THE KINGDOM OF THAILAND

# FEASIBILITY REPORT ON IRRIGATED AGRICULTURAL DEVELOPMENT PROJECT IN THE WEST BANK TRACT OF THE GREATER CHAO PHYA

(APPENDIX)

MAY 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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# LIST OF TABLES

# LIST OF FIGURES

Table A. 1-1 Personnel Concerns the Mission Contacted

| | |
|---|---|
| Dr. Thalerng Thamlong Nawasawat | Deputy Undersecretary of MOAC |
| Dr. Chaiyong Chuchart | Secretary General of ALRO |
| Mr. Xujati Pramoolpol | Director General of Department of Technical and Economic Cooperation |
| Mr. Chamlong Attanatho | Inspector General, MOAC |
| Mr. Charin Atthayodhin | Deputy Director General, RID |
| Mr. Chern Banrungwong | Deputy Director General, Department of Cooperative Promotion, MOAC |
| Mr. John Boonlu | Director of COLC |
| Mr. Kangwang Dhephasadin Na Ayutthaya | Deputy Secretary General, ALRO |
| Mr. Paitoon Palayasoot | Deputy Director of COLC |
| Dr. Suthiporn Chirapanda | Chief of Division of Research & Planning, ALRO |
| Mr. Leck Jindasangwan | Head of Water Operation Center, RID |
| Mr. Pitipong Pungbun Na Ayutthaya | Chief of Operation Division, ALRO |
| Mr. Suraphol Phetlom | Chief of Extension Land Reform Office, Ayutthaya |
| Mr. Chutchawal Swatdirurk | Assistant Chief of Water Operation & Maintenance Section, RID |
| Mr. Chalermthep Ratanaprayooh | Project Coordinator, Secretary of Deputy D.G., RID |
| Mr. Prasart Milintrangul | Head of Research & Applied Hydrology Section, Hydrology Division, RID |
| Mr. Damrong Jaratwat | Chief of Division of Hydrology, RID |
| Mr. Danai Triyadhen | Chief of Land Classification Section, RID |
| Mr. Pradit Ritrungdej | Agronomist of Division of O/M, RID |
| Mr. Maitri Poolsup | Civil Engineer at Design Section, RID |
| Mr. Annokul Saravisuta | Project Manager of Sappaya Land Consolidation Project, RID |

| | |
|---|---|
| Mr. Poonsin Lekmanee | Project Engineer of Chao Phya Irrigation Development Project, RID |
| Mr. Laiad Sainamkeon | Staff of Chanasut Land Consolidation Project, RID |
| Mr. Sutin Mulphruk | Engineer of Operation Division, ALRO |
| Mr. Witchitr Warakitpanich | Project Manager of Bangbarn Pumping Irrigation Project, RID |
| Mr. Phrnchai Arworn | Project Manager of Chao-Chet Bangyeehon Project, RID |
| Mr. Tirasakdi Packdijitt | Agricultural Officer in Chao-Chet Project, RID |
| Mr. Anurat Ratanakwan | Project Manager of Bhak Hai Irrigation Project, RID |
| Mr. Pornsak Choloipock | Staff of Bhak Hai Irrigation Office, RID |
| Mr. Prakit Oon Vimol | Regional Engineer of Region 7, RID |
| Mr. Suporn Pornprapunth | Chief of O/M of Phraya Banlu Project, RID |
| Mr. Suphon Chirapuntu | Soil and Civil Engineer, Geotechnical Division, RID |
| Mr. Kamol Toleb | Staff of Operation Division, ALRO |
| Mr. Surathep Kowangoon | Staff of Operation Division, ALRO |
| Mr. Sunthorn Tanthavorn | Chief of Project and Planning Division, Provincial Electricity Authority (PEA) |
| Mr. Pracherd Sook Kaew | Chief of Project Area No.3 Section, PEA |
| Mr. Y. Yamada | Electric Expert of PEA, under Colombo Plan, JICA |
| Mr. Damrongsak Tasanasanta | Staff of Agricultural Land Reform Office |
| Mr. Peerasak Booranasophon | Planning Division, Dep't of Cooperative Promotion, MOAC |
| r. T. Hidaka | Entomologist of Tropical Agriculture Research Center, Japan |
| Mr. Sadao Hatta | Project Leader, Tropical Agriculture Research Center, Japan |

| | |
|---|---|
| Mr. Kohn Chuvanond | Chief of Marketing Section, Agricultural Cooperative Division, MOAC |
| Mr. Surin Chulpraser | Director General of Dep't of Cooperative Promotion, MOAC |
| Mr. Hiroshi Takagi | Technical Advisor of BAAC |
| Mr. Oosot Chanlej | Agronomist of Agricultural Division, RID |
| Mr. Prayong Prayunhong | Chief of Ayuthaya Provincial Agricultural Extension Office |
| Mr. Vibul Malisen | Provincial Agricultural Extension Officer, Amphoe Lad Bao Laung |
| Mr. Pirot Vivasanan | Provincial Agricultural Extension Officer, Amphoe Lad Bao Laung |
| Mr. Srony Taso | Provincial Statistical Officer |
| Mr. Piroat Nivanont | Staff of Amphoe Lad Bao Laung Office, Cooperative |
| Mr. Sunthorn Naka | Staff of Experimental Station Hantra |
| Mr. Boonlert Klajprayong | Staff of Suphan Buri Rice Experimental Station |
| Mr. Vichien Sasiprapa | Staff of Suphan Buri Rice Experimental Station |
| Dr. Hitoshi Takahashi | Agronomist, Tropical Agriculture Research Centre, Japan |
| Mr. Thawal Polpuech | Chief of Projects, Colombo Plan Programme, DTEC |
| Mr. Sutin Sulila | Staff, Colombo Plan Programme, DTEC |
| Mr. Takanori Igarashi | Soil Scientist, Tropical Agriculture Research Center, Japan |
| Mr. Kunio Hamamura | Rice Breeder, Tropical Agriculture Research Center, Japan |
| Mr. Ektrika Kohkongha | Deputy Director General, National Statistical Office |
| Dr. Thiravira Subhanoi | Staff of Agricultural Land Reform Implementation Division, ALRO |

| | |
|---|---|
| Dr. Gisuke Takahashi | Colombo Plan Expert on Soil Fertility, Dep't of Agriculture, MOAC |
| Mr. Fumio Kobayashi | Irrigated Agriculture Specialist, Mekong Committee, ESPAP |
| Mr. Vichak Monsri | Chief Geotechnical Engineer, Krungthep Engineering Consultants, Co., Ltd. |
| Mr. Tanom Kladkaew | Managing Director, Krungthep Engineering Consultants, Co., Ltd. |
| Mr. Kitti Phanick | Deputy Manager, Federation of Agricultural Cooperatives |
| Mr. Koichi Nonaka | Project Manager of Regional Development Studies Project, JICA |
| Miss. Supha Sing Inn | Chief of Statistic Section, Planning Division, RID |
| Mr. Somphol Pithiyakul | Chief of Farm Products Division, Agricultural Co-operatives Federation |
| Mr. Prom Totieng | Chief of Legal Division, ALRO |
| Mr. Wera Ubolelket | Legal Division, ALRO |
| Mr. Tasanapong Ettakkapark | Division of Research and Planning LARO |
| Mr. Hideo Kanamori | Secretary General, Japanese Chamber of Commerce, Bangkok |
| Mr. Isami Itoh | Unicoop Japan, Bangkok Branch |
| Mrs. Nongnuch Rochanavedya | Chief of Analysis and Control Data Unit, Statistical Technique Division, National Statistics Office |
| Mr. Udom Kasetravetin | Chief of Design Section, Village Water Supply Division, Department of Health |
| Mr. Krairirik Chaliengratchai | Acting Chief of Land Reform Coordination and Farm Development, Land Reform Division, ALRO |
| Mr. Arli Kuldilokchai | Operation Division, ALRO |
| Mr. Amnuey Somsin | Hydrologist, O/M Division, RID |
| Mr. Songpol Suvannadabbe | Land Reform Division, ALRO |

Table A. 1-2 Data List used for Feasibility Study

A. Hydrology

Water Level and Discharge

1. Thailand Hydrological Year Book, Volume 5-9, Royal Irrigation Department (RID)

2. Daily Water Level in Chao Phya river at Sing Ha Nat Apr. 1967 - Oct. 1976, Chao-chet Bangyeehon Project Office, RID

3. Daily water level in Suphan river at Phraya Banlu, Apr. 1966 - Oct. 1976, Phraya Banlu Project Office, RID

4. Daily water level in Pasak river, at A. Muang, Ayutthaya, Apr. 1950 - Mar. 1972

5. Daily Water level in Chao Phya river at Wat Chulamani A. Bangbar Ayutthaya, Jun. 1950 - Oct. 1976, Bangbar Project Office, RID

6. Daily Water level and discharge in Chao Phya river, RID

| | |
|---|---|
| at Nakon Sawan | Apr. 1967 - Mar. 1976 |
| at Chai Nat | Apr. 1967 - Mar. 1976 |
| at Wat Chulamani | Apr. 1967 - Mar. 1976 |
| at In Buri | Apr. 1967 - Mar. 1969 |

