s)
min	minute(s)
M.P.H.	miles per hour
Para.	paragraph
Paras.	paragraphs
%	per cent
ppm	parts per million
sec	second(s)
Sg.	Sungai (River)
sq	square
Tab.	table
Tabs.	tables
yr	year
yen	Japanese yen

Appendix 12.. CONVERSION TABLES

1 LENGTH

Unit	Equivalents					
	in.	ft	yd	mi	cm	m
Inches	1	0.08333	0.02778	0.00002	2.54	0.0254
feet	12	1	0.33333	0.00019	30.48	0.3048
yards	36	3	1	0.00057	91.44	0.9144
miles	63360	5280	1760	1	160934	1609.34
centimeters	0.39370	0.03281	0.01094	0.00001	1	0.01
meters	39.3701	3.28084	1.09361	0.00062	100	1

2 AREA

Unit	Equivalents								
	sq in.	sq ft	sq yd	sq mmi	acre	ha	sq m	sq km	sq cm
square inches	1	0.00694	0.00077	----	----	----	0.00065	----	6.4516
square feet	144	1	0.11111	----	0.00002	----	0.09290	----	929.030
square yards	1296	9	1	----	0.00021	----	0.83613	----	8361.27
square miles	----	----	-----	1	----	259.000	----	2.58999	----
acre	----	43560	4840	0.00156	1	0.404686	4046.86	0.00405	----
hectare	15500000	107639	1196	0.00386	2.24711	1	10000	0.01	----
square meters	1550	10.7639	1.19599	----	0.00025	0.0001	1	0.000001	10000
square kilometers	----	----	----	0.3861	247.105	100	1000000	1	----
square centimeters	0.15500	0.00108	0.00012	----	----	----	0.0001	----	1

3 VOLUME

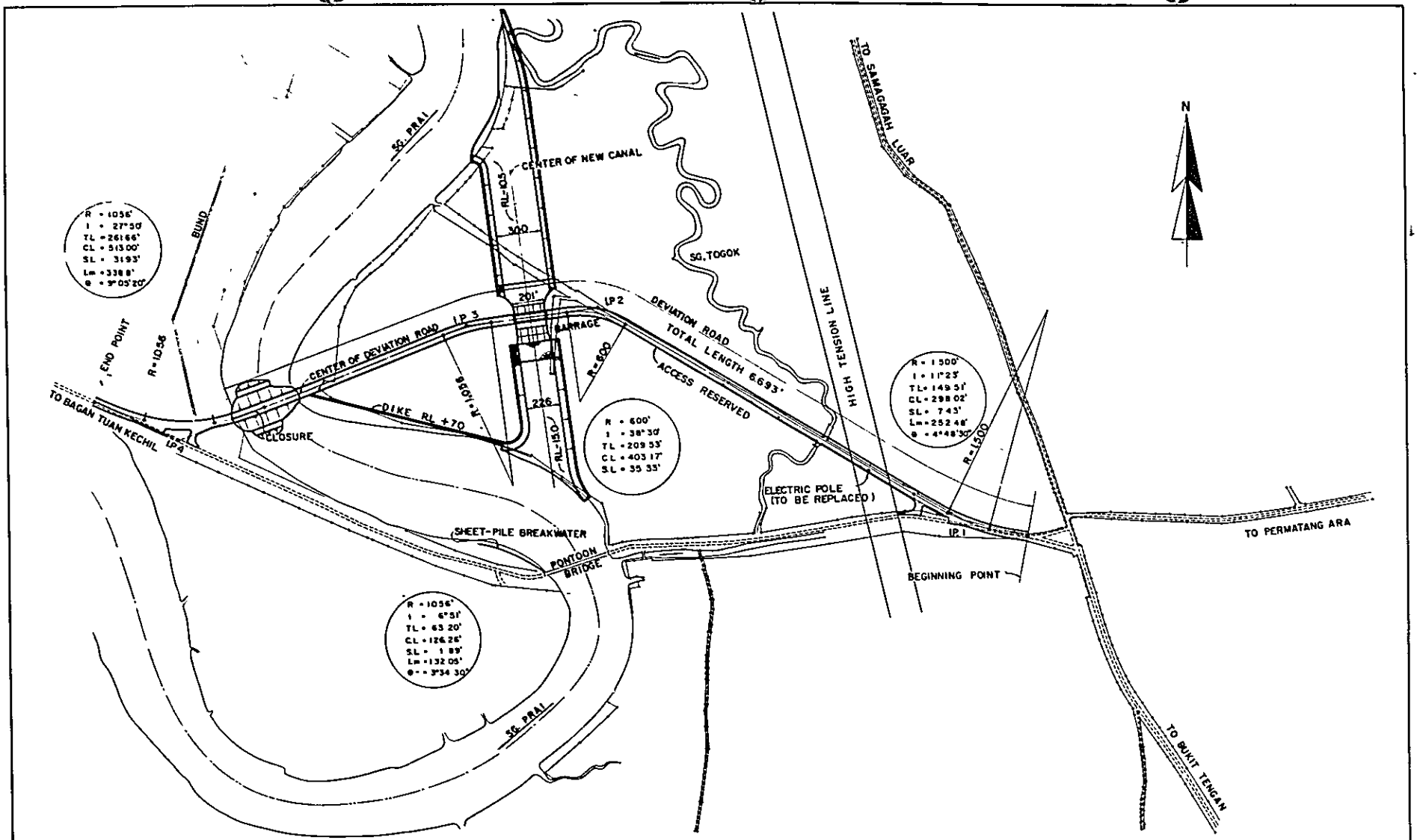
Unit	Equivalent							
	cu in.	cu ft	cu yd	gallon	lit	cu cm	cu cm	gantang
cubic inches	1	0.00058	0.00002	0.00360	0.01639	16.3871	0.00002	0.00360
cubic feet	1728	1	0.03704	6.22883	28.3161	28316.8	0.02832	6.22883
cubic yards	46656	27	1	168.179	764.555	7.64555	0.76455	168.179
Imperial gallong	277.42	0.16054	0.00595	1	4.54596	4546.09	0.00455	1
liter	61.0255	0.03532	0.00131	0.21998	1	1000	0.001	0.21998
cubic centimeters	0.06102	0.00004	----	0.00022	0.001	1	0.000001	0.00022
cubic meters	61023.7	35.3147	1.30795	219.975	1000	1000000	1	219.975
gantangs	277.42	0.16054	0.00595	1	4.54596	4546.09	0.00455	1

4. WEIGHT

Unit	Equivalents					
	g	kg	lbs	ton	picul	kati
grams	1	0.001	0.00220	----	----	0.0016535
kilograms	1000	1	2.20462	0.00098	0.01650	1.65347
pounds	453.592	0.45359	1	0.00045	0.00750	0.75000
long ton	----	1016.05	2240	1	16.667	1666.67
piculs	60611.998	60.6120	133.333	0.06000	1	100
katies	604.7867	0.60479	1.33333	0.00060	0.01000	1

5. MOSCE:OAMEPIS CPMVERSOPNS

1 cubic feet per second = 0.0283 cubic meters per second
1 cubic meter per second = 35.31 cubic feet per second
1 inch of runoff per square miles = 53.3 acre - feet
1 pound per swuare inches = 0.070 kilogram per square centimeters
1 kilogram per square centimeters = 14.22 pounds per square inches
1 gantangs, padi (unhulled) = 5.6 pounds, padi = 2.54 kilogram, padi
= 0.00249 long ton, padi
1 kilogram, padi = 0.3936 gantangs, padi
1 pound, padi = 0.1785 gantangs, padi
1 gantang, rice(polished) = 0.65 gantangs, padi (unhulled)
1 MALAYSIA dollar (M$) = 117.60 yen at official rate, February 1968
= 0.32667 UNITED STATES dollar (US$)
1 US$ = 3.06122 M$



SCALE

264 FEET (4 CHAINS) = ONE INCH

0 — 800 FEET

ITEM	AMENDMENTS	INITIAL	DATE

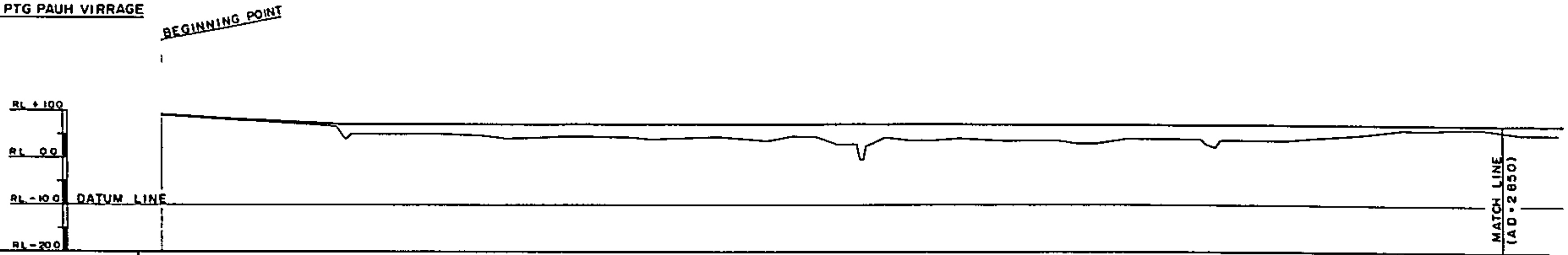
SG. PRAI ON DRAINAGE AND RECLAMATION PROJECT

LOCATION PLAN OF DEVIATION ROAD (PLAN A)

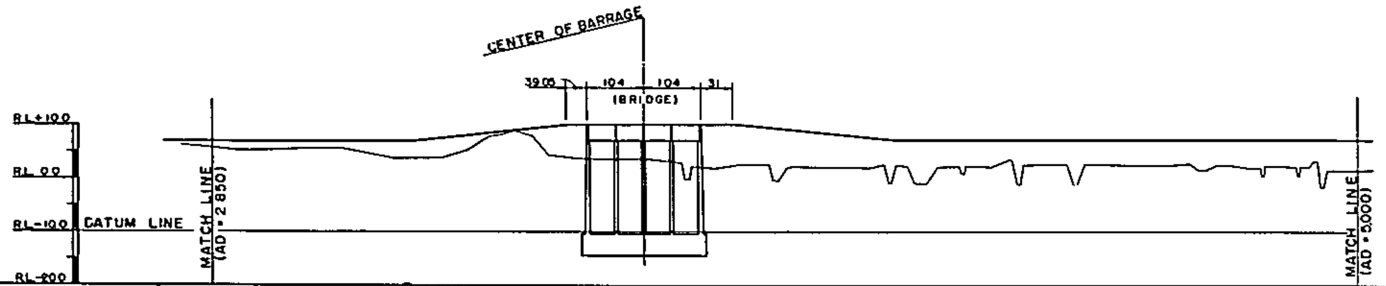
	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION	ASST DIRECTOR DRAINAGE & IRRIGATION	S. D. I. D. DRAINAGE & IRRIGATION
CONTRACT PLAN NO R-1		

FROM PTG PAUH VIRRAGE



LONGITUDINAL SLOPE	+5/1000			LEVEL RL+700												
ROAD SURFACE	810	770	708	700	700	700	700	700	700	700	700	700	700	700	700	700
ORIGINAL GROUND SURFACE						4 22	4 22	4 16	3 52	3 40	3 02	4 01	3 76	5 60	6 44	
ACCUMULATIVE DISTANCE	000	282 40	401 49	550 50	802 98	990 85	1184 39	1390 85	1590 85	1790 85	1990 85	2190 85	2390 85	2593 70	2793 50	2913 32
DISTANCE	0 00	282 40	119 01	149 01	282 48	187 87	193 54	206 46	200 70	200 00	200 00	200 00	200 00	202 85	200 00	119 82
NUMBAR	BP (BTC)	BCC	BP1	ECC	ETC	NO.101	NO.102 (TP 9)	NO.103	NO.104 (TP 10)	NO.105	NO.106	NO.107	NO.108	NO.109	NO.110	BT



LONGITUDINAL SLOPE	LEVEL RL+700			+10/1000		LEVEL RL+10 00				-10/1000		LEVEL RL+700				
ROAD SURFACE	700	700	700	700	9 01	10 00	10 00		10 00	10 00	9 04	700	7 00	700	700	700
ORIGINAL GROUND SURFACE	6 44		6 46		8 35		9 46	3 51	2 12	1 91	1 34	2 08	2 00	1 95	1 96	1 67
ACCUMULATIVE DISTANCE	2793 50	2913 32	3013 32	3215 10	3416 68	3516 68	3555 74	3659 74	3763 74	3794 74	3924 54	4137 98	4394 71	4594 71	4794 71	4994 71
DISTANCE		119 82	100 00	201 80	201 58	100 00	39 05	104 00	104 00	31 00	129 80	213 45	256 72	200 00	200 00	200 00
NUMBAR	NO.110	BT	BCC	BP2	ECC	ET	NO.111	NO.112	NO.113	TP11	NO.114	NO.115	NO.116	NO.117	NO.118	NO.119

SCALE

HORIZONTAL 100 FEET = ONE INCH (0 — 300 FEET)

VERTICAL 10 FEET = ONE INCH (0 — 30 FEET)