7. Daily intake discharge of Water and Water level at Pakai Chao-chet, Bang Puraman, Bangyeehon and Lat Chadoo, Oct. 1972 - Oct. 1976, RID

8. Daily water level at inland canal surrounding Project area

   Phraya Banlu canal at Sing Ha Nat Regulator, Apr. 1967 - Oct. 1976

   Nai Chat canal at Nai Chat Regulator, May 1975 - Oct. 1976 Chao-chet Bangyeehon Project Office, RID

   Phraya Banlu canal at Phraya Banlu Regulator, Apr. 1966 - Oct. 1976

   Phra Udom canal at Khlong Phra-Udom Regulator, Apr. 1971 - Oct. 1976, Phraya Banlu Project Office, RID

Tide

9. Tidal data of Chao Phya estuary

10. Tide table, Vol. 1, Vol. 2, Thai Water 1976, Hydrographic Department, RID

Salt Water Intrusion

11. Salt water intrusion to Chao Phya river in the dry season (Jan. - May) at Samut Prakarn, Smrong, Pra-Kanhong, Krungtep Bridge and Memorial Bridge, 1964 - 1976, RID

Water Quality

12. Enclosed data on water analysis, Greater Chao Phya Project, Jun. - Dec. 1961, RID

13. Water quality test of Suphan Noi river at Sena, Jan. - Oct. 1976, Sena Domestic Water Supply Office

14. Water quality of Bang Bua Thong canal at Bang Bua Thong, Sep. 1975 - Oct. 1976, Bang Bua Thong Domestic Water Supply Office.

Profile and Cross Section

15. Longitudinal profile of Chao Phya river, from Nakon Sawan to Pra Chu Fort, RID

16. Cross section to Phraya Banlu canal, Phraya Banlu Project Office, RID

Meteorology

17. List of rainfall station in Thailand, July 1975, RID

18. Daily and monthly rainfall records

| | |
|---|---|
| at Lop Buri | Apr. 1995 - Dec. 1975 |
| at Suphan Buri | Apr. 1995 - Dec. 1975 |
| at Bang Kapi | Apr. 1995 - Dec. 1975 |
| at Kanchana Buri Meteorological Department & RID | Apr. 1995 - Dec. 1975 |
| at Sing Ha Nat Regulator, Chao-chet Bangyeehon Project Office, RID | Apr. 1952 - Dec. 1976 |
| at Phraya Banlu Regulator, (except 1963) | Apr. 1962 - Oct. 1976 |
| at Lakkhon Regulator Phraya Banlu Project Office, RID | Apr. 1962 - Oct. 1976 |

19. Maximum rainfall of continuous 1 to 3 days in a year and its probability study, at Lop Buri, Suphan Buri, Bang Kapi, and Kanchana Buri, 1952 - 1975, RID

20. Hourly rainfall records at Bangkok, 1952 - 1975, RID

21. Climatological data on temperature, humidity, evaporation, wind, dew point and others, 1951 - 1970 Meteorological Department

22. Monthly sunshine hour duration, Mekong Secretariat Report No. NKG/29, Mekong Committee

23. Monthly solar radiation, Meteorological Department

| | |
|---|---|
| at Bangkok | 1965 - 1975 |
| at Bhumibol Dam | 1973 - 1975 |
| at Chang Mai | 1970 - 1973 |
| at Nakhon Phanom | 1965 - 1967 |
| at Sonkhla | 1963 - 1967 |

24. Meteorological map to Thailand, Meteorological Department
    - Mean annual and monthly rainfall over Thailand
    - Mean annual and monthly temperature over Thailand
    - Mean annual and monthly relative humidity over Thailand

B. Agriculture

Soil

25. Detailed reconnaissance soil map of Southern Central Plain Area, Department of Land Development, 1972

26. Detailed reconnaissance soil survey of Southern Central Plain Area, W. Van Der Kevie and Banchong Yenmanas, 1972

27. Some morphological physical and chemical aspects of acid sulphate soil in Thailand, 1971

Agronomy

28. Brief history of RD series of rice variety developed in Thailand from 1769 to 1975, Rice Division Department of Agriculture, MOAC

29. Statistical data of rice planting for 5 years. (1971 - 1975) in the Project area, Agricultural Extension Office of Amphoe

30. On-farm agricultural imput per rai in the Project area, 1971 - 1975, Agricultural Extension Office of Amphoe

31. Price of agricultural imput in the Project area, 1971 - 1975, Agricultural Extension Office of Amphoe.

32. Farm labour requirements for growing rice in the project area, Agricultural Extension Office of Amphoe

33. Method for Practice of growing rice, Agricultural Extension Office of Amphoe

34. Some important data of each village after surveying in village in Sep. 1975, Ayutthaya Provincial Statistical Office

35. Annual report in 1969, Rice Department, MOAC

36. Statistical data on crop and fruit yield in the Amphoe Lad Bao Laung (1973 - 1976)

37. Crop labour time and motion study of selected crops in Northeast Thailand, prepared by Mr. Angkorn Kamolpatana and Mr. Lewis D. Walker, 1969

C. Irrigation and Drainage

Maps

38. Map showing irrigation projects on the Central Plain of Thailand, 1/400,000, RID

39. Chao Phya Irrigated Agriculture Development Project, Northern Chao Phya area, 1/200,000, RID

40. Irrigation and drainage network on the Central Plain of Thailand, 1/200,000, RID

41. Present land use map of Chao-chet Bangyeehon Project 1/50,000, Chao-chet Bangyeehon Irrigation Office, RID

42. Present land use map of Phraya Banlu Project, 1/50,000 Phraya Banlu Irrigation Office, RID

43. Contour map of West Bank Tract, 1/100,000 Phraya Banlu Irrigation Office

44. Detailed contour map of Phraya Banlu Project, 1/50,000 Phraya Banlu Irrigation Office

45. Lad Bao Laung Project area in Ayutthaya, 1/50,000 Land Reform Operation Division, ALRO

46. Development plan of irrigation and drainage systems in West Bank Tract of Chao Phaya river, 1/200,000, RID

47. Second rice and dry season crop 1976 on the West Bank Tract of Chao Phya river, 1/200,000, RID

48. Administrative map of Amphoe Lad Bau Laung (1/50,000) and Changwat Ayutthaya (1/100,000), Ayutthaya Extension Agricultural Land Reform Office

Reports and Other Data

49. Northeast Thailand Irrigation Improvement Project, Lam Pao Subject Feasibility study, prepared by Tahal Engineering Consultants Inc. 1971.

50. Lam Pra Plerng Irrigation Project, prepared by Engineering Consultants Inc. 1971

51. Northern Chao Phya Study prepared by NEDECO, 1970, RID

52. Observed evapotranspiration of rice at Sam Chook Experimental Farm and Mae-Kuang Water Use Experimental Station, Central Land Consolidation Office.

## D. Land Consolidation

Reports

53. Agriculture Land Reform Act, ALRO

54. Pamphlet No. 8, Training and Research Center for Agriculture Reform Division of Research & Planning, ALRO

55. Chao Phya Irrigated Agriculture Development Project, Stage I, Technical Note, No. 29, Operation and Maintenance at service unit level, Sep. 1976, prepared by ILACO

56. Land Reform Bulletin No. 3, proposal of land reform and development in Thailand, ALRO

57. An Empirical Evidence in Support of Land Reform, Division of Research and Planning, 1976, ALRO

Maps

58. $E_3$ Patial on-farm development alternative 2 of Channasutra Project area, 1/10,000, Central Land Consolidation Office

59. $E_5$ intensive on-farm development with schematic real location plan alternative 4, 5 of Channasutra Project area, 1/100,000, CLCO

60. Pilot area before land consolidation of Channasutra Project area, 1/25,000, CLCO

61. Pilot area after land consolidation of Channasutra Project area, 1/25,000, CLCO

62. Detail layout and construction in pilot area of Sappaya Project area, 1/25,000, CLCO

63. Land consolidation plan of Right Bank ( 1L - 1R) and Left Bank (1R - 2L - 1R) areas in Channasutra Project, CLCO

64. Cadastral map of Project area in Lad Bua Laung, 1/5,000, Ayutthaya Extension Land Reform Office

65. Land consolidation plan in Sappanya Project area, 1/4,000, Sappaya Land Consolidation Office

66. Land consolidation plan in Channasutra Project area, 1/4,000, Channasutra Land Consolidation Office

E. Design and Cost Estimate

67. Drawings of standard facilities, canal, road and pumping station, Design Division, RID

68. Brief description of Bangbar Pumping Irrigation Area, Bangbar Pumping Irrigation Office.

69. Unit cost of labour, materials, RID, ALRO

70. Unit cost of electric facilities and transmission networks in Thailand, Provincial Electric Authority (PEA)

71. Cost of construction equipments, ALRO

72. Geological log of bore hole at Bangbar Pumping Irrigation Project, Bangbar Pumping Irrigation Office

F. Agri-institution

73. Statistic data of rice planting for 1971 - 1975, ayutthaya Extension Land Reform Office

74. Number of land owner and farm size of area in three Tambons, Ayutthaya Extension Land Reform Office.

75. The cooperative societies act. B.E. 2511, Cooperative Promotion Department, MOAC

76. Bank for Agriculture and Agricultural Cooperative Act. B.C. 2509, Bank of Agriculture and Agricultural Cooperative (BAAC)

77. Bank for Agriculture and Agricultural Cooperative Regulation 25, prescribing polices for making agricultural long-tern loans to individual farmers, BAAC

78. The cooperative marketing and purchasing federation of Thailand, Cooperative Marketing and Puschasing Federation (CMPF)

79. The cooperative movement in Thailand, Cooperative Promotion Departmwnt

80. Operation and maintenance review and recommendations for irrigation project in Thailand

G. Economy

81. Statistical Report of Changwat, Phra Nakhon Si Ayutthaya, National Statistical Office, Office of Prime Minister, Thailand

82. Population and Housing Census 1970, Changwat Phra Nakhon Si Ayutthaya, N.S.O., O.P.M., Thailand

83. Economic and Social Situation of Farmers, Crop-Year 1974, Amphoe Lad Bao Luang, Division of Research and Planning, Land Reform Office, 1976

84. Foreign Trade Statistics of Thailand, Dec. 1975 Department of Customs, Bangkok

85. Thailand Year Book 1975 - 1976

86. Land Taxation in Thailand (Pamphlet No. 10, Division of Research and Planning, ALRO, MOAC

87. Agricultural Statistics of Thailand, crop-year 1974/75, Division of Agricultural Economics, MOAC

88. Report of Community Potable Water Project, Department of Health, Ministry of Health

Table A 3-1 Temperature

(Unit: °C)

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Monthly Mean Temperature** | | | | | | | | | | | | | Mean |
| Lop Buri | 26.4 | 28.5 | 30.2 | 31.1 | 30.1 | 29.1 | 28.4 | 28.3 | 72.9 | 27.7 | 26.8 | 25.8 | 28.3 |
| Suphan Buri | 26.1 | 28.5 | 30.5 | 31.8 | 30.7 | 29.9 | 29.2 | 28.9 | 28.4 | 28.0 | 27.0 | 25.6 | 28.7 |
| Bangkok | 25.5 | 27.1 | 28.6 | 29.5 | 29.0 | 28.5 | 28.0 | 27.8 | 27.5 | 27.4 | 26.6 | 25.3 | 27.6 |
| Kanchana Buri | 25.5 | 28.1 | 30.2 | 32.4 | 29.9 | 28.7 | 28.2 | 28.1 | 27.9 | 27.1 | 26.1 | 24.8 | 28.0 |
| Mean (1) | 26.0 | 28.0 | 29.8 | 30.8 | 29.9 | 29.2 | 28.5 | 28.3 | 27.9 | 27.7 | 26.8 | 25.6 | 28.2 |
| Mean (2) | 25.9 | 28.1 | 29.9 | 31.0 | 29.9 | 29.1 | 28.5 | 28.3 | 27.9 | 27.6 | 26.6 | 25.4 | 28.2 |
| **Monthly Extreme Minimum Temperature** | | | | | | | | | | | | | Low |
| Lop Buri | 8.4 | 13.5 | 16.1 | 17.5 | 20.0 | 20.5 | 21.0 | 21.0 | 20.5 | 16.6 | 10.5 | 10.7 | 8.4 |
| Suphan Buri | 9.2 | 12.0 | 14.8 | 19.4 | 20.9 | 20.2 | 21.1 | 20.8 | 20.8 | 19.4 | 14.5 | 10.0 | 9.2 |
| Bangkok | 9.9 | 14.9 | 16.5 | 19.9 | 21.1 | 21.7 | 21.9 | 21.2 | 21.3 | 19.8 | 14.2 | 10.5 | 9.9 |
| Kanchana Buri | 5.5 | 12.1 | 11.2 | 17.2 | 21.5 | 22.0 | 20.8 | 21.5 | 20.8 | 18.0 | 11.6 | 6.8 | 5.5 |
| Mean (1) | 9.2 | 13.5 | 15.8 | 18.9 | 20.7 | 20.8 | 21.3 | 21.0 | 20.9 | 18.6 | 13.1 | 10.4 | 9.2 |
| Mean (2) | 8.3 | 13.1 | 14.7 | 18.5 | 20.9 | 21.1 | 21.2 | 21.1 | 20.9 | 18.5 | 12.7 | 9.5 | 8.3 |
| **Monthly Mean Minimum Temperature** | | | | | | | | | | | | | Mean |
| Lop Buri | 19.0 | 21.9 | 23.8 | 24.8 | 24.8 | 24.3 | 24.0 | 24.1 | 24.0 | 23.5 | 21.4 | 19.2 | 22.8 |
| Suphan Buri | 18.7 | 21.1 | 23.2 | 25.0 | 25.1 | 24.8 | 24.5 | 24.5 | 24.5 | 24.2 | 22.1 | 19.4 | 23.1 |
| Bangkok | 20.4 | 22.7 | 24.5 | 25.6 | 25.3 | 25.0 | 24.8 | 24.6 | 24.4 | 24.3 | 22.9 | 20.6 | 23.7 |
| Kanchana Buri | 17.5 | 20.4 | 22.8 | 24.7 | 24.9 | 24.5 | 24.0 | 24.0 | 23.7 | 23.0 | 20.8 | 17.9 | 22.3 |
| Mean (1) | 19.4 | 21.9 | 23.8 | 25.1 | 25.1 | 24.7 | 24.4 | 24.4 | 24.3 | 24.0 | 22.0 | 19.7 | 23.2 |
| Mean (2) | 18.9 | 21.5 | 23.6 | 25.0 | 25.0 | 24.7 | 24.3 | 24.3 | 24.2 | 23.8 | 21.7 | 19.3 | 23.0 |
| **Monthly Mean Maximum Temperature** | | | | | | | | | | | | | Mean |
| Lop Buri | 32.6 | 34.6 | 36.2 | 37.1 | 35.4 | 33.6 | 32.7 | 32.3 | 31.7 | 31.6 | 31.4 | 31.4 | 33.4 |
| Suphan Buri | 31.9 | 34.2 | 36.2 | 37.4 | 35.5 | 34.3 | 33.3 | 32.9 | 31.8 | 31.2 | 30.6 | 30.4 | 33.2 |
| Bangkok | 31.8 | 32.7 | 33.8 | 34.8 | 34.1 | 32.9 | 32.3 | 32.1 | 31.7 | 31.5 | 31.1 | 31.1 | 32.5 |
| Kanchana Buri | 32.2 | 34.9 | 37.0 | 37.8 | 35.5 | 33.6 | 32.8 | 32.8 | 32.4 | 31.5 | 30.8 | 30.5 | 33.5 |
| Mean (1) | 32.1 | 33.8 | 35.4 | 36.4 | 35.0 | 33.6 | 32.8 | 32.4 | 31.7 | 31.4 | 31.0 | 31.0 | 33.0 |
| Mean (2) | 32.1 | 34.1 | 35.8 | 36.8 | 35.1 | 33.6 | 32.8 | 32.5 | 31.9 | 31.4 | 31.0 | 30.9 | 33.2 |
| **Monthly Extreme Maximum Temperature** | | | | | | | | | | | | | High |
| Lop Buri | 38.4 | 38.5 | 40.6 | 41.8 | 41.5 | 38.5 | 37.0 | 36.0 | 35.2 | 34.4 | 34.6 | 34.6 | 41.8 |
| Suphan Buri | 36.7 | 39.8 | 41.0 | 42.2 | 42.6 | 39.8 | 38.0 | 37.1 | 35.6 | 34.5 | 34.9 | 35.0 | 42.6 |
| Bangkok | 36.0 | 36.6 | 39.9 | 39.0 | 39.4 | 36.8 | 36.0 | 35.3 | 35.7 | 34.5 | 35.1 | 35.2 | 39.8 |
| Kanchana Buri | 37.2 | 40.3 | 41.7 | 43.5 | 41.6 | 38.4 | 37.8 | 37.5 | 37.6 | 37.3 | 37.5 | 35.5 | 43.5 |
| Mean (1) | 37.0 | 38.3 | 40.5 | 41.0 | 41.2 | 38.4 | 37.0 | 36.1 | 35.5 | 34.5 | 34.9 | 34.9 | 41.2 |
| Mean (2) | 37.1 | 38.8 | 40.8 | 41.6 | 41.3 | 38.4 | 37.2 | 36.5 | 36.0 | 35.2 | 35.5 | 35.1 | 41.6 |

Note: Mean (1): Mean value of three stations except Kanchana Buri
Mean (2): Mean value of four stations