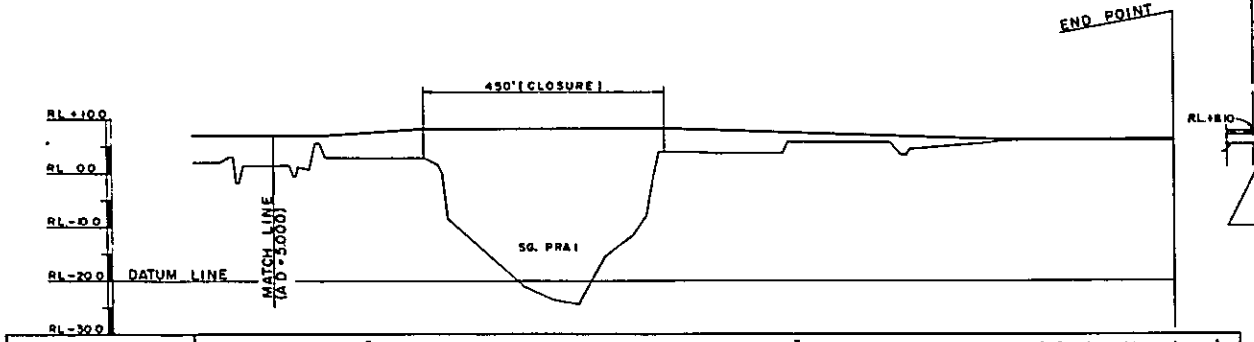
ITEM	AMENDMENTS	INITIAL	DATE

SG. PRAI DRAINAGE AND RECLAMATION PROJECT

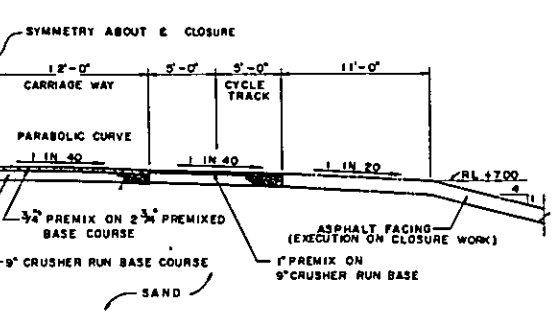
LONGITUDINAL SECTION OF DEVIATION ROAD, (SHEET. 1)
(PLAN A)

	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION	ASST DIRECTOR DRAINAGE & IRRIGATION	S D I D DRAINAGE & IRRIGATION
CONTRACT PLAN NO. R-2		

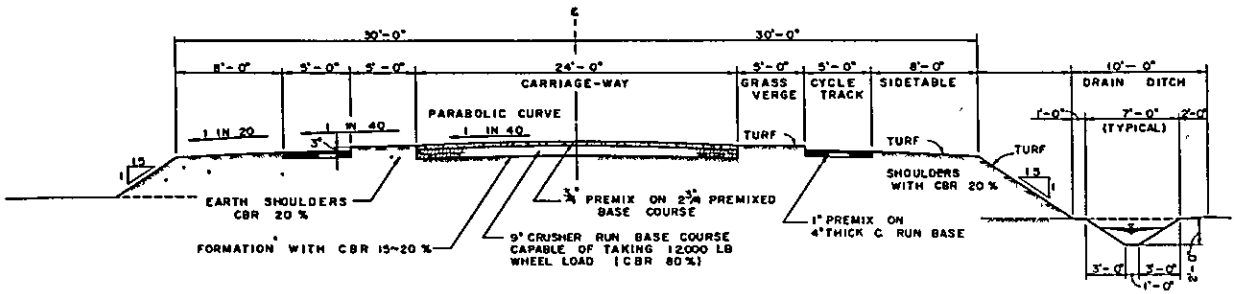


LONGITUDINAL SLOPE	R.L +7.00	+6/1000	LEVEL R.L +8.10	-3/1000	LEVEL R.L +6.30
ROAD SURFACE	7.00	7.00 8.10	8.10	8.10 7.88	7.00 6.30
ORIGINAL GROUND SURFACE	6.37	8.33 8.84	9.78	9.30 9.61	8.88 6.30
ACCUMULATIVE DISTANCE	4894.71	5005.48 5260.00	3750.00	3870.43 8097.27	6324.11 8858.00
DISTANCE	200.00	90.78 194.52	450.00	140.43 2826.84	2260.84 534.89
NUMBAR	MO 118	MO 119 MO 120	MO 121	MO 122 MO 123	MO 124 MO 125



TYPICAL CROSS SECTION OF ROAD AT CLOSURE

SCALE 4 FEET = ONE INCH



TYPICAL CROSS SECTION OF ROAD

SCALE 4 FEET = ONE INCH

SCALE	ITEM	AMENDMENTS	INITIAL	DATE
LONGITUDINAL SECTION HORIZONTAL 100 FEET = ONE INCH; VERTICAL 10 FEET = ONE INCH				

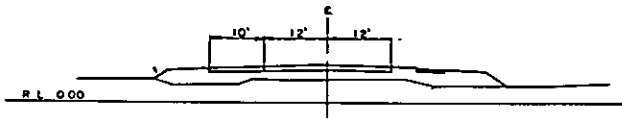
PROJECT ON DRAINAGE AND RECLAMATION OF SG. PRAI

LONGITUDINAL SECTION OF DEVIATION ROAD. (SHEET 2)

TYPICAL CROSS SECTION OF DEVIATION ROAD (PLAN A)

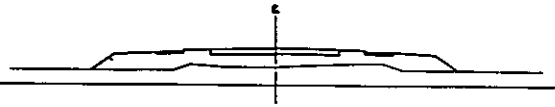
	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION	ASST DIRECTOR DRAINAGE & IRRIGATION	S D I D DRAINAGE & IRRIGATION
CONTRACT PLAN NO. R-3		



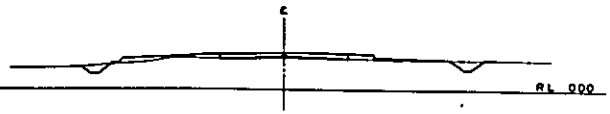
E T C
(AD = 802.98)

E	—
B	163
CA-P	34
CY-P	10
T	29



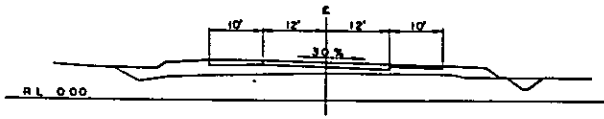
NO 105
(A.D = 1.790.85)

E	—
B	194
CA-P	24
CY-P	10
T	36



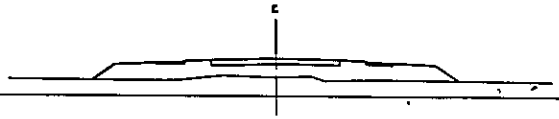
NO 110
(AD=2793.50)

E	14
B	36
CA-P	24
CY-P	10
T	27



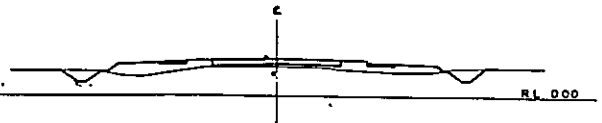
E C C
(AD = 550.50)

E	8
B	132
CA-P	34
CY-P	10
T	21



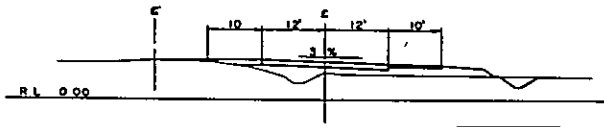
NO.104 (T P 10)
(A D = 1.590.85)

E	—
B	209
CA-P	24
CY-P	10
T	36



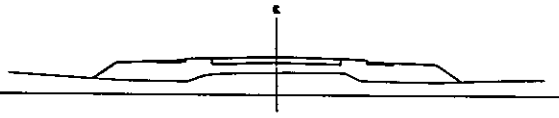
NO 109
(AD = 2593.70)

E	16
B	102
CA-P	24
CY-P	10
T	30



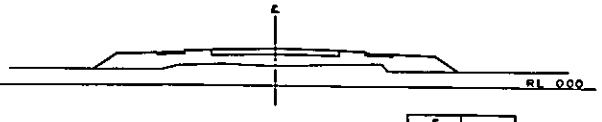
S P I
(A D =401.49)

E	8
B	110
CA-P	34
CY-P	10
T	10



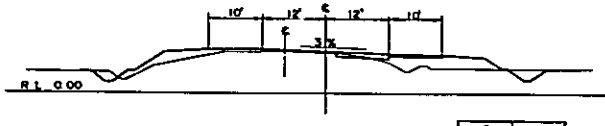
NO 103
(A D = 1.390.85)

E	—
B	211
CA-P	24
CY-P	10
T	37



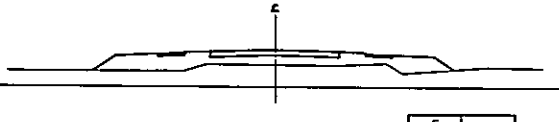
NO 108
(AD = 2.390.85)

E	—
B	188
CA-P	24
CY-P	10
T	26



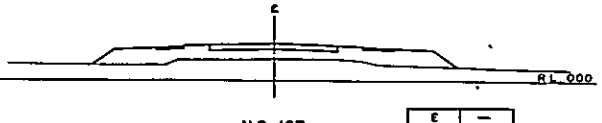
B. C C
(A.D = 252.48)

E	14
B	92
CA-P	34
CY-P	10
T	27



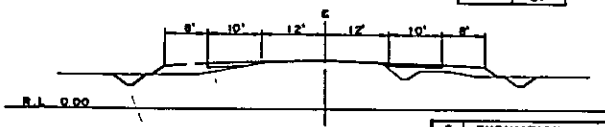
NO102 (T P 9)
(A D = 1184.39)

E	—
B	177
CA-P	24
CY-P	10
T	35



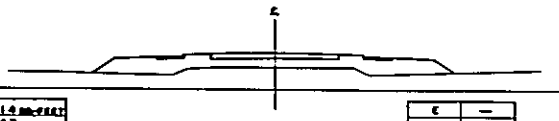
NO 107
(A D = 2.190.85)

E	—
B	200
CA-P	24
CY-P	10
T	37



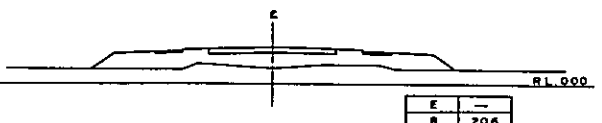
B P (B.T.C)

E	EXCAVATION	14 SQ. FEET
B	BANKING	67 "
CA-P	CARRIAGE PAVEMENT	34 FEET
CY-P	CYCLE TRACK PAVEMENT	10 "
T	TURFING	22 "



NO 101
(A.D = 990.85)

E	—
B	181
CA-P	24
CY-P	10
T	35



NO 106
(A D = 1.990.85)

E	—
B	206
CA-P	24
CY-P	10
T	36

SCALE
10 FEET = ONE INCH
0 35 FEET

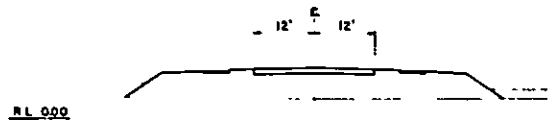
ITEM	AMENDMENTS	INITIAL	DATE

SG. PRAI DRAINAGE AND RECLAMATION PROJECT

CROSS SECTION OF DEVIATION ROAD. (SHEET 1)
(PLAN A)

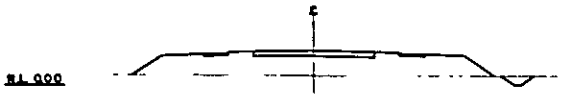
	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECED BY		

DIRECTOR DRAINAGE AND IRRIGATION	ASST DIRECTOR DRAINAGE AND IRRIGATION	S.D.I.D DRAINAGE AND IRRIGATION
CONTRACT PLAN NO. R-4		



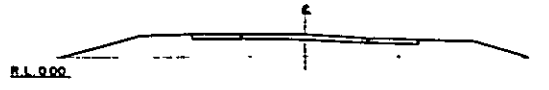
E T
(A D = 3,516 69)

E	–
B	352
CA – P	24
CY – P	10
T	36



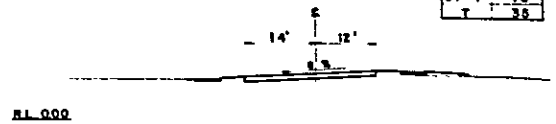
NO 116
(A D = 4 394 71)

E	7
B	280
CA – P	24
CY – P	10
T	40



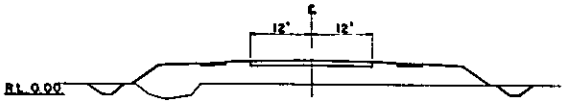
NO. 121
(A D = 5730)

E	–
B	310
CA – P	45
CY – P	–
T	50



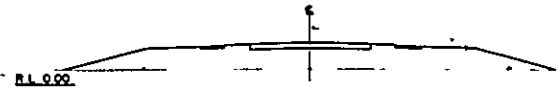
E C C
(A D = 3,416.69)

E	12
B	31
CA – P	26
CY – P	10
T	18



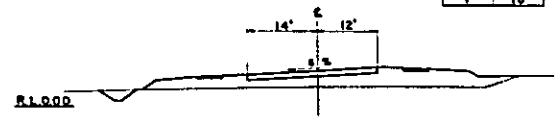
NO 115
(A D = 4137 99)

E	20
B	311
CA – P	24
CY – P	10
T	39



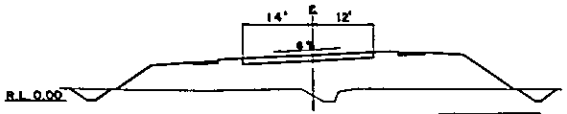
NO. 120
(A.D = 5,280)

E	–
B	376
CA – P	24
CY – P	10
T	65



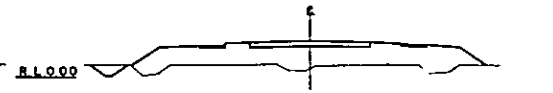
S P 2
(A.D = 3,215 105)

E	8
B	212
CA – P	26
CY – P	10
T	31



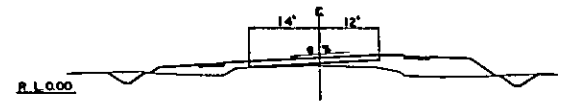
NO 114
(A D = 392454)

E	17
B	464
CA – P	26
CY – P	10
T	46



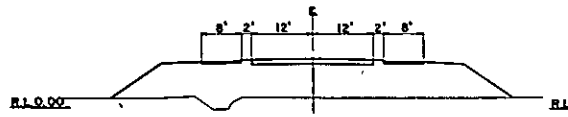
NO. 119
(A.D = 4994.71)

E	8
B	301
CA – P	24
CY – P	10
T	39



B C C
(A D = 3,013 52)

E	16
B	147
CA – P	26
CY – P	10
T	34

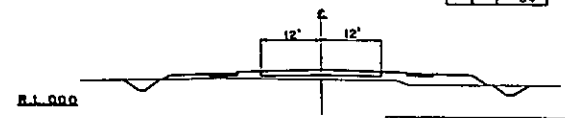


NO 113
(A D = 3,763 74)

E	–
B	516
CA – P	24
CY – P	16
T	29

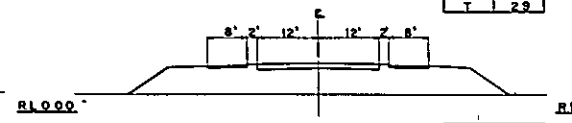
NO 118
(A D = 4794 71)

E	16
B	296
CA – P	24
CY – P	10
T	40



B T
(A.D = 2,913.52)

E	EXCAVATION 17
B	BANKING 93
CA-P	CARRIAGE PAVEMENT 24 FEET
CY-P	CYCLE TRACK PAVEMENT 10
T	TURFING 31



NO 111
(A D = 3,555 74)

E	–
B	397
CA – P	24
CY – P	16
T	29

NO 117
(A D = 4594 71)

E	15
B	282
CA – P	24
CY – P	10
T	40

SCALE
10 FEET = ONE INCH
0 35 FEET

ITEM	AMENDMENTS	INITIAL	DATE

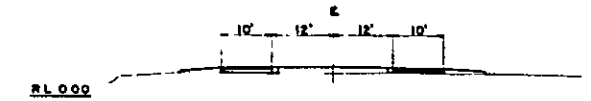
SG. PRAI DRAINAGE AND RECLAMATION PROJECT

CROSS SECTION OF DEVIATION ROAD. (SHEET 2)
(PLAN A)

	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECED BY		

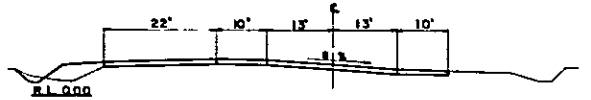
DIRECTOR DRAINAGE AND IRRIGATION | ASST DIRECTOR DRAINAGE AND IRRIGATION | S D I D DRAINAGE AND IRRIGATION

CONTRACT PLAN NO 4-5



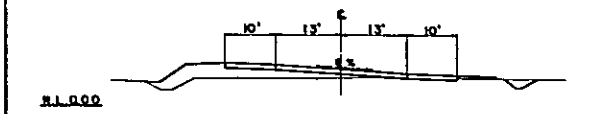
EP. (E T C)
(A D = 6 693)

E	15
B	7
CA - P	44
CY - P	–
T	18



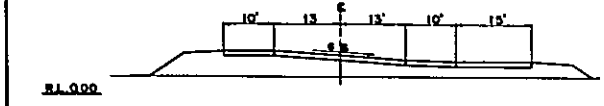
NO. 124
(A.D = 6324 11)

E	15
B	38
CA - P	68
CY - P	–
T	13



NO. 123
(A.D = 6.097 27)

E	–
B	118
CA - P	46
CY - P	–
T	22



NO. 122
(A D = 5.870 43)

E	EXCAVATION	–
B	BANKING	3270 cu FEET
CA-P	CARRIAGE PAVEMENT	61 FEET
CY-P	CYCLE TRACK PAVEMENT	–
T	TURFING	29 FEET

SCALE
10 FEET = ONE INCH
0 30 FEET

ITEM	AMENDMENTS	INITIAL	DATE

SG PRAI DRAINAGE AND RECLAMATION PROJECT

CROSS SECTION OF DEVIATION ROAD. (SHEET 3)

(PLAN A)

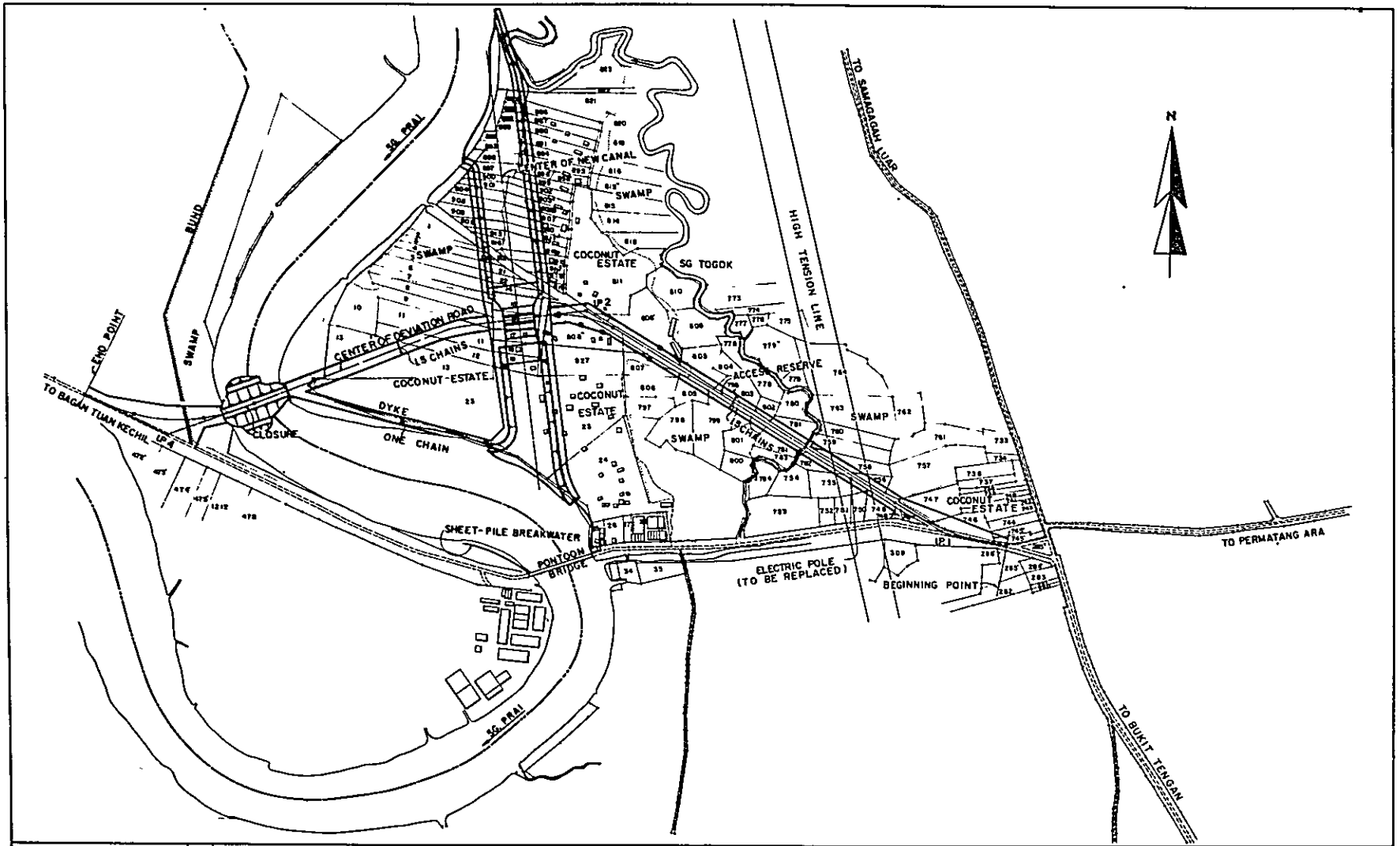
	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION

CONTRACT PLAN NO R-6

ASST DIRECTOR DRAINAGE & IRRIGATION

S D I D DRAINAGE & IRRIGATION



SCALE

4 CHAINS = ONE INCH

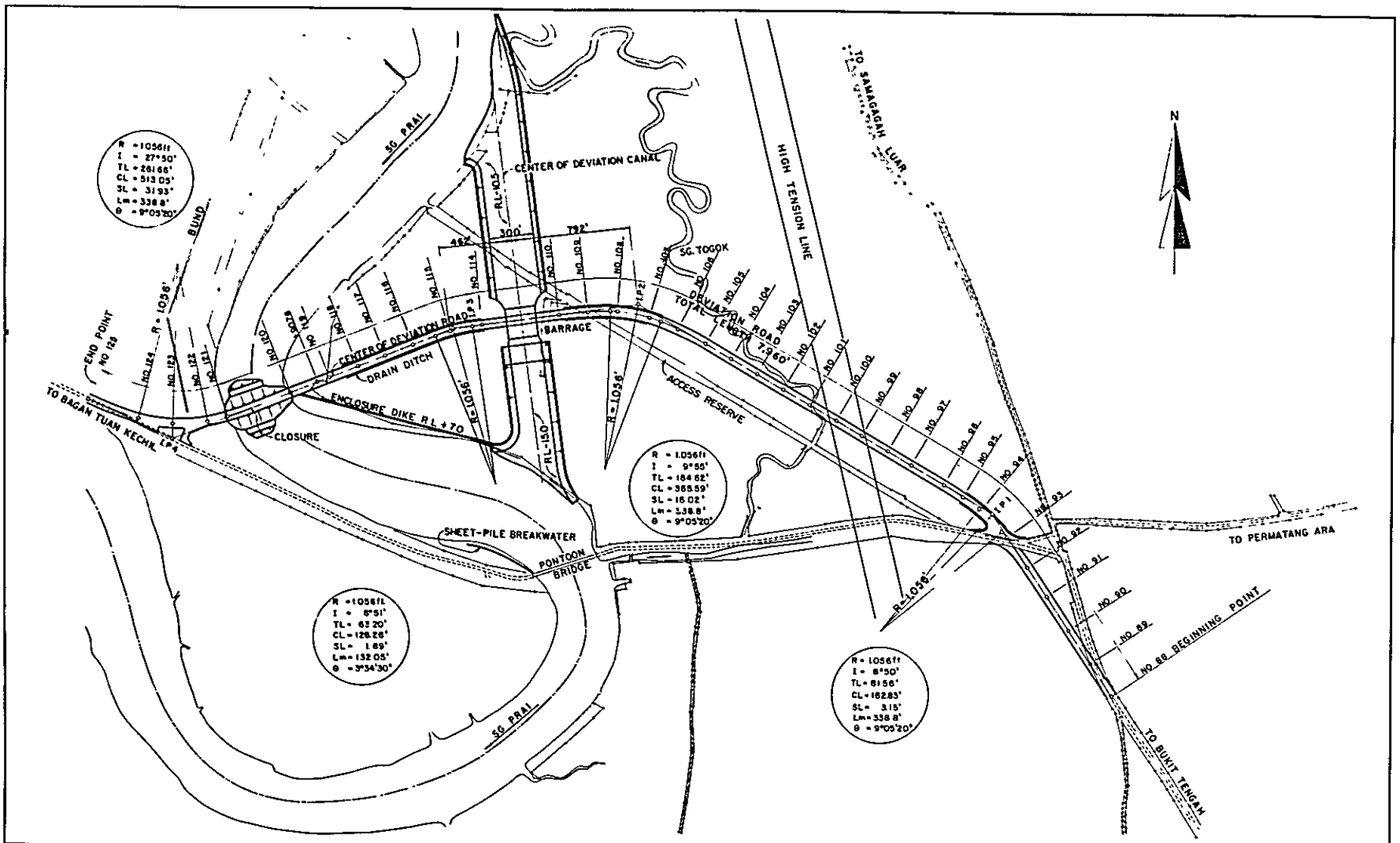
ITEM	AMENDMENTS	INITIAL	DATE

SG. PRAI DRAINAGE AND RECLAMATION PROJECT

LAND ACQUISITION AND COMPENSATION PLAN (PLAN A)