Source: Meteorological Department

| | |
|---|---|
| Monthly Mean Temperature | 25 years (1951 - 1975) |
| Monthly Extreme Minimum Temperature | 25 years (1951 - 1975) |
| Monthly Mean Minimum Temperature | 25 years (1951 - 1975) |
| Monthly Mean Maximum Temperature | 23 years (1951 - 1973) |
| Monthly Extreme Maximum Temperature | 25 years (1951 - 1975) |

Table A 3-2 Relative Humidity, Pan Evaporation and Sunshine Hours Duration

Mean Relative Humidity (%)

| Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lop Buri | 56.9 | 60.5 | 61.5 | 63.9 | 71.0 | 74.5 | 77.0 | 78.5 | 81.0 | 76.5 | 69.0 | 60.8 | 69.3 |
| Suphan Buri | 63.7 | 64.2 | 61.4 | 62.1 | 68.3 | 70.0 | 72.7 | 74.8 | 79.5 | 79.6 | 74.5 | 68.3 | 69.9 |
| Bangkok | 72.2 | 76.0 | 76.3 | 76.5 | 79.9 | 79.9 | 80.9 | 81.7 | 84.4 | 83.5 | 79.5 | 74.7 | 78.8 |
| Kanchana Buri | 62.5 | 60.7 | 57.5 | 60.0 | 70.2 | 72.8 | 73.9 | 74.3 | 77.6 | 79.9 | 74.6 | 67.4 | 69.1 |
| Mean (1) | 64.3 | 66.9 | 66.4 | 67.5 | 73.1 | 74.8 | 76.9 | 78.3 | 81.6 | 79.9 | 74.3 | 67.9 | 72.7 |
| Mean (2) | 63.8 | 65.4 | 64.2 | 65.6 | 72.4 | 74.3 | 76.1 | 77.3 | 80.6 | 79.9 | 74.4 | 67.8 | 71.8 |

Note: Mean (1): mean except Kanchana Buri Mean (2): mean of four stations
Source: Meteorological Department, 22 years (1951-1972)

Pan Evaporation (mm/month)

| Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Suphan Buri | 131.6 | 131.0 | 185.1 | 205.9 | 191.7 | 165.8 | 154.0 | 146.2 | 135.9 | 120.8 | 121.0 | 116.1 | 1,805.1 |
| Bangkok | 138.6 | 137.7 | 185.8 | 189.1 | 165.0 | 147.9 | 142.9 | 137.4 | 129.8 | 122.5 | 121.2 | 126.5 | 1,744.4 |
| Mean | 135.1 | 134.4 | 185.5 | 197.5 | 178.4 | 156.9 | 148.5 | 141.8 | 132.9 | 121.7 | 121.1 | 121.3 | 1,774.8 |

Source: Meteorological Department Suphan Buri, 8 years (1963-1970)
Bangkok, 10 years (1961-1970)

Sunshine Hours Duration (hours/day)

| Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bangkok | 8.9 | 8.8 | 8.6 | 8.5 | 7.3 | 6.3 | 5.4 | 5.4 | 5.3 | 6.8 | 8.2 | 8.5 | 7.3 |

Source: Meteorological Department, 20 years (1951-1972)

Solar Radiation (cal/cm$^2$/day)

| Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bangkok | 398 | 424 | 457 | 470 | 425 | 409 | 403 | 385 | 370 | 375 | 412 | 401 | 411 |

Source: Meteorological Department, 11 years (1965-1975)

Table A 3-3 Wind

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Prevailing Wind Direction** | | | | | | | | | | | | | |
| Lop Buri | NE | S | S | S | S | S | S | S | S | NE | NE | NE | |
| Suphan Buri | NE | S | S | S | SW | SW | SW | SW | SW | NE | NE | NE | |
| Bangkok | NE | S | S | S | S | S | SW | SW | SW | NE | N | N | |
| Kanchana Buri | NE | SE | W | W | W | W | W | W | W | W | NE | NE | |
| **Mean Wind Speed (knots)** | | | | | | | | | | | | | Annual Mean |
| Lop Buri | 6.5 | 6.4 | 7.4 | 7.1 | 5.9 | 6.2 | 5.5 | 5.2 | 4.7 | 5.3 | 6.8 | 6.5 | 6.13 |
| Suphan Buri | 6.1 | 6.2 | 7.2 | 7.5 | 7.2 | 7.8 | 7.9 | 7.4 | 6.6 | 6.6 | 7.2 | 6.6 | 7.03 |
| Bangkok | 4.3 | 5.6 | 6.6 | 6.3 | 5.1 | 5.4 | 5.0 | 5.1 | 4.5 | 4.1 | 4.0 | 3.9 | 4.99 |
| Kanchana Buri | 3.3 | 3.8 | 4.2 | 4.6 | 4.4 | 4.6 | 4.5 | 5.0 | 3.9 | 3.4 | 3.5 | 4.1 | 4.11 |
| Mean (1) | 5.63 | 6.07 | 7.07 | 6.97 | 6.07 | 6.47 | 6.13 | 5.90 | 5.27 | 5.33 | 6.00 | 5.67 | 6.05 |
| Mean (2) | 5.05 | 5.50 | 6.35 | 6.38 | 5.65 | 6.00 | 5.73 | 5.68 | 4.93 | 4.85 | 5.38 | 5.28 | 5.57 |
| **Maximum Wind Speed and Direction (knots)** | | | | | | | | | | | | | Max. |
| Lop Buri | 45 | 52 | 45 | 50 | 40 | 44 | 40 | 40 | 40 | 33 | 45 | 45 | 50 |
| | NE | NE | N,NE | NE,E | N,SW | W | S,W | S | NE | NNE | ENE | E | |
| Suphan Buri | 30 | 30 | 33 | 45 | 35 | 30 | 34 | 30 | 35 | 35 | 30 | 24 | 45 |
| | NE | NE,SW | E | E | W | S,SW,W | SW | SW | SW | N,S,NNW | NE | NE | |
| Bangkok | 31 | 37 | 48 | 56 | 42 | 43 | 43 | 45 | 44 | 40 | 45 | 31 | 56 |
| | NNE | N | ENE | E | W | S,SW | SW,W | WNW | SSW | NE | ENE | NNE,SE | |
| Kanchana Buri | 25 | 25 | 33 | 50 | 33 | 33 | 55 | 40 | 40 | 30 | 21 | 30 | 55 |
| | ENE | SE | S | SE | E,W | W | SW | NW | W | W | NE | N | |

Note: mean (1): mean value except Kanchana Buri
mean (2): mean value of four stations

Source: Meteorological Department, 20 years (1951-1970)