	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION	ASST DIRECTOR DRAINAGE & IRRIGATION	D R I D DRAINAGE & IRRIGATION
CONTRACT PLAN NO. P-7		



SCALE	ITEM	AMENDMENTS	INITIAL	DATE
264 FEET (4 CHAINS) = ONE INCH				

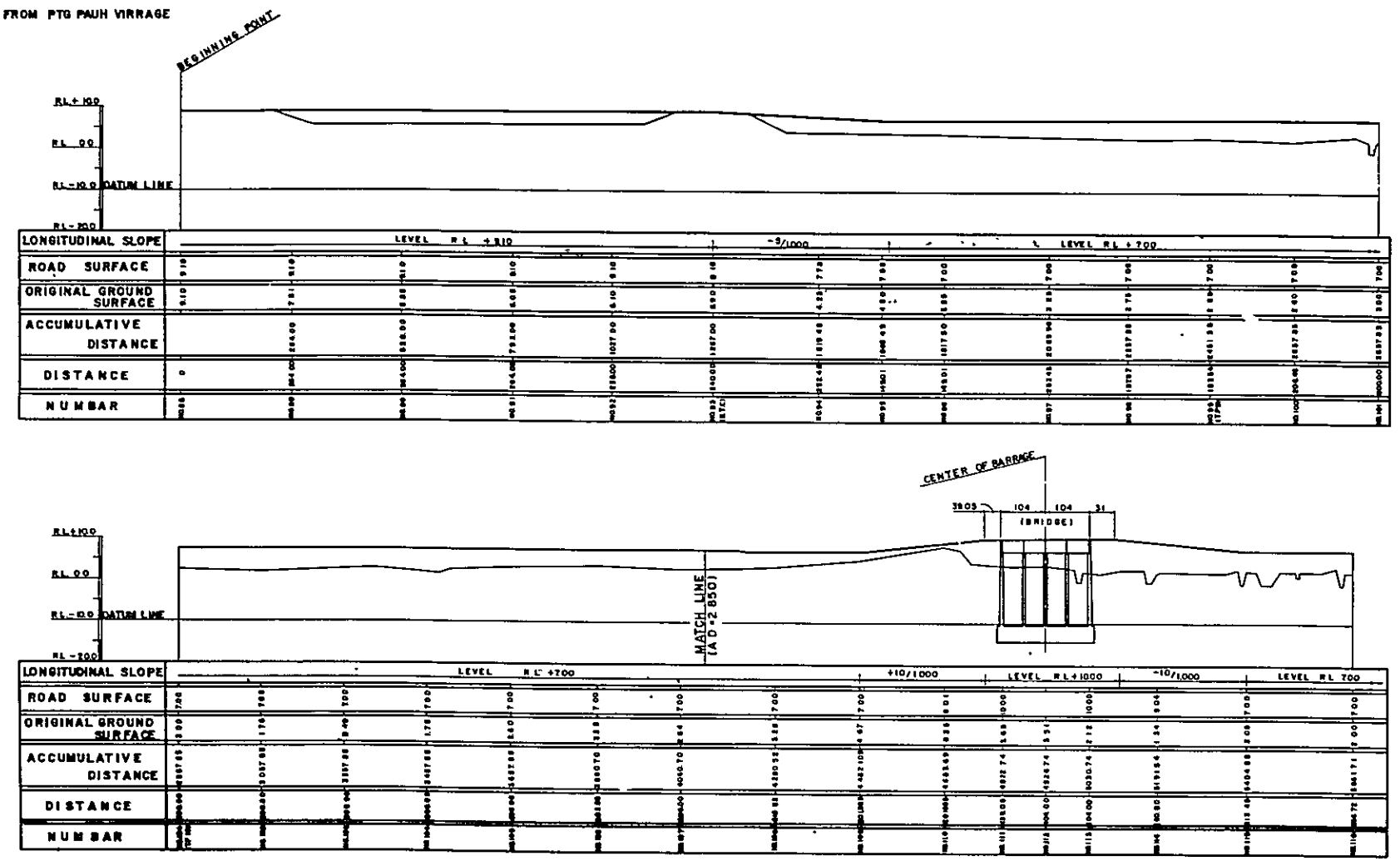
SG. PRAI DRAINAGE AND RECLAMATION PROJECT

LOCATION PLAN OF DEVIATION ROAD
(PLAN B)

	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION	ASST DIRECTOR DRAINAGE & IRRIGATION	S.D.I.D DRAINAGE & IRRIGATION
CONTRACT PLAN NO. R-6		

FROM PTG PAUH VIRRAGE



SCALE

REV	AMENDMENTS	INITIAL	DATE

SG. PRAI DRAINAGE AND RECLAMATION PROJECT

LONGITUDINAL SECTION OF DEVIATION ROAD. (SHEET 1)
(PLAN B)

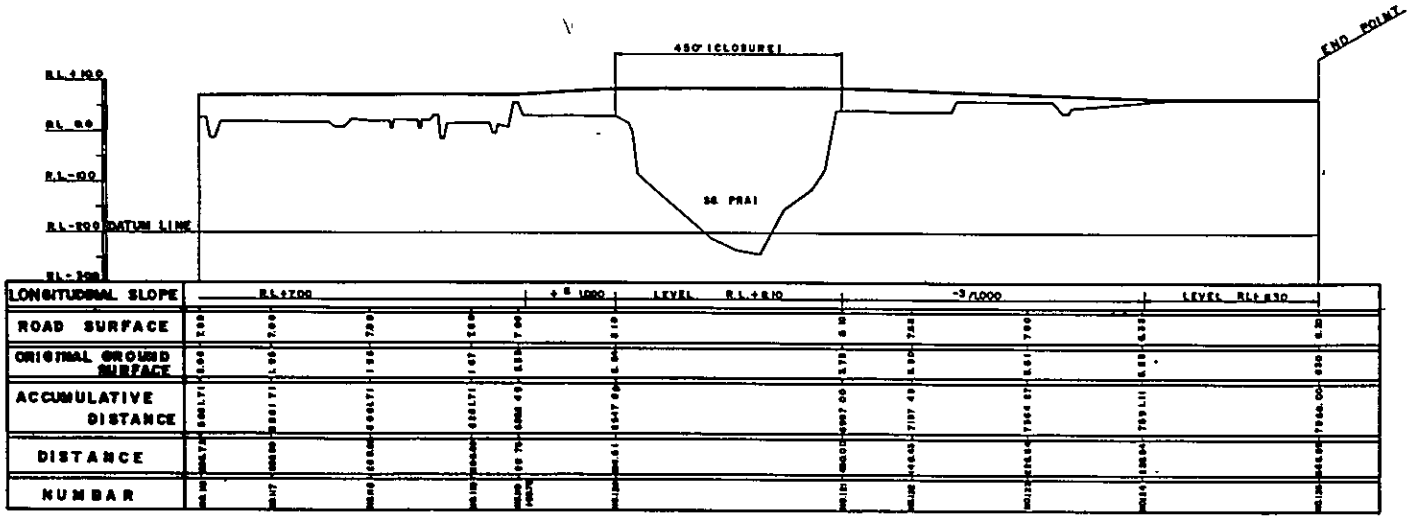
	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

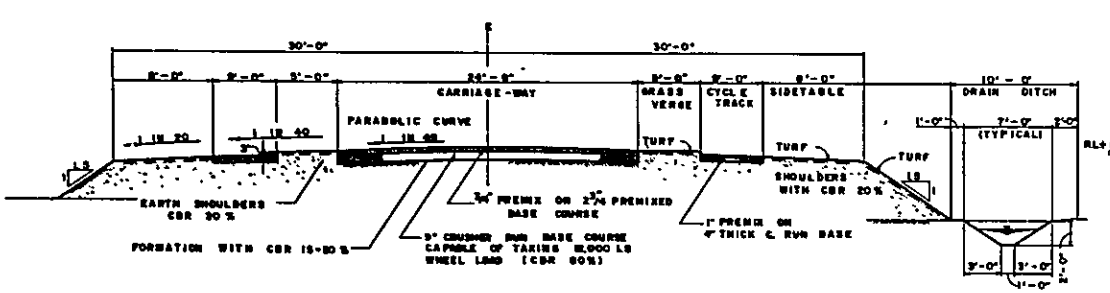
DIRECTOR (DRAINAGE & IRRIGATION)

CONTRACT PLAN NO B-6

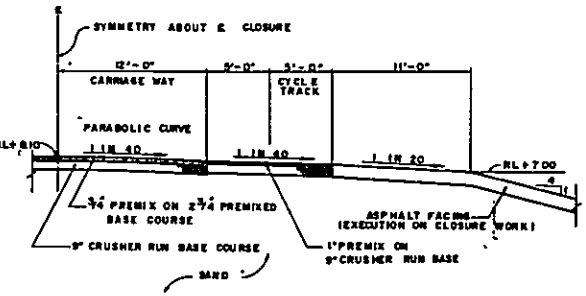
ASST DIRECTOR (DRAINAGE & IRRIGATION)

S.D.I.S (DRAINAGE & IRRIGATION)





TYPICAL CROSS SECTION OF ROAD
SCALE 4FEET = ONE INCH



TYPICAL CROSS SECTION OF ROAD AT CLOSURE
SCALE 4FEET = ONE INCH

SCALE	ITEM	AMENDMENTS	INITIAL	DATE

SG. PRAI DRAINAGE AND RECLAMATION PROJECT

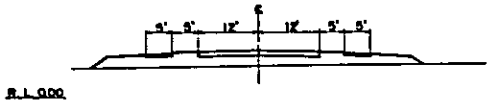
LONGITUDINAL SECTION OF DEVIATION ROAD. (SHEET 2)
TYPICAL CROSS SECTION OF DEVIATION ROAD
(PLAN B)

	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR	ASST DIRECTOR	G.A.I.D.
CONTRACT PLAN 60 B-10		

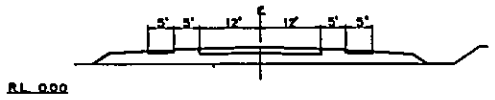
NO 92

E	–
B	147
CA-P	24
CY-P	10
T	32



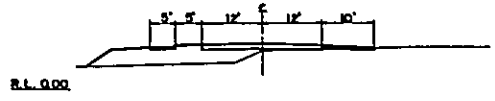
NO 91

E	–
B	159
CA-P	24
CY-P	10
T	32



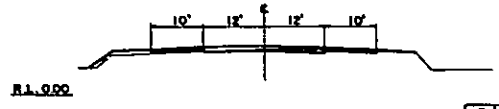
NO 90

E	–
B	162
CA-P	24
CY-P	10
T	32



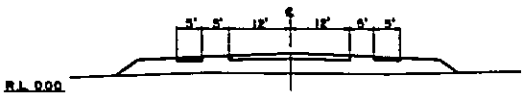
NO. 89

E	–
B	98
CA-P	24
CY-P	15
T	19



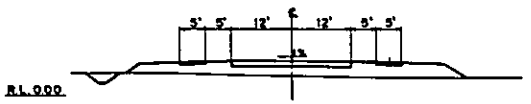
NO 88 (BEGINNING POINT)

E	EXCAVATION	2850-FEET
B	BANKING	34 "
CA-P	CARRIAGE PAVEMENT	24 FEET
CY-P	CYCLE TRACK PAVEMENT	10 "
T	TURFING	12 "



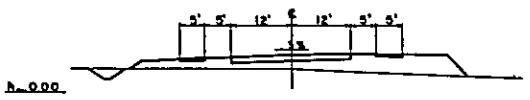
NO. 97

E	–
B	193
CA-P	24
CY-P	10
T	34



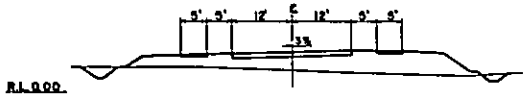
NO 96

E	B
B	170
CA-P	24
CY-P	10
T	31



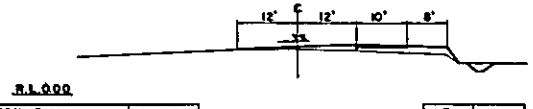
NO 95

E	B
B	171
CA-P	24
CY-P	10
T	20



NO. 94

E	3
B	223
CA-P	24
CY-P	10
T	37

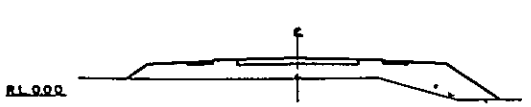


NO 93

E	–
B	31
CA-P	24
CY-P	20
T	21

NO 102

E	–
B	283
CA-P	24
CY-P	10
T	38

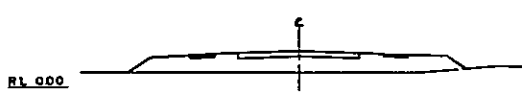


NO 101

E	–
B	278
CA-P	24
CY-P	10
T	36

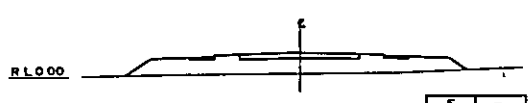
NO 100

E	–
B	246
CA-P	24
CY-P	10
T	37



NO. 99

E	–
B	216
CA-P	24
CY-P	10
T	35



NO 98

E	–
B	247
CA-P	24
CY-P	10
T	35

SCALE

10 FEET = ONE INCH

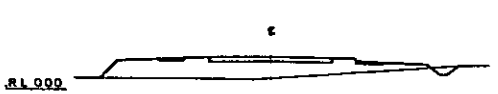
ITEM	AMENDMENTS	INITIAL	DATE

SG. PRAI DRAINAGE AND RECLAMATION PROJECT

CROSS SECTION OF DEVIATION ROAD. (SHEET 1)
(PLAN B)

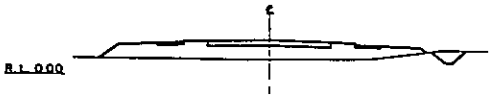
	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION	ASST DIRECTOR DRAINAGE & IRRIGATION	S D I D DRAINAGE & IRRIGATION
CONTRACT PLAN NO 11		



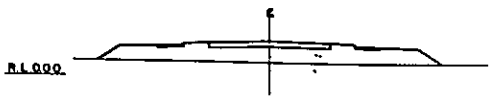
NO 107

E	5
B	177
CA - P	24
CY - P	10
T	32



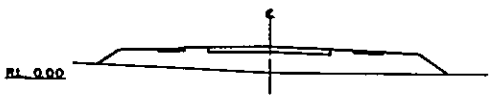
NO 106

E	10
B	191
CA - P	24
CY - P	10
T	36



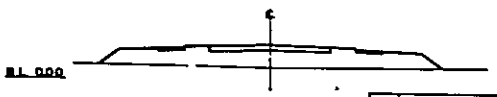
NO 105

E	—
B	240
CA - P	24
CY - P	10
T	26



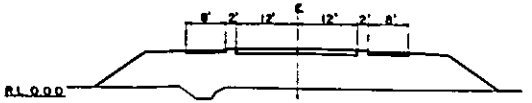
NO 104

E	—
B	281
CA - P	24
CY - P	10
T	38



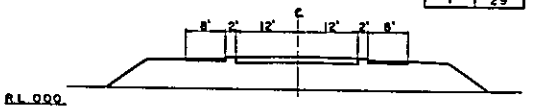
NO 103

E	EXCAVATION	—
B	BANKING	24030 FEET
CA-P	CARRIAGE PAVEMENT	24 FEET
CY-P	CYCLE TRACK PAVEMENT	10 "
T	TURFING	36 "



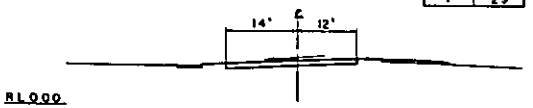
NO 113

E	—
B	516
CA - P	24
CY - P	16
T	29



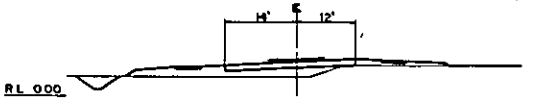
NO 111

E	—
B	397
CA - P	24
CY - P	16
T	29



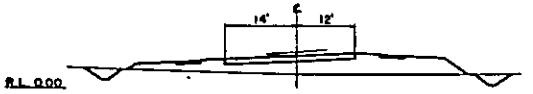
NO 110

E	12
B	31
CA - P	26
CY - P	10
T	18



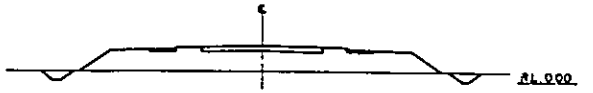
NO 109

E	13
B	116
CA - P	26
CY - P	10
T	30



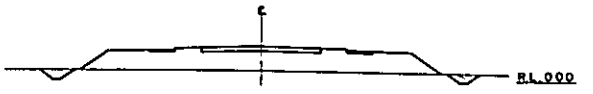
NO 108

E	15
B	199
CA - P	26
CY - P	10
T	34



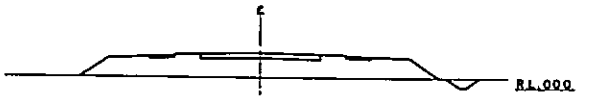
NO 118

E	16
B	296
CA - P	24
CY - P	10
T	40



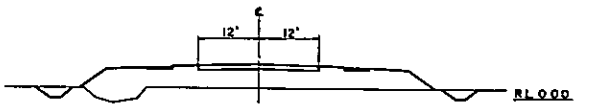
NO 117

E	15
B	282
CA - P	24
CY - P	10
T	40



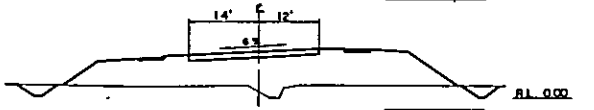
NO 116

E	7
B	280
CA - P	24
CY - P	10
T	40



NO 115

E	20
B	311
CA - P	24
CY - P	10
T	39



NO 114

E	17
B	464
CA - P	26
CY - P	10
T	46

SCALE

10 FEET = ONE INCH

ITEM	AMENDMENTS	INITIAL	DATE

96 PRAI DRAINAGE AND RECLAMATION PROJECT

CROSS SECTION OF DEVIATION ROAD. (SHEET 2)
(PLAN B)

	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR	ASST. DIRECTOR	D. D. I. R.
DRAINAGE & IRRIGATION	DRAINAGE & IRRIGATION	DRAINAGE & IRRIGATION
CONTRACT PLAN NO. 11-12		

NO 123

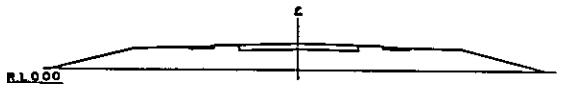
E	-
B	118
CA-P	46
CY-P	-
T	22

NO 122

E	-
B	327
CA-P	61
CY-P	-
T	29

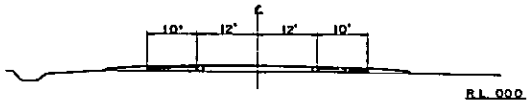
NO 121

E	-
B	310
CA-P	45
CY-P	-
T	50



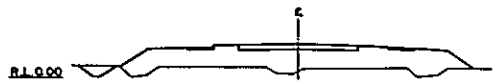
NO 120

E	-
B	376
CA-P	24
CY-P	10
T	65



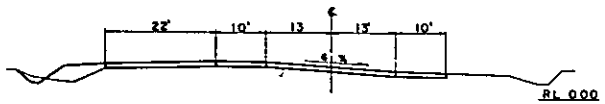
NO 125

E	15
B	7
CA-P	44
CY-P	-
T	18



NO 119

E	EXCAVATION	850 FEET
B	BANKING	301 "
CA-P	CARRIAGE PAVEMENT	24 FEET
CY-P	CYCLE TRACK PAVEMENT	10 "
T	TURFING	58 "



NO. 124

E	15
B	38
CA-P	68
CY-P	-
T	13

SCALE

20 FEET = ONE INCH

0 20 FEET

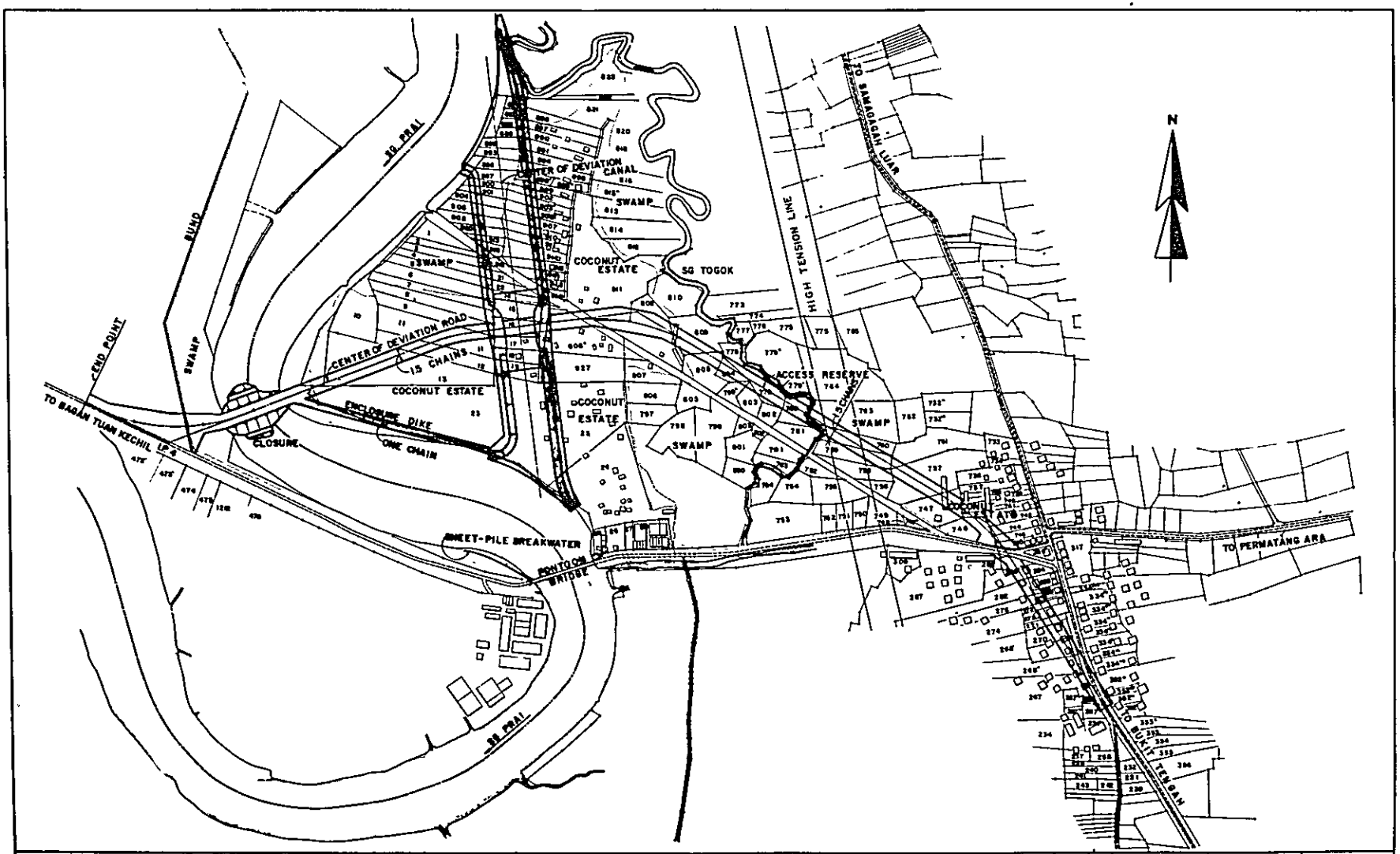
ITEM	AMENDMENTS	INITIAL	DATE

56. PRAI DRAINAGE AND RECLAMATION PROJECT

CROSS SECTION OF DEVIATION ROAD. (SHEET 3)
(PLAN B)

	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION	ASST DIRECTOR DRAINAGE & IRRIGATION	S D I D DRAINAGE & IRRIGATION
CONTRACT PLAN BB 8-43		



SCALE	ITEM	AMENDMENTS	INITIAL	DATE
4 CHAINS = ONE INCH				

SG PRAI DRAINAGE AND RECLAMATION PROJECT

LAND ACQUISITION AND COMPENSATION PLAN
PLAN B1

	INITIAL	DATE
DESIGNED BY		
DRAWN BY		
CHECKED BY		
TRACED BY		
CHECKED BY		

DIRECTOR DRAINAGE & IRRIGATION	ASST DIRECTOR DRAINAGE & IRRIGATION	D.D.I.D DRAINAGE & IRRIGATION
CONTRACT PLAN NO. 8-14		

MALAYSIA

PRELIMINARY REPORT
ON
INDUSTRIAL WATER SUPPLY
OF SG. PRAI BASIN

SEPTEMBER 1968

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

PRELIMINARY REPORT
ON
INDUSTRIAL WATER SUPPLY
OF SG. PRAI

CONTENTS

I. Introduction

1. The Government of Malaysia is vigorously promoting the industrial development of Sg. Prai basin in Penang State as one of the important policies under her "First Five Year Plan".

2. Accordingly, the proportions of the Prai and Mak Mandin industrial areas in Sg. Prai basin are rapidly expanding. However, the cost of production is being adversely affected by the fact that the supply capacity of the existing water works have reached its limit and that the price of water now being supplied is relatively high. Therefore, a new source of supply of industrial water is urgently needed.

3. The Sg. Prai Basin Industrial Water Supply Project is intended to secure the source of water by facilities to be used in common with the Sg. Prai Basin drainage and Reclamation Project. Since it will become the key to the industrial development in Penang, it is gradually drawing public attention.

4. With regard to the Sg. Prai Basin Drainage and Reclamation Project, a feasibility report was submitted in March 1968 by way of technical cooperation of the Government of Japan, and a plan of execution and in succession preparations for work are making progress.

The preliminary survey of industrial water was concurrintly made by the Japanese survey team for the Sg. Prai Basin Drainage and Reclamation Project at the request of E.P.U. of Malaysia.