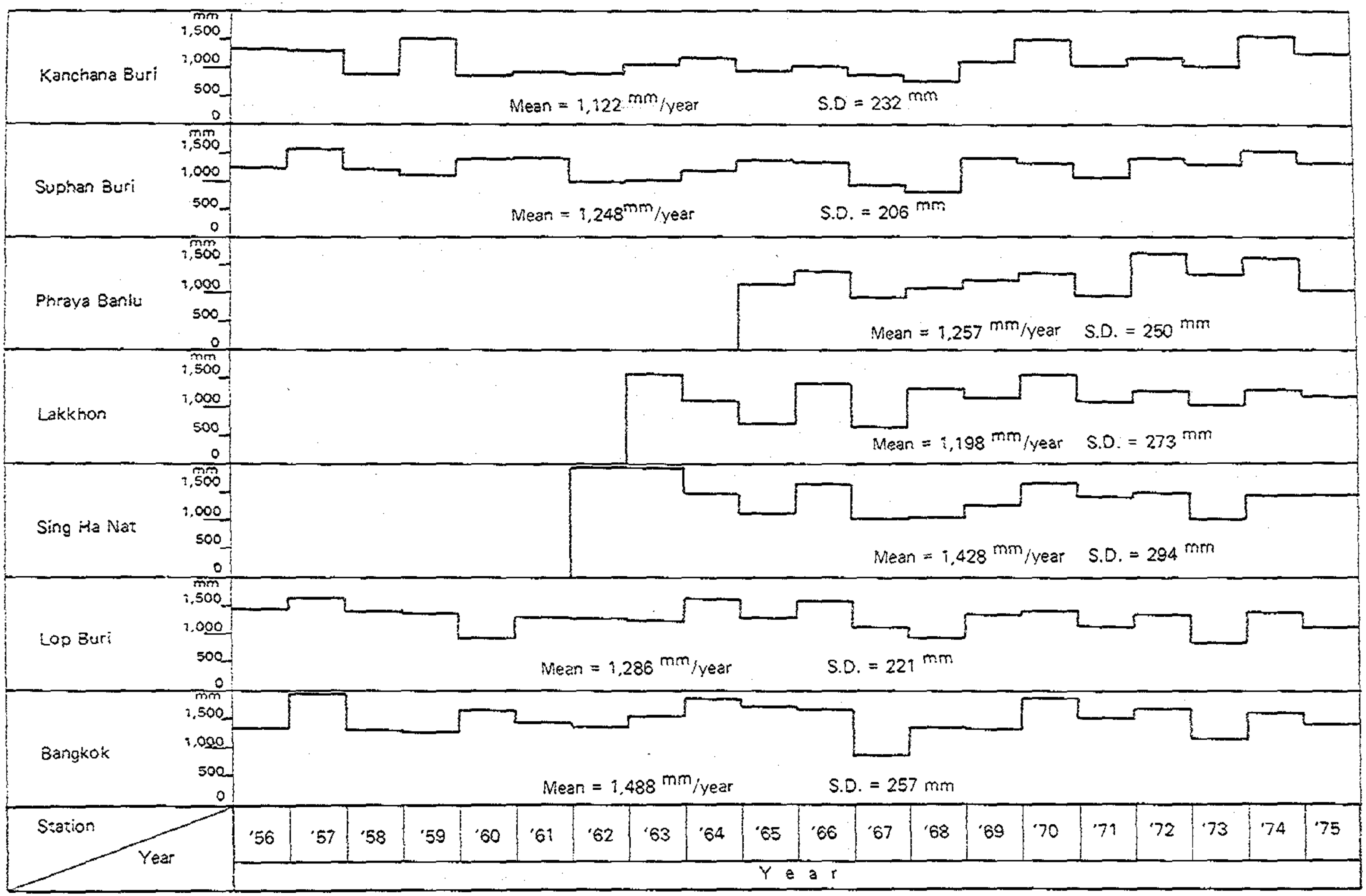
Table A. 3-4 Solar Radiation

(Unit: cal/cm$^2$/day)

| Year | Daily Solar Radiation | | | | | | | | | | | | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
| 1965 | 426.73 | 435.52 | 472.32 | 536.27 | 424.67 | 342.80 | 420.74 | 395.01 | 354.24 | 372.77 | 460.45 | 437.50 | 423.25 |
| 1966 | 427.12 | 420.26 | 516.64 | 516.79 | 399.32 | 466.21 | 364.44 | 395.15 | 418.28 | 406.79 | 424.71 | 378.61 | 427.86 |
| 1967 | 411.38 | 449.68 | 473.71 | 487.17 | 433.72 | 448.25 | 414.21 | 355.94 | 360.04 | 390.35 | 398.37 | 436.68 | 421.63 |
| 1968 | 386.83 | 378.88 | 466.91 | 437.16 | 408.66 | 403.74 | 380.42 | 406.15 | 366.04 | 324.61 | 344.72 | 337.48 | 386.80 |
| 1969 | 382.46 | 423.03 | - | 477.33 | 406.40 | 415.29 | 335.23 | 355.93 | 369.26 | 391.91 | 426.03 | 429.06 | - |
| 1970 | 424.27 | 407.71 | 368.99 | - | - | - | 419.45 | 406.28 | 371.38 | 368.84 | 389.23 | 377.06 | 392.58 |
| 1971 | 403.60 | 364.80 | 431.86 | 430.31 | 425.12 | 392.70 | 494.72 | 402.57 | 367.57 | 393.14 | 447.96 | 380.94 | 411.27 |
| 1972 | 403.53 | 412.19 | 473.03 | 429.03 | 519.43 | 415.08 | 370.76 | 353.78 | 347.36 | 351.69 | 359.02 | 389.34 | 402.87 |
| 1973 | 402.27 | 452.82 | 421.99 | 488.01 | 428.12 | 417.39 | 357.03 | 347.09 | 312.47 | 410.15 | 417.75 | 448.10 | 409.43 |
| 1974 | 366.98 | 415.05 | 473.47 | 444.92 | 411.16 | 418.88 | 437.19 | 407.48 | 432.48 | 347.49 | 404.46 | 394.09 | 412.80 |
| 1975 | 340.83 | 449.23 | 474.05 | 451.88 | 389.71 | 376.85 | 431.68 | 397.88 | 366.59 | 370.92 | 458.85 | 403.13 | 409.30 |
| Mean($\bar{x}$) | 397.82 | 423.56 | 457.30 | 469.93 | 424.63 | 409.32 | 403.26 | 384.84 | 369.61 | 375.35 | 411.96 | 401.09 | 410.63 |
| Standard Deviation(S) | 25.62 | 30.00 | 38.20 | 35.38 | 34.22 | 32.72 | 42.68 | 22.68 | 30.81 | 25.20 | 36.08 | 32.07 | 12.06 |
| S/$\bar{x}$ | 0.064 | 0.071 | 0.084 | 0.075 | 0.081 | 0.080 | 0.106 | 0.059 | 0.083 | 0.067 | 0.088 | 0.080 | 0.030 |

Source: Meteorological Department, Station Bangkok, 11 years (1965-1975)

# FIGURE A. 3-1 ANNUAL RAINFALL DISTRIBUTION




Note : S.D ; Standard Deviation of Annual Rainfall

Table A. 3-5 Annual Rainfall

(Unit: mm)

| Year | Sing Ha Nat Regulator | Lakkhon Regulator | Phraya Banlu Regulator | Lop Buri | Suphan Buri | Bang Kapi (Bangkok) | Kanchana Buri |
|---|---|---|---|---|---|---|---|
| | Stations | | | | | | |
| 1956 | | | | 1,465.6 | 1,267.4 | 1,362.6 | 1,357.0 |
| 1957 | | | | 1,639.6 | 1,584.9 | 1,946.1 | 1,296.6 |
| 1958 | | | | 1,391.8 | 1,217.5 | 1,307.8 | 871.0 |
| 1959 | | | | 1,372.8 | 1,106.8 | 1,267.2 | 1,515.8 |
| 1960 | | | | 920.3 | 1,388.0 | 1,646.3 | 867.6 |
| 1961 | | | | 1,289.3 | 1,432.2 | 1,454.3 | 919.9 |
| 1962 | 1,941.5 | | | 1,284.3 | 984.9 | 1,376.8 | 901.8 |
| 1963 | 1,931.2 | 1,568.3 | | 1,222.9 | 1,004.7 | 1,540.5 | 1,055.2 |
| 1964 | 1,486.7 | 1,118.7 | | 1,652.6 | 1,182.6 | 1,866.8 | 1,179.0 |
| 1965 | 1,130.3 | 700.7 | 1,179.5 | 1,292.8 | 1,357.0 | 1,689.0 | 961.5 |
| 1966 | 1,636.2 | 1,422.2 | 1,387.4 | 1,598.1 | 1,332.7 | 1,668.1 | 1,031.6 |
| 1967 | 1,044.0 | 659.4 | 926.4 | 1,123.7 | 911.6 | 865.6 | 873.3 |
| 1968 | 1,036.1 | 1,331.7 | 1,010.8 | 930.5 | 800.2 | 1,361.4 | 780.2 |
| 1969 | 1,263.8 | 1,181.8 | 1,231.6 | 1,247.8 | 1,410.8 | 1,348.1 | 1,124.1 |
| 1970 | 1,663.6 | 1,577.7 | 1,366.1 | 1,427.8 | 1,336.2 | 1,855.4 | 1,500.4 |
| 1971 | 1,438.4 | 1,117.2 | 961.3 | 1,138.1 | 1,055.9 | 1,483.9 | 1,067.9 |
| 1972 | 1,501.8 | 1,304.3 | 1,714.1 | 1,353.9 | 1,395.6 | 1,652.3 | 1,192.2 |
| 1973 | 1,019.7 | 1,046.9 | 1,343.8 | 855.0 | 1,300.2 | 1,103.0 | 1,063.5 |
| 1974 | 1,450.4 | 1,332.9 | 1,639.2 | 1,390.7 | 1,552.6 | 1,579.3 | 1,581.7 |
| 1975 | 1,449.5 | 1,212.1 | 1,073.3 | 1,114.7 | 1,335.6 | 1,377.8 | 1,288.8 |
| Mean ($\bar{x}$) | 1,428.1 | 1,198.0 | 1,257.1 | 1,285.6 | 1,247.9 | 1,487.6 | 1,121.5 |
| S | 293.9 | 272.8 | 250.1 | 220.5 | 206.1 | 256.7 | 231.9 |
| S/$\bar{x}$ | 0.206 | 0.228 | 0.199 | 0.172 | 0.165 | 0.173 | 0.206 |

Note: S - Standard Deviation

Source: Sing Ha Nat, Phraya Banlu and Lakkhon; RID
Lop Buri, Suphan Buri, Bangkapi and Kanchana Buri; Meteorological Department

Table A. 3-6 Probable Annual Rainfall

(Unit: mm)