II. Summary of the Industrial Water Supply Project

5. The source of industrial water is desalinized water impounded by the barrage to be erected at Pmtg Pau on Sg. Prai.

6. Industrial water is mainly used for a refrigerating purpose. The areas to be supplied are the Mak Mandin industrial area on the right bank of the barrage and Prai industrial area on the bank of the estuary of the Sg. Prai, and the daily supply will be 6,000,000 gallons (1,000,000 gallons for the Mak Mandin area and 5,000,000 gallons for the Prai area).

7. An intake of water will be built on the left bank of Kg. Sama Gagah upstream of the barrage, and water will be conducted by a pipe line.

8. Source water will be purified by chemical treatment. A filtration plant will be built near Pmtg. Pauh,where the condition will branch out to the two areas.

9. The topography from the intake to the supply area is a flat lowland less than R.L. + 5.0 feet high. Since gravity feed in not possible, pumps must be used.

10. For the conduits from the intake to the filtration plant and from the intake to the Prai area, the Electric High Tension Reserve Area will be utilized. The main canal of the Mak Mandin industrial area will start from the filtration plant and go past the barrage and the deviation road.

III. Existing Conditions

a) Industry

11. The Prai industrial area is situated on the left bank of the estuary of the Sg. Prai and faces Penang Island. Plants are mostly those of heavy industry, and the new establishment or extension of iron and steel, ashipbuilding, automotive, and sugar refining plants are taking place. All industries are operating briskly, and the area has great potentialities of future development.

12. The Mak Mandin industrial area is situated on the right bank of the Pontoon Bridge. A new industrial areas of 300 acres has been created, and thirty-two light industry lots have been allotted. Factories are under construction, and some of them are already operating.

13. Industrial water of these areas in taken from the water works of Butter-worth. But the limit of the supply capacity has already been reached, and the increase of water is no longer possible, and the price of water, M$1.0 per 1,000 gallons, is high. These factors are adversely affecting the costs of products. Accordingly, the volume of water urgently needed in

this area is 1,700,000 gallons/day and it will increase to 6,000,000 gallons/day in five years.

b) Consideration of Water Resources

14. In order to secure the source of industrail water by the construction of the barrage, a study must be made as to whether the following matters are satisfactionly settled:

1) Whether it is possible to collect the planned intake of water in case of droughty water discharge of Sg. Prai;
2) Quality of water of Sg. Prai;
3) Infiltration of salinity to impounded water

15. The main river is affected by tidal action and its effects are found clearly from the river mouth up to the confluence of the tributary, Sg. Dua. They disappear upstream around the three tributaries, Sg. Kulim, Jarak, and Kereh. The data on the discharge of the main river contain the tidal flow, and it is difficult to estimate the discharge flow of the river itself.

Fig.-2. Topographic Condition of Sg. Prai

16. Therefore, the discharge flow of the main river may be estimated by data on the discharges of the three upstream tributaries.

The data on discharge collected at the Arakuda Gauging Station are assumed to be indicative of the discharge in the Sg. Prai basin. Therefore, the minimum discharge at Arakuda is considered to be the droughty discharge of the basin, and the specific droughty discharge is calculated.

Reference:

Fig.-3. Locations of Hydrologic Gauging Stations.
Fig.-4. Runoff regime at Arakuda Gauging Station

17. If the whole discharge at the head works of the three upstream tributaries (Sg. Kulim, Jarak, and Kereh) were to be taken in during the paddy irrigation period, it would cause droughty conditions downstream. In this case, there would still remain an area of 11.5 square miles in Sg. Prai basin from the points of head works to the barrage.

The droughty discharge of this remaining area of the river basin is estimated at 15.5 cusec on the basis of the specific discharge and will able to meet fully the designed requirement of 11.6 cusec. of water.

18. Furthermore, percolating water in paddy fields flows will return to the Sg. Prai via the low-lying flat land.

Suppose percolation takes place at the rate of 1/6 in/day against 1 in/day of water requirement in 5,400 acres of paddy fields with improved drainage, 34.6 cusec of water will be flowing out, and sufficient water can be secured.

19. If the droughty condition of the Sg. Prai is anticipated, it is concevable to discharge water collected from the Muda river through the facilities of the Muda project in Sg. Prai and utilize it for industrial water.

Fig.-5. Existing systems of drainage and irrigation

c) Water Quality

20. The Sg. Prai is affected by tidal action; therefore water quality should be assumed on the basis of the quality of water of the upstream tributaries.

In this preliminarly investigation, the data on water quality was not available. Generally speaking, turbidity is high, and water cannot be immediately utilized, unless it is purified by chemical treatment. The water temperature is about 80°F. according to records.

Fig.-6. Analysis for NaCl content in river channel.

21. The barrage is equipped with the double stage roller gates, and the intrusion of seawater is constantly prevented by the lower stage roller gates.

The method of intake is surface collection, and the location of the intake should be upstream of the barrage at a suitable distance to prevent of the collection of salt water.

The impounded water level should be maintained at R.L.+2.00 ft. The percolation of seawater through the closure bund is negligible.

IV. Design

a) The Basic plan for Industrial Water

22. The scheduled abailable water supply per day and the purpose of the use of industrial water have been instructed by the Government of Malaysia.

Supply Areas	Scheduled available water supply per day	Purpose
Prai Area	5,000,000 gallons	refrigeration
Mak Mandin Area	1,000,000 -"-	
Total	6,000,000 gallons	

23. The industrial water works will cover from the intake, conduits, filtration plant, water distribution reservoir, and the main water distribution channels leading to each area. It will be distributed to factories at 7.1 lb/sq. in of terminal water pressure.

24. Water quality should be kept below the ASTM limits

Purpose	Turbidity	Gross solidity $CaCO_3$	Fe	Mn	Fe + Mn
	PPM	PPM	PPM	PPM	PPM
Refrigeration	50	50	0.5	0.5	0.5

b) Selection of Intake Site and Pipe Line Route

25. The site for the intake should be selected on the upstream side of the barrage. General conditions required for the intake site are as follows:

1) Little variation in the river channel and the river bed;
2) Construction of the intake should be easy and inexpensive.
3) The distance of feeding to the water purification plant and the supply areas
4) The topographical conditions should be favorable hydrographically.

In this plan, water should be collected as far upstream as possible to avoid the accidental intrusion of salt water from the barrage.

26. As a possible site of the intake, three places shown in Fig. 1 will be examined.

Site A is located very near to the barrage. The length of the distribution pipe is 3.6 miles, which is the shortest. However this site cannot be adopted, because of the danger of the intrusion of salt water.

27. Site B is located on the right bank of Kg. Bagan Lagan near to the Mak Mandin area. The Sg. Prai area is reached by way of the barrage and the deviation road, and the pipeline will extend 5 miles.

28. Site C is situated at Kg. Sama Gagah. The distribution pipe will be laid by utilizing the public-owned Electric High Tention Reserve Area. The Mak Mandin area will be served by establishing the proposed water purification plant at Pmtg. Pauh and feeding water through a branch conduit along the deviation road.

Site C compares with Site B as follows:

1) The total length of the distribution pipe is almost the same as Site B;
2) Land for channels is secured, and only the purchase of land for the water purification plant is needed;
3) The intake site is more suitable;
4) The excavated soil from the deviation canal can be utilized for the construction of the water purification plant.

c) The Design of Industrial Waterworks

29. Intake and Conduit Facilities

Industrial water will be taken in by pumping and driven into the treatment plant through a main duct.

Pumping Station

Building: Reinforced concrete, The floor space is 400 square feet.
Pump: 2 centrifugal pumps (one spare pump)
Size: Inside diameter 16 inch; Discharge; 4,600 gal/minut
Head: 36 feet
Capacity of motor: 50 KW

Main Duct

Steel pipe:
Size: Inside diameter 24 inches
Velocity of flow: 3.3 feet/second
Total length: 2,140 yards

30. Treatment plant, filtration pump, and supply main

The treatment plant will be constructed in Pmtg. Pauh, and will include a flash mixer, chemical dosing equipment, flocculator, horizontal sedimentation basin, PH controller, and control building, and power distribution equipment. A reservoir and supply pipes will be constructed at the

same time, and the Prai and Mak Mandin industrial areas will be supply with water respectively by a separate pump and supply line.

Treatment Plant

Flash mixer			1 basin
Structure	° reinforced concrete	12 x 12 x 10 feet	
	° Retention time	2 minutes	
	° Flash mixer		1
Flocculator pool			
	° reinforced	46 x 41 x 9 feet	
	° Retention time	40 minutes	
	° Capacity	175,000 gal/one basin	
	° Flocculator	double-gear	
Chemical dosing equipment			1
	including PH controller		
Sedimentation basin			2 basins
	° reinforced concrete	$46^{feet} \times 234^{feet} \times 11.5^{feet}$	2
	° Retention time:	4 hours	
	° Capacity:	1,000,000 gal/basin	
	° Desludge equipment		1
Control Building			
	° reinforced concrete two stories	floor space 12 x 30 feet	1
	° Test equipment		1
	° Control meter		1
	° Accessory equipment		1
Supply pump and supply main pipe			
Reservoir			1 basin
	° reinforced concrete	$46^{feet} \times 234^{feet} \times 9.0^{feet}$	
	° Retention time:	4 hours	
	° Capacity:	1,000,000 gal	
Supply pump:			
	centrifugal pump	for Prai area	2
	° Diameter:	14'	
	° Discharge:	3,500 gallon/m	
	° Total head:	46 feet	
	° Motor:	45 kw	

Centrifugal pump	for Mak Mandin area	2
° Diameter:	7"	
° Discharge:	688 gallon/m	
° Total head:	66 feet	
° Motor:	9 kw	

Supply main pipe

(for Prai main) Steel pipe (24" Dia)

- ° Total length 5,000 yards
- ° Aqueduct bridge
- ° National road, railway culvert

(for Mak Mandin main)

- ° Steel pipe (12" Dia)
- ° Total length 1,900 yards
- ° Aqueduct bridge

Construction Cost

Intake	
Pumping station	125,000
Driving pipe line	275,000
Sub total	400,000
Treatment Plant	1,440,000
Supply main	720,000
Land aquisition	10,000
Reserve	280,000
Total	2,850,000

Meintenance and operation cost per day

Personnel expenditure	100 M$
Chemicals	240
Power rates	85
Miscellaneous expenditures	75
Repair cost	235
	735 M$ (per 6,000,000 gallon)
Water rates	M$ 0.1225/1,000 gallon

V. Proposal

31. Since the data on water quality are scarce, investigation into water quality, which is the basis of planning, should be carried out in full detail.

32. Investigation of the character of soil at the foundation of the main structures and survey of the routes have carried out only in a general way, and should be conducted in more detail in the stage of planning for execution.

33. A study for the definite plan for execution should be quickly started, in order that the industrial water works may be carried out in parallel with the Sg. Prai Project.

34. Sg. Prai industrial water supply project will assure the most advantageous supply of industrial water, because it will be available at a price of 0.5 M$/1000 gallons.

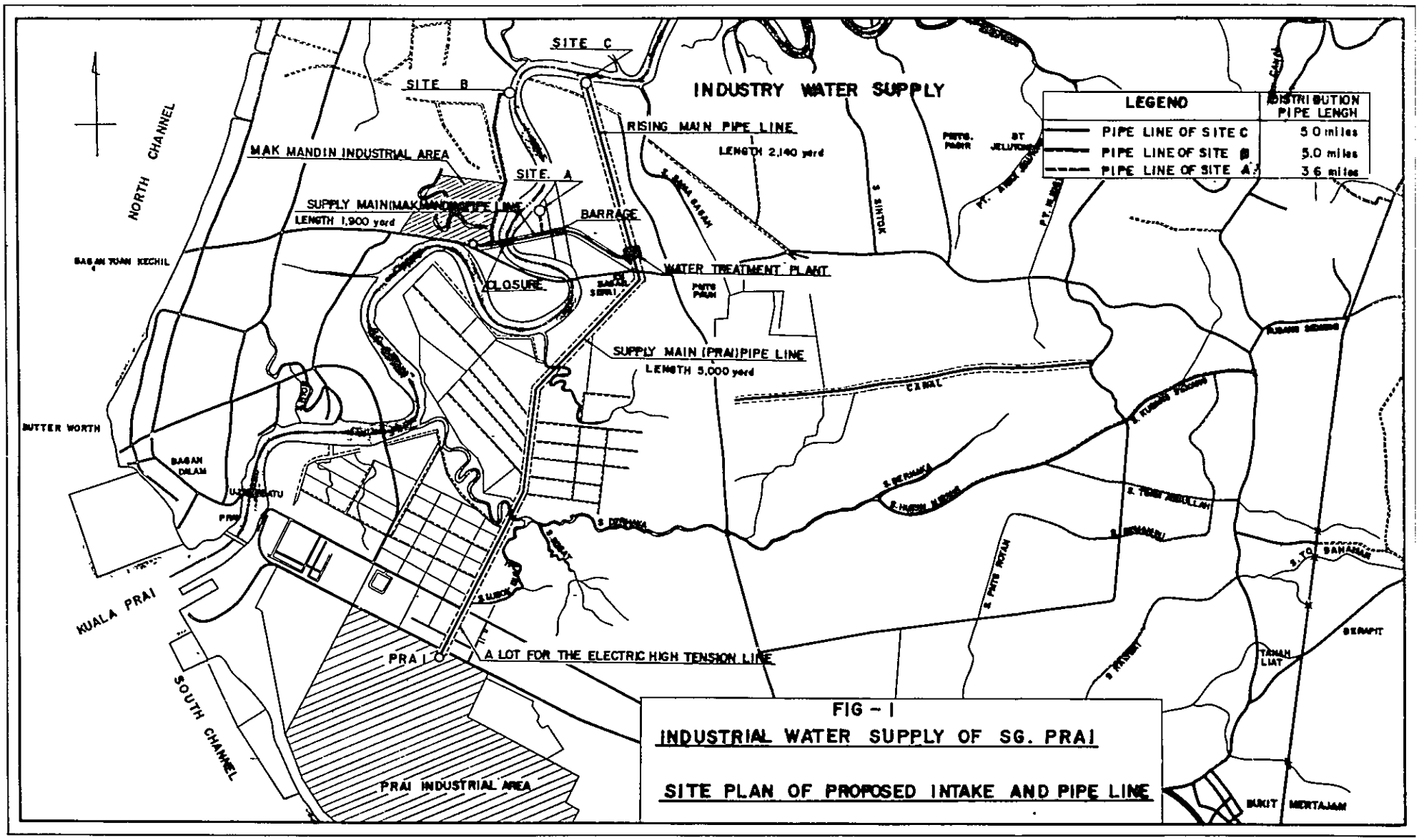
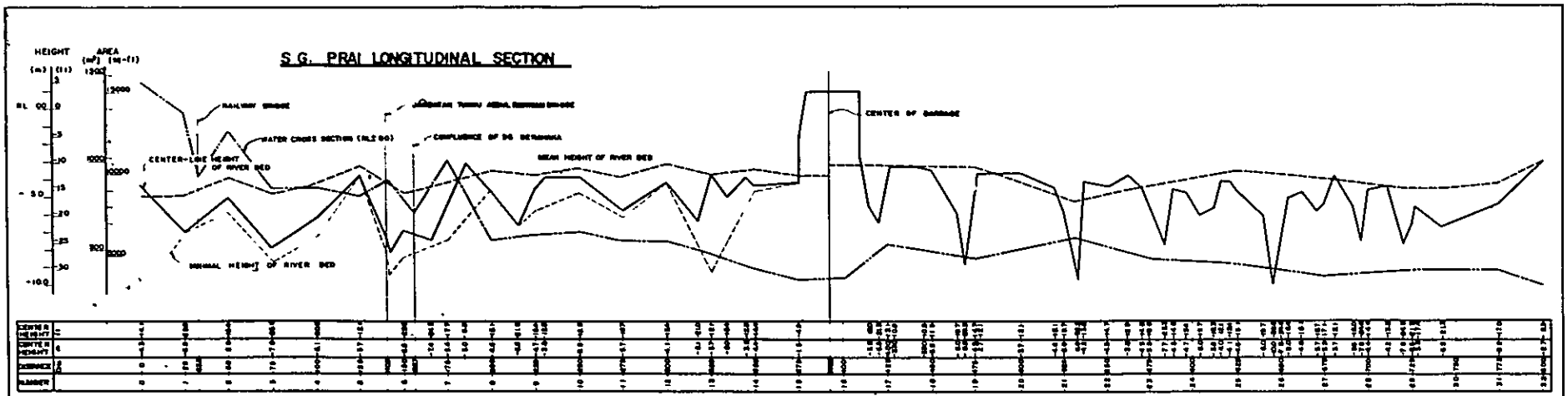


FIG - 1

INDUSTRIAL WATER SUPPLY OF SG. PRAI

SITE PLAN OF PROPOSED INTAKE AND PIPE LINE



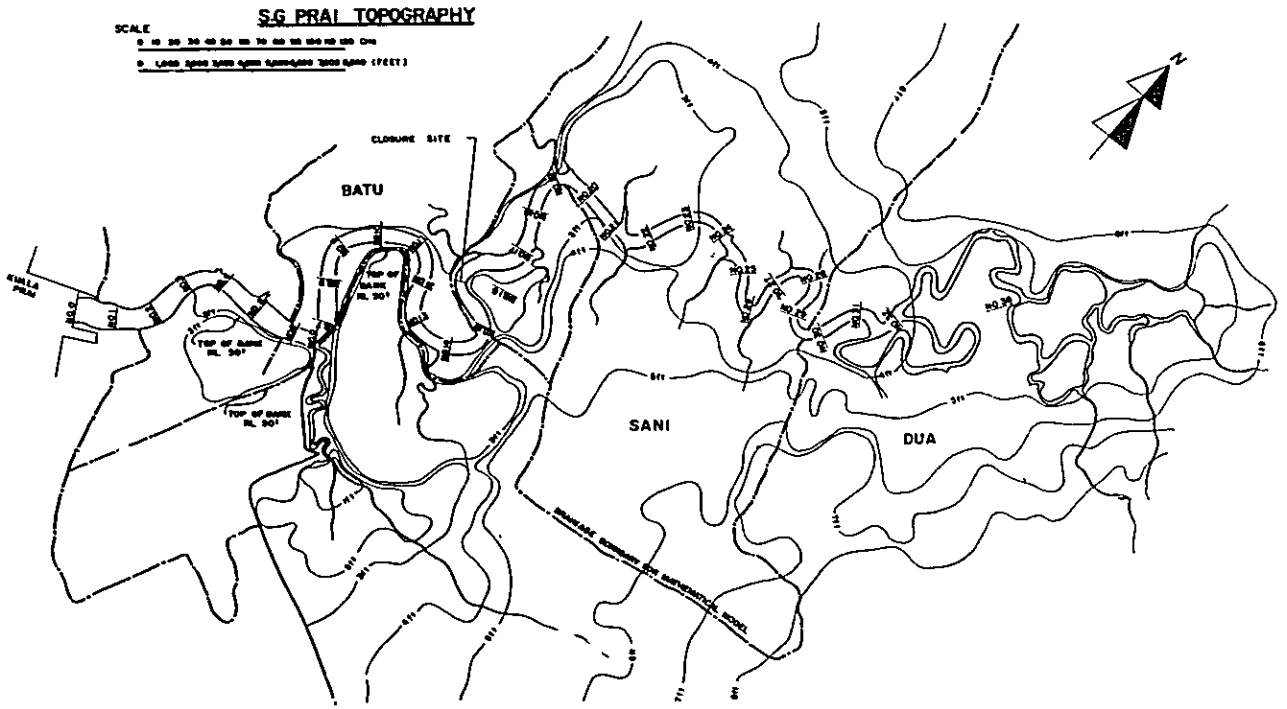
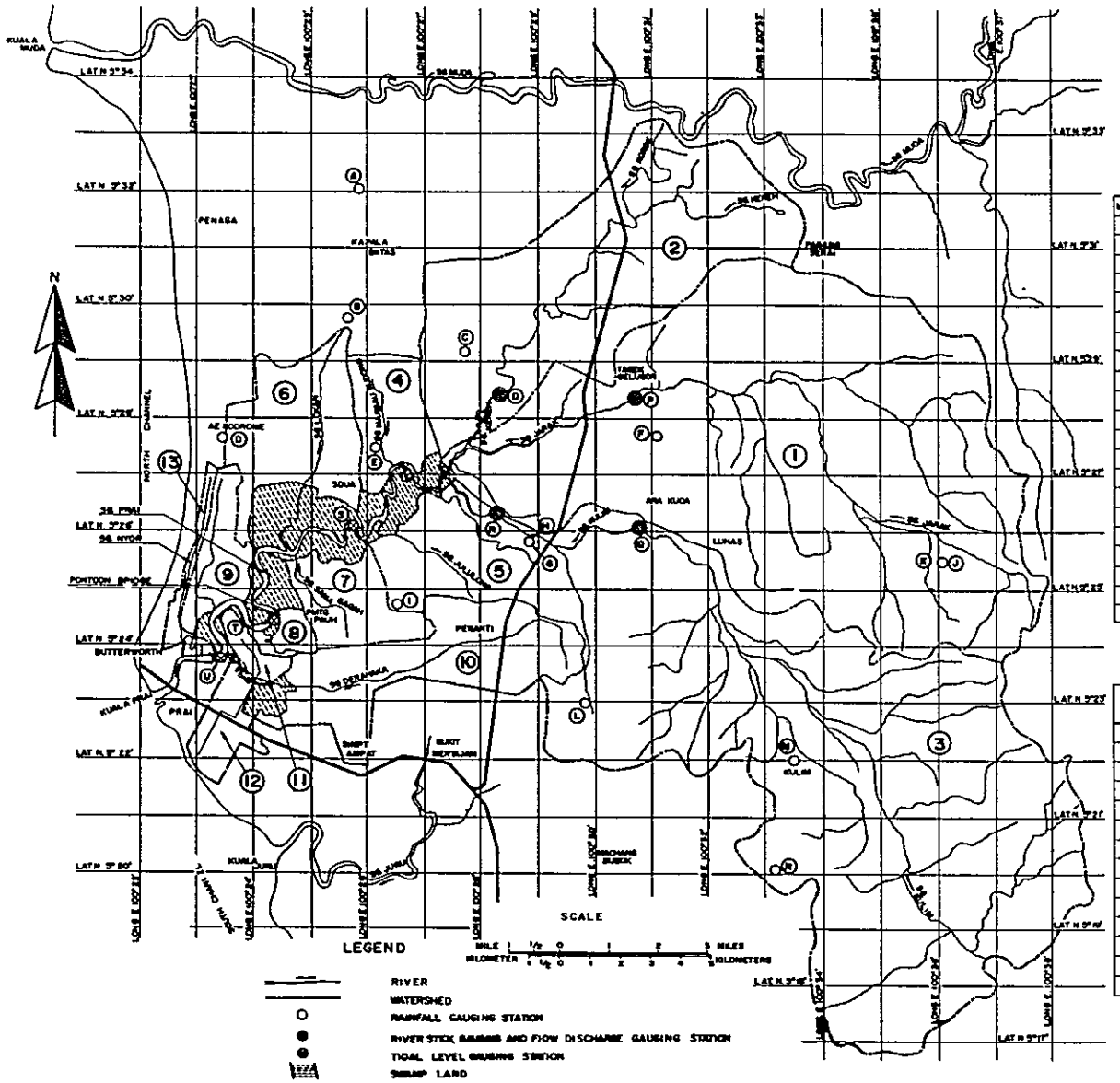


FIG. 2 TOPOGRAPHIC CONDITIONS OF SG. PRAI



HYDROLOGIC OBSERVATIONS

MARK	GAUGING STATION	ITEM	RECORD	REMARKS
A	LAHAR IKAN MATI	RAINFALL	FROM 1960	AUTOMATIC TYPE
B	PARIT LAGAN	RAINFALL	FROM 1958	
C	MALAKOFF ESTATE	RAINFALL	FROM 1958	
D	METEOLOGICAL STATION,BUTTERWORTH	RAINFALL	FROM 1955	
E	SG DUA	RAINFALL	FROM 1946	
F	MAYFIELD ESTATE	RAINFALL	FROM 1947	
G	SG KULIM HEADWORKS	RAINFALL	FROM 1946	
H	SG KULIM HEADWORKS	RAINFALL	FROM 1967	AUTOMAIC TYPE
I	BUKIT MERAH PADI STATION	RAINFALL	FROM 1946	
J	BUKIT MERTAJAM ESTATE	RAINFALL	FROM 1958	
K	BUKIT MERTAJAM ESTATE	RAINFALL	FROM 1967	AUTOMATIC TYPE
L	BUKIT BERAPIT RESERVOIR	RAINFALL	FROM 1932	
M	P W D OFFICE KULIM	RAINFALL	FROM 1957	
N	BUKIT BESAR RESERVOIR	RAINFALL	FROM 1948	
O	SG. KEREH HEADWORKS	WATER LEVEL	FROM 1967	
P	SG. JARAK AT TASEK GELUGOR	WATER LEVEL	FROM 1967	
Q	SG KULIM AT ARA KUDA	WATER LEVEL	FROM 1961	
R	SG KULIM AT GUA PEROHU	WATER LEVEL	FROM 1967	
S	SG. PRAI AT PERMATANG PASIR	WATER LEVEL	FROM 1967	TIDAL RIVER
T	SG. PRAI AT PERMATANG PAUH	WATER LEVEL	FROM 1967	TIDAL RIVER
U	SG PRAI AT NEW BRIDGE	WATER LEVEL	FROM 1967	TIDAL RIVER

SUMMARY OF SG.PRAI BASIN

NO	DESIGNATION	CATCHMENT AREA		ACCUMULATED CATCHMENT AREA		LENGTH OF RIVER CHANNEL IN EACH BASIN	
		IN SQ MI	IN SQ KM	IN SQ MI	IN SQ KM	IN MI	IN KM
1	JARAK	57 53	149 01	57 53	149 01	15 70	25 26
2	KEREH	23 39	60 58	80 92	209 59	10 27	16 52
3	KULIM	67 50	174 82	148 42	384 41	17 96	28 82
4	DUA (R)	5 09	13 17	153 51	397 58	1 76	2 83
5	DUA (L)	4 87	12 61	158 38	410 19	2 15	3 46
6	SANI (R)	7 02	18 19	165 40	428 38	2 90	4 66
7	SANI (L)	3 57	9 25	168 97	437 63	1 95	3 14
8	BATS (L)	0 84	2 17	169 81	439 80	1 17	1 89
9	BATS (R)	2 54	6 58	172 35	446 38	2 86	4 60
10	DERHAKA(1)	10 98	28 45	—	—	6 85	11 03
11	DERHAKA(2)	0 87	2 26	—	—	0 94	1 52
12	DERHAKA(3)	1 93	4 99	186 13	482 08	1 76	2 85
13	NYOR	1 16	3 04	187 31	485 12	4 24	6 83
	SWAMP LAND	4 78	12 38	192 09	497 50	—	—