Probable Maximum Annual Rainfall

| Return Period (years) | Sing Ha Nat | Lakkhon | Phraya Banlu | Average of Three Stations | Lop Buri | Suphan Buri | Bangkok | Kanchana Buri | Average of Seven Stations |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 1,398 | 1,162 | 1,233 | 1,264 | 1,266 | 1,229 | 1,464 | 1,098 | 1,264 |
| 5 | 1,678 | 1,458 | 1,468 | 1,535 | 1,480 | 1,433 | 1,718 | 1,308 | 1,506 |
| 10 | 1,846 | 1,641 | 1,607 | 1,698 | 1,606 | 1,552 | 1,868 | 1,434 | 1,651 |
| 15 | 1,936 | 1,741 | 1,682 | 1,786 | 1,672 | 1,615 | 1,948 | 1,501 | 1,728 |
| 20 | 1,997 | 1,809 | 1,733 | 1,846 | 1,717 | 1,658 | 2,002 | 1,546 | 1,780 |
| 25 | 2,043 | 1,862 | 1,771 | 1,892 | 1,752 | 1,690 | 2,042 | 1,581 | 1,820 |
| 30 | 2,081 | 1,904 | 1,802 | 1,929 | 1,779 | 1,716 | 2,075 | 1,608 | 1,852 |
| 40 | 2,138 | 1,970 | 1,850 | 1,986 | 1,821 | 1,756 | 2,125 | 1,651 | 1,902 |
| 50 | 2,182 | 2,020 | 1,885 | 2,029 | 1,852 | 1,786 | 2,163 | 1,683 | 1,939 |

Probable Minimum Annual Rainfall

| Return Period (years) | Sing Ha Nat | Lakkhon | Phraya Banlu | Average of Three Stations | Lop Buri | Suphan Buri | Bangkok | Kanchana Buri | Average of Seven Stations |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 1,394 | 1,162 | 1,222 | 1,259 | 1,266 | 1,229 | 1,464 | 1,087 | 1,261 |
| 5 | 1,163 | 927 | 1,035 | 1,042 | 1,083 | 1,055 | 1,247 | 920 | 1,061 |
| 10 | 1,060 | 823 | 954 | 946 | 998 | 974 | 1,147 | 850 | 972 |
| 15 | 1,013 | 776 | 918 | 902 | 958 | 936 | 1,100 | 818 | 931 |
| 20 | 984 | 746 | 895 | 875 | 933 | 912 | 1,070 | 798 | 914 |
| 25 | 962 | 725 | 879 | 855 | 914 | 894 | 1,049 | 784 | 887 |
| 30 | 946 | 709 | 867 | 841 | 901 | 881 | 1,032 | 773 | 873 |
| 40 | 922 | 686 | 849 | 819 | 880 | 861 | 1,008 | 758 | 852 |
| 50 | 905 | 669 | 836 | 803 | 865 | 846 | 990 | 747 | 837 |

Data Source: Table A. 3-8 to Table A. 3-14.

Table A. 3-7 Monthly Mean Rainfall

(Unit: mm)

| Station | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monthly Mean Rainfall | | | | | | | | | | | | |
| (1) Sing Ha Nat | 7.2 | 11.9 | 26.9 | 63.3 | 152.0 | 153.0 | 165.9 | 213.4 | 347.2 | 245.6 | 36.1 | 16.8 | 1,439.3 |
| (2) Lakkon | 4.5 | 6.9 | 20.3 | 42.8 | 108.0 | 144.7 | 131.1 | 191.5 | 289.9 | 205.4 | 37.0 | 15.9 | 1,198.0 |
| (3) Phraya Banlu | 2.3 | 8.0 | 25.6 | 58.2 | 137.7 | 104.5 | 108.7 | 180.2 | 301.9 | 245.6 | 69.6 | 15.4 | 1,257.7 |
| (4) Lop Buri | 12.3 | 10.4 | 49.0 | 75.4 | 164.3 | 148.8 | 159.2 | 164.8 | 281.6 | 171.9 | 38.4 | 10.7 | 1,286.8 |
| (5) Suphan Buri | 5.9 | 9.4 | 32.1 | 83.2 | 159.6 | 127.8 | 112.4 | 150.5 | 316.5 | 204.3 | 32.3 | 14.2 | 1,248.2 |
| (6) Bangkok | 8.6 | 31.8 | 24.7 | 67.1 | 185.4 | 149.0 | 148.4 | 209.4 | 352.1 | 236.9 | 47.5 | 12.7 | 1,473.6 |
| (7) Kanchana Buri | 5.9 | 9.6 | 34.9 | 77.3 | 147.2 | 90.2 | 97.6 | 106.3 | 249.4 | 229.3 | 60.7 | 10.9 | 1,119.3 |
| Mean (1) | 4.7 | 8.9 | 24.3 | 54.8 | 132.6 | 134.1 | 135.2 | 195.0 | 313.0 | 232.2 | 47.6 | 16.0 | 1,298.4 |
| Mean (2) | 6.7 | 12.6 | 30.5 | 66.8 | 150.6 | 131.1 | 131.9 | 173.7 | 305.5 | 219.9 | 45.9 | 13.8 | 1,289.0 |

Note: mean (1): Average of Sing Ha Nat, Lakkhon and Phraya Banlu
mean (2): Average of seven stations

Source: (1)-(3) Royal Irrigation Department
Sing Ha Nat : 14 years (1962-1975)
Lakkhon : 13 years (1963-1975)
Phraya Banlu: 11 years (1965-1975)

(4)-(7) Meteorological Department: 20 years (1956-1975)

Table A. 3-8 Monthly Rainfall Records in the Vicinity of Project Area

Station: Sing Ha Nat Regulator

(Unit: mm)

| Year | Monthly Rainfall | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | |
| 1962 | 0 | 30.8 | 2.2 | 57.5 | 216.4 | 161.1 | 277.6 | 182.0 | 645.4 | 318.7 | 49.7 | 0 | 1,941.5 |
| 1963 | 0 | 0 | 9.5 | 2.0 | 78.4 | 213.8 | 161.1 | 123.3 | 531.8 | 646.8 | 54.5 | 0 | 1,931.2 |
| 1964 | 0 | 4.0 | 7.5 | 138.0 | 298.9 | 156.4 | 292.1 | 142.1 | 300.3 | 91.2 | 8.8 | 47.4 | 1,486.7 |
| 1965 | 0 | 15.3 | 107.3 | 18.4 | 148.2 | 68.1 | 38.2 | 170.5 | 313.5 | 211.4 | 19.7 | 19.7 | 1,130.3 |
| 1966 | 2.5 | 10.6 | 0 | 30.7 | 339.5 | 128.6 | 200.3 | 209.2 | 294.3 | 349.0 | 32.9 | 38.6 | 1,636.2 |
| 1967 | 43.4 | 0 | 12.8 | 40.5 | 54.8 | 171.6 | 166.2 | 62.9 | 280.3 | 171.9 | 39.6 | 0 | 1,044.0 |
| 1968 | 0 | 34.0 | 21.5 | 49.2 | 132.7 | 137.2 | 95.4 | 210.8 | 275.0 | 65.8 | 13.5 | 0 | 1,036.1 |
| 1969 | 7.3 | 0 | 29.0 | 18.0 | 106.1 | 121.6 | 154.3 | 278.6 | 258.1 | 229.2 | 61.6 | 0 | 1,263.8 |
| 1970 | 0 | 6.1 | 29.6 | 182.1 | 154.9 | 244.4 | 127.9 | 404.6 | 251.2 | 163.8 | 20.0 | 69.0 | 1,663.6 |
| 1971 | 0 | 23.3 | 49.9 | 58.5 | 175.5 | 167.8 | 79.0 | 294.1 | 309.2 | 284.1 | 0 | 2.0 | 1,438.4 |
| 1972 | 0 | 5.2 | 22.2 | 163.5 | 88.5 | 158.8 | 112.5 | 82.6 | 548.4 | 171.5 | 97.9 | 50.7 | 1,501.8 |
| 1973 | 0 | 0 | 61.3 | 45.0 | 66.0 | 66.5 | 144.8 | 182.2 | 275.1 | 133.2 | 41.4 | 4.2 | 1,019.7 |
| 1974 | 24.4 | 0 | 10.1 | 114.9 | 131.7 | 96.3 | 236.1 | 183.1 | 206.6 | 401.1 | 46.1 | 0 | 1,450.4 |
| 1975 | 30.7 | 0 | 36.4 | 8.0 | 129.5 | 182.5 | 179.2 | 252.8 | 405.8 | 200.6 | 20.0 | 4.0 | 1,449.5 |
| 1976 | 0 | 48.5 | 9.9 | 23.6 | 158.9 | 219.9 | 223.3 | 312.6 | 302.5 | 194.3 | - | - | - |
| Mean ($\bar{x}$) | 7.2 | 11.9 | 27.3 | 63.3 | 152.0 | 153.0 | 165.9 | 213.4 | 347.2 | 242.2 | 36.1 | 16.8 | 1,436.3 |
| S | 13.4 | 14.9 | 27.2 | 56.0 | 78.0 | 50.2 | 69.1 | 85.1 | 122.9 | 140.2 | 24.6 | 23.2 | |
| S/$\bar{x}$ | 1.86 | 1.25 | 0.997 | 0.885 | 0.513 | 0.328 | 0.416 | 0.399 | 0.354 | 0.579 | 0.682 | 1.380 | |

Note: S - Standard Deviation
Source: Chao-chet Bangyeehon and Phraya Banlu Project Offices, RID

Table A. 3-9 Monthly Rainfall Record

Station: Lakkhon Regulator

(Unit: mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1963 | 0.0 | 0.0 | 0.0 | 0.0 | 85.6 | 87.5 | 178.1 | 338.7 | 492.6 | 374.6 | 11.2 | 0.0 | 1,568.3 |
| 1964 | 0.0 | 0.0 | 0.0 | 101.9 | 298.0 | 162.4 | 103.3 | 120.7 | 241.4 | 39.0 | 0.0 | 52.0 | 1,118.7 |
| 1965 | 0.0 | 27.4 | 15.6 | 1.4 | 59.5 | 88.3 | 3.4 | 123.7 | 308.7 | 67.0 | 5.2 | 0.0 | 700.7 |
| 1966 | 0.0 | 60.4 | 3.6 | 0.0 | 237.1 | 191.0 | 239.3 | 183.2 | 174.9 | 217.3 | 57.7 | 57.7 | 1,422.2 |
| 1967 | 28.7 | 0.0 | 26.5 | 12.6 | 59.1 | 62.5 | 132.9 | 35.8 | 165.2 | 136.1 | 0.0 | 0.0 | 659.4 |
| 1968 | 0.0 | 1.8 | 7.4 | 112.1 | 139.5 | 196.9 | 106.5 | 203.0 | 317.5 | 158.8 | 88.2 | 0.0 | 1,331.7 |
| 1969 | 4.5 | 0.0 | 90.8 | 13.9 | 61.2 | 169.4 | 62.1 | 213.2 | 302.1 | 209.3 | 55.3 | 0.0 | 1,181.8 |
| 1970 | 0.0 | 0.0 | 18.4 | 63.4 | 108.2 | 385.8 | 133.3 | 369.2 | 228.5 | 233.6 | 18.4 | 18.9 | 1,577.7 |
| 1971 | 0.0 | 0.0 | 51.5 | 57.5 | 134.7 | 118.1 | 133.3 | 282.9 | 232.2 | 107.0 | 0.0 | 0.0 | 1,117.2 |
| 1972 | 0.0 | 0.0 | 43.2 | 97.6 | 33.0 | 110.2 | 72.3 | 90.9 | 500.3 | 159.8 | 118.8 | 78.2 | 1,304.3 |
| 1973 | 0.0 | 0.0 | 0.0 | 0.0 | 46.3 | 138.8 | 162.1 | 186.2 | 327.8 | 178.3 | 7.4 | 0.0 | 1,046.9 |
| 1974 | 0.0 | 0.0 | 0.0 | 96.3 | 46.8 | 86.6 | 176.1 | 117.4 | 177.1 | 573.4 | 59.2 | 0.0 | 1,332.9 |
| 1975 | 24.6 | 0.0 | 6.4 | 0.0 | 94.8 | 83.3 | 201.0 | 225.8 | 300.6 | 215.6 | 60.0 | 0.0 | 1,212.1 |
| Mean($\bar{x}$) | 4.5 | 6.9 | 20.3 | 42.8 | 108.0 | 144.7 | 131.1 | 191.6 | 289.9 | 205.4 | 37.0 | 15.9 | 1,198.0 |
| S | 9.58 | 17.1 | 26.0 | 44.4 | 76.1 | 81.4 | 60.6 | 93.2 | 103.4 | 133.4 | 37.3 | 26.6 | 272.8 |
| S/$\bar{x}$ | 2.15 | 2.48 | 1.28 | 1.04 | 0.70 | 0.56 | 0.46 | 0.49 | 0.36 | 0.65 | 1.01 | 1.67 | 0.23 |

Station: Phraya Banlu Regulator

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1965 | 0.0 | 74.4 | 0.0 | 68.5 | 131.3 | 34.0 | 89.6 | 112.7 | 385.0 | 122.0 | 120.2 | 41.8 | 1,179.5 |
| 1966 | 0.0 | 0.0 | 8.5 | 15.8 | 313.3 | 107.0 | 129.0 | 357.0 | 155.6 | 221.2 | 24.5 | 55.5 | 1,382.4 |
| 1967 | 0.0 | 0.0 | 0.0 | 5.6 | 112.0 | 127.6 | 98.6 | 74.3 | 364.0 | 136.2 | 8.1 | 0.0 | 926.4 |
| 1968 | 0.0 | 6.0 | 8.5 | 29.7 | 95.6 | 99.3 | 61.4 | 215.1 | 260.5 | 139.0 | 95.7 | 0.0 | 1,010.8 |
| 1969 | 5.2 | 0.0 | 41.4 | 5.5 | 49.4 | 120.3 | 135.0 | 205.2 | 345.7 | 189.7 | 134.2 | 0.0 | 1,231.6 |
| 1970 | 0.0 | 0.0 | 29.0 | 16.8 | 169.1 | 213.9 | 102.5 | 258.3 | 342.8 | 156.5 | 40.8 | 36.4 | 1,366.1 |
| 1971 | 0.0 | 0.0 | 20.5 | 126.7 | 14.1 | 41.9 | 67.9 | 215.9 | 215.5 | 258.8 | 0.0 | 0.0 | 961.3 |
| 1972 | 0.0 | 0.0 | 11.3 | 180.1 | 144.4 | 74.9 | 55.0 | 131.4 | 701.9 | 271.1 | 108.7 | 35.3 | 1,714.1 |
| 1973 | 0.0 | 3.5 | 159.9 | 0.0 | 174.0 | 129.4 | 254.0 | 109.5 | 210.5 | 303.0 | 0.0 | 0.0 | 1,343.8 |
| 1974 | 0.0 | 0.0 | 2.3 | 191.4 | 86.4 | 109.6 | 158.1 | 256.9 | 118.7 | 563.6 | 152.2 | 0.0 | 1,639.2 |
| 1975 | 20.1 | 3.7 | 0.0 | 0.0 | 224.9 | 91.2 | 44.3 | 45.7 | 221.2 | 341.0 | 81.2 | 0.0 | 1,073.3 |
| Mean($\bar{x}$) | 2.3 | 8.0 | 25.6 | 58.2 | 137.7 | 104.5 | 108.7 | 180.2 | 301.9 | 245.6 | 69.6 | 15.4 | 1,257.1 |
| S | 5.82 | 21.1 | 44.3 | 70.1 | 79.2 | 46.1 | 57.3 | 89.2 | 151.8 | 122.3 | 54.1 | 20.9 | 250.0 |
| S/$\bar{x}$ | 2.53 | 2.65 | 1.73 | 1.20 | 0.58 | 0.44 | 0.53 | 0.50 | 0.50 | 0.50 | 0.78 | 1.36 | 0.20 |