FIG. 3 LOCATION MAP OF HYDROLOGIC GAUGING STATIONS

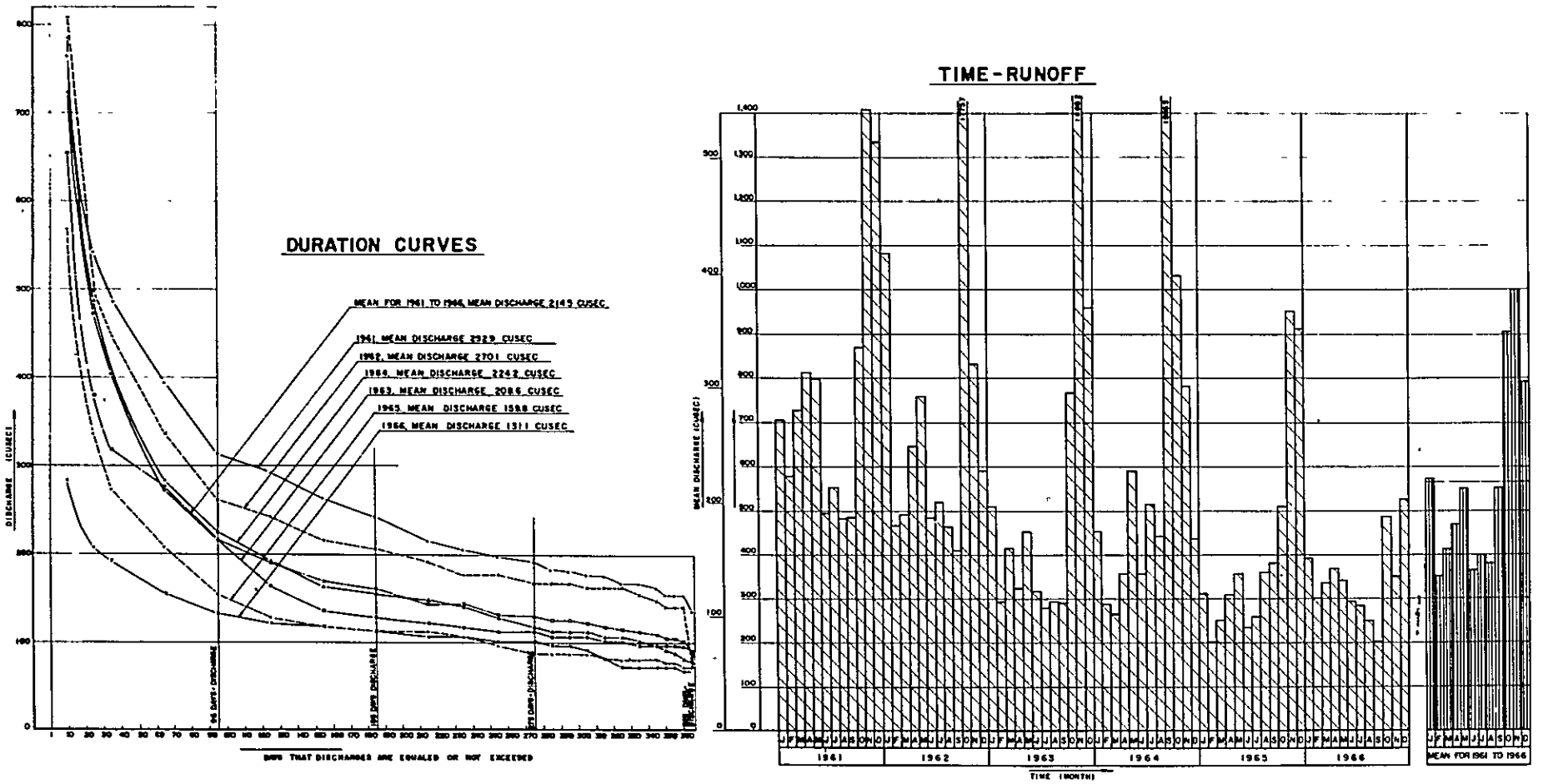


FIG. 4 PUNOFF REGIME AT ARAKUDA GAUGING STATION

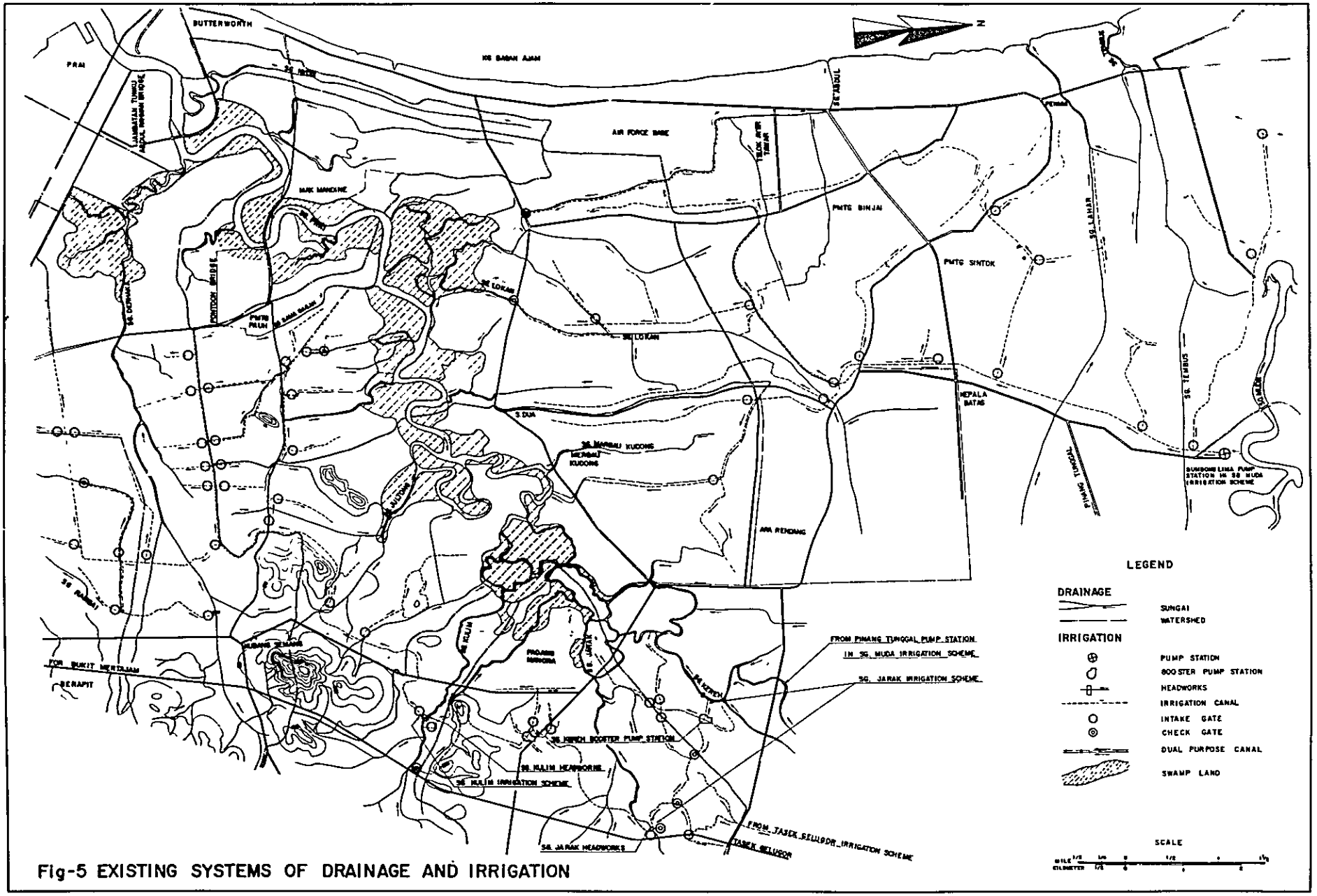
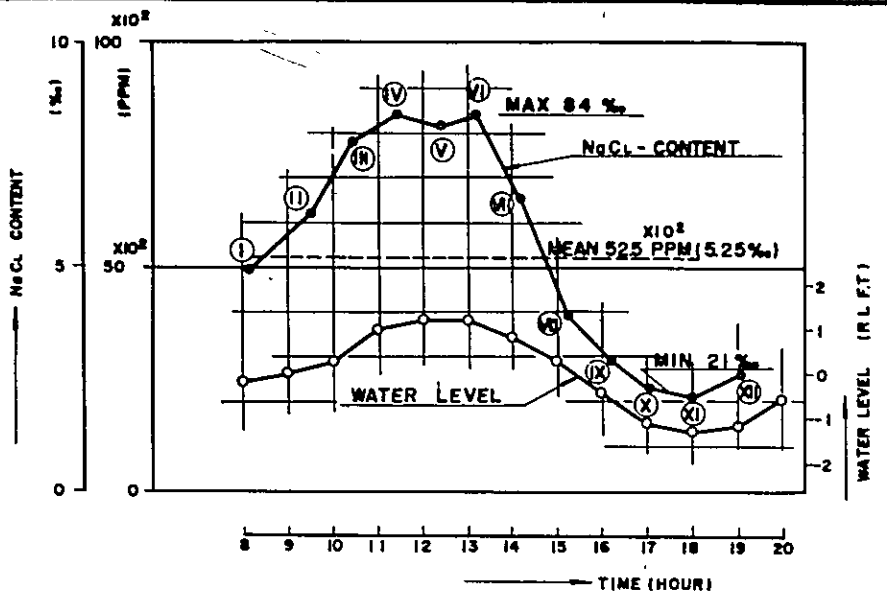
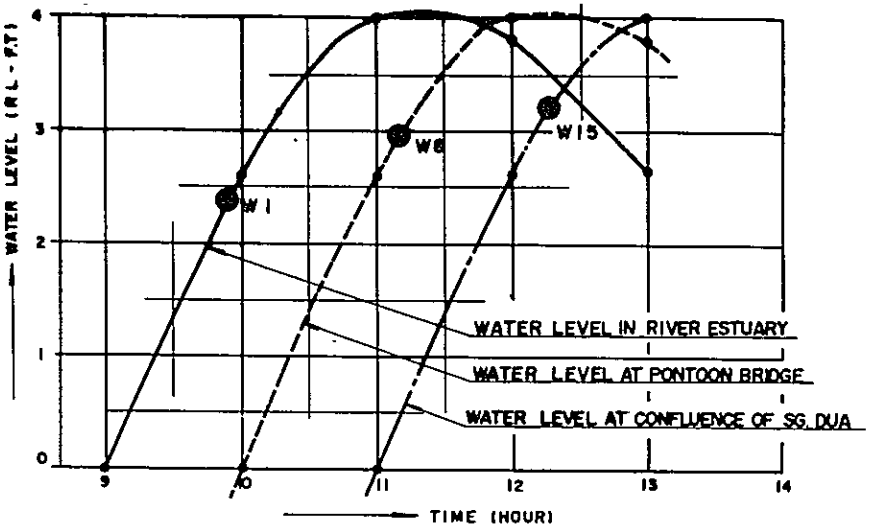


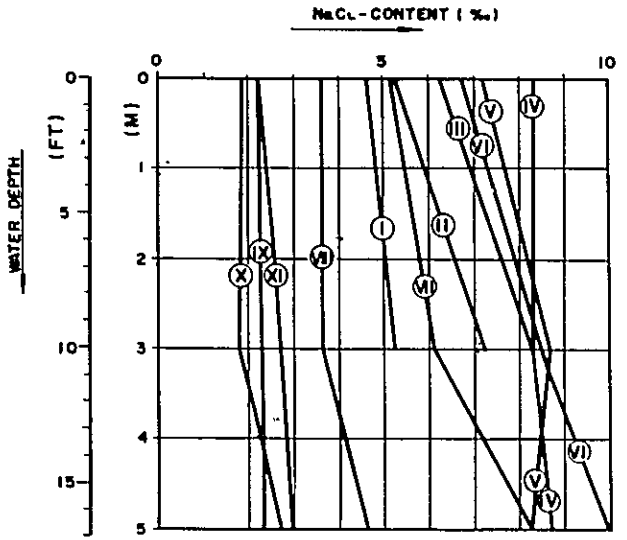
Fig-5 EXISTING SYSTEMS OF DRAINAGE AND IRRIGATION



(1) RELATION BETWEEN NaCl - CONTENT AND TIDAL WATER LEVEL



(3) RELATION AMONG SAMPLING POINTS, SAMPLING TIME AND WATER LEVELS (18TH. OCT. 1967)



(2) VERTICAL DISTRIBUTION OF NaCl - CONTENT AT PONTOON BRIDGE
(NO. REFER TO (1))

FIG. 6 ANALYSIS FOR NaCl CONTENT IN RIVER CHANNEL