Table A. 3-10 Monthly Rainfall Record

Station: Lop Buri

(Unit: mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | 0.0 | 14.2 | 63.8 | 95.0 | 257.5 | 192.1 | 185.0 | 188.2 | 343.6 | 98.9 | 27.3 | 0.0 | 1,465.6 |
| 1957 | 0.0 | 4.1 | 0.0 | 91.8 | 70.8 | 140.0 | 117.1 | 121.2 | 496.9 | 494.7 | 103.0 | 0.0 | 1,639.6 |
| 1958 | 7.8 | 0.0 | 271.2 | 91.8 | 112.5 | 214.5 | 166.7 | 121.9 | 317.1 | 88.3 | 0.0 | 0.0 | 1,391.8 |
| 1959 | 1.3 | 13.6 | 123.9 | 92.4 | 283.5 | 70.8 | 196.9 | 73.8 | 321.8 | 193.7 | 10.8 | 0.2 | 1,372.8 |
| 1960 | 0.0 | 40.0 | 25.4 | 8.5 | 46.0 | 113.7 | 159.3 | 78.9 | 120.5 | 272.6 | 55.0 | 0.4 | 920.3 |
| 1961 | 0.0 | 10.3 | 62.3 | 153.7 | 165.3 | 197.7 | 153.7 | 164.5 | 82.5 | 285.7 | 12.8 | 0.8 | 1,289.3 |
| 1962 | 0.0 | 0.0 | 2.1 | 47.5 | 289.1 | 107.0 | 317.0 | 167.0 | 234.8 | 115.9 | 1.3 | 2.0 | 1,284.3 |
| 1963 | 0.0 | 0.0 | 0.8 | 75.4 | 64.3 | 144.8 | 163.3 | 118.9 | 360.2 | 197.1 | 98.0 | 0.1 | 1,222.9 |
| 1964 | 2.6 | 31.0 | 3.9 | 182.1 | 352.8 | 113.7 | 183.7 | 176.4 | 319.4 | 245.1 | 9.4 | 32.5 | 1,652.6 |
| 1965 | 0.0 | 12.1 | 16.2 | 28.4 | 189.1 | 133.8 | 119.7 | 285.1 | 295.0 | 127.0 | 75.7 | 10.7 | 1,292.8 |
| 1966 | 137.5 | 1.1 | 12.0 | 90.9 | 340.2 | 159.7 | 183.6 | 281.7 | 150.5 | 159.8 | 13.1 | 68.0 | 1,598.1 |
| 1967 | 2.2 | 0.8 | 0.0 | 129.7 | 125.7 | 174.6 | 188.8 | 67.9 | 281.2 | 81.0 | 71.6 | 0.0 | 1,123.7 |
| 1968 | 0.0 | 20.4 | 0.3 | 45.5 | 182.1 | 100.8 | 112.7 | 130.1 | 239.4 | 71.5 | 27.2 | 0.5 | 930.5 |
| 1969 | 59.3 | 0.0 | 56.0 | 4.1 | 73.5 | 118.9 | 213.8 | 179.2 | 430.9 | 97.6 | 14.3 | 0.2 | 1,247.8 |
| 1970 | 0.0 | 14.8 | 139.3 | 70.7 | 132.8 | 288.5 | 160.5 | 234.6 | 168.5 | 158.0 | 11.0 | 49.1 | 1,427.8 |
| 1971 | 0.0 | 26.6 | 42.3 | 68.1 | 184.7 | 126.2 | 51.2 | 328.0 | 179.2 | 120.1 | 7.6 | 4.1 | 1,138.1 |
| 1972 | 0.0 | 1.1 | 21.1 | 91.8 | 4.9 | 179.7 | 98.3 | 125.4 | 516.5 | 172.4 | 108.8 | 33.9 | 1,353.9 |
| 1973 | 0.0 | 0.0 | 46.2 | 0.0 | 126.7 | 151.0 | 97.5 | 85.8 | 279.1 | 67.0 | 11.6 | 0.1 | 855.0 |
| 1974 | 0.0 | 0.0 | 67.6 | 108.7 | 181.4 | 155.3 | 142.7 | 138.7 | 297.1 | 252.4 | 44.9 | 2.7 | 1,390.7 |
| 1975 | 35.2 | 18.4 | 24.6 | 31.0 | 102.6 | 93.7 | 172.3 | 227.7 | 197.4 | 139.2 | 64.2 | 8.4 | 1,114.7 |
| Mean ($\bar{x}$) | 12.3 | 10.4 | 49.0 | 75.4 | 164.3 | 148.8 | 159.2 | 164.8 | 281.6 | 171.9 | 38.4 | 10.7 | 1,285.6 |
| S | 32.2 | 11.7 | 64.1 | 47.2 | 95.8 | 48.6 | 53.5 | 72.5 | 113.1 | 99.2 | 35.5 | 18.9 | 220.5 |
| S/$\bar{x}$ | 2.62 | 1.13 | 1.31 | 0.63 | 0.58 | 0.33 | 0.34 | 0.44 | 0.40 | 0.58 | 0.92 | 1.77 | 0.172 |

Note: S - Standard Deviation
Source: Meteorological Department

Table A. 3-11 Monthly Rainfall Record

Station: Suphan Buri

(Unit: mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | 0.0 | 5.1 | 63.8 | 61.3 | 151.2 | 276.9 | 144.4 | 141.3 | 174.1 | 223.5 | 25.8 | 0.0 | 1,267.4 |
| 1957 | 0.0 | 0.0 | 56.6 | 89.7 | 66.0 | 159.7 | 102.5 | 282.8 | 474.6 | 287.8 | 65.2 | 0.0 | 1,584.9 |
| 1958 | 0.0 | 6.0 | 0.0 | 92.8 | 42.8 | 205.7 | 92.2 | 76.2 | 392.2 | 309.6 | 0.0 | 0.0 | 1,217.5 |
| 1959 | 0.0 | 11.8 | 9.0 | 41.4 | 102.4 | 61.2 | 133.1 | 130.4 | 450.1 | 125.2 | 40.3 | 0.0 | 1,106.8 |
| 1960 | 0.0 | 10.1 | 63.2 | 24.4 | 189.9 | 120.7 | 128.2 | 52.3 | 350.4 | 346.1 | 102.7 | 1.9 | 1,388.0 |
| 1961 | 24.1 | 0.0 | 24.2 | 194.0 | 323.8 | 85.2 | 184.9 | 199.6 | 149.5 | 239.5 | 4.4 | 0.0 | 1,432.2 |
| 1962 | 0.0 | 2.5 | 0.0 | 22.8 | 62.5 | 39.8 | 84.8 | 149.4 | 388.1 | 234.7 | 0.3 | 3.0 | 984.9 |
| 1963 | 0.0 | 0.0 | 66.1 | 24.4 | 85.4 | 137.3 | 55.5 | 96.0 | 279.1 | 241.8 | 16.6 | 0.0 | 1,004.7 |
| 1964 | 0.0 | 39.9 | 1.0 | 75.3 | 326.0 | 56.4 | 176.1 | 79.1 | 266.6 | 136.8 | 22.8 | 2.5 | 1,182.6 |
| 1965 | 0.0 | 39.7 | 0.0 | 127.1 | 253.6 | 83.4 | 60.8 | 141.2 | 442.4 | 101.6 | 82.8 | 2.6 | 1,357.0 |
| 1966 | 2.8 | 0.0 | 0.0 | 93.2 | 267.4 | 130.8 | 117.6 | 232.8 | 250.4 | 207.7 | 0.0 | 24.4 | 1,332.7 |
| 1967 | 0.9 | 0.0 | 4.8 | 134.8 | 180.8 | 65.0 | 134.9 | 37.1 | 227.1 | 109.8 | 6.4 | 30.0 | 911.6 |
| 1968 | 0.0 | 29.0 | 9.6 | 62.9 | 116.4 | 136.5 | 75.6 | 130.4 | 173.0 | 50.8 | 15.6 | 0.0 | 800.2 |
| 1969 | 0.0 | 39.4 | 37.8 | 126.2 | 74.2 | 100.6 | 197.8 | 186.5 | 487.5 | 95.9 | 63.9 | 0.0 | 1,410.8 |
| 1970 | 0.4 | 1.8 | 7.9 | 38.8 | 239.8 | 199.0 | 123.5 | 220.3 | 240.4 | 189.0 | 14.8 | 0.0 | 1,336.2 |
| 1971 | 3.0 | 1.4 | 104.0 | 138.9 | 93.8 | 91.8 | 54.4 | 185.4 | 259.2 | 221.6 | 0.6 | 60.4 | 1,055.9 |
| 1972 | 0.0 | 0.2 | 16.1 | 71.7 | 78.8 | 104.4 | 71.0 | 96.8 | 488.4 | 235.4 | 68.9 | 10.0 | 1,395.6 |
| 1973 | 0.0 | 0.0 | 55.2 | 5.8 | 196.3 | 180.6 | 127.8 | 160.2 | 409.8 | 154.7 | 8.4 | 71.8 | 1,300.2 |
| 1974 | 0.2 | 0.0 | 115.3 | 227.2 | 82.7 | 196.9 | 102.7 | 175.4 | 228.0 | 380.9 | 43.3 | 1.4 | 1,552.6 |
| 1975 | 86.1 | 0.0 | 7.4 | 10.6 | 258.3 | 123.4 | 80.7 | 237.4 | 198.3 | 193.1 | 62.4 | 0.0 | 1,335.6 |
| Mean($\bar{x}$) | 5.88 | 9.35 | 32.1 | 83.2 | 159.6 | 127.8 | 112.4 | 150.5 | 316.5 | 204.3 | 32.3 | 76.2 | 1,247.9 |
| S | 19.1 | 14.4 | 35.2 | 58.9 | 89.6 | 59.1 | 41.2 | 64.1 | 112.7 | 84.6 | 30.9 | 14.2 | 206.1 |
| S/$\bar{x}$ | 3.25 | 1.54 | 1.10 | 0.71 | 0.56 | 0.46 | 0.37 | 0.43 | 0.36 | 0.41 | 0.96 | 24.7 | 0.165 |

Note: S - Standard Deviation
Source: Meteorological Department

Table A. 3-12 Monthly Rainfall Record

Station: Bang Kapi, Phra Na Khon (Bangkok)

(Unit: mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | 2.2 | 0.4 | 0.0 | 83.7 | 121.0 | 162.0 | 130.0 | 193.8 | 365.2 | 189.0 | 115.0 | 0.0 | 1,362.6 |
| 1957 | 1.0 | 2.2 | 47.5 | 150.7 | 36.1 | 244.3 | 165.0 | 302.0 | 448.4 | 490.1 | 68.8 | 0.0 | 1,946.1 |
| 1958 | 35.5 | 39.6 | 3.2 | 2.7 | 36.9 | 175.3 | 168.0 | 316.0 | 278.7 | 228.7 | 12.3 | 0.0 | 1,307.8 |
| 1959 | 0.0 | 38.6 | 20.8 | 60.6 | 218.7 | 138.5 | 240.2 | 102.5 | 210.3 | 224.6 | 20.9 | 0.0 | 1,267.2 |
| 1960 | 0.0 | 0.0 | 34.4 | 1.8 | 112.0 | 79.4 | 127.4 | 243.9 | 499.7 | 443.2 | 94.4 | 10.1 | 1,646.3 |
| 1961 | 39.3 | 88.1 | 60.0 | 86.2 | 194.3 | 208.6 | 119.1 | 180.0 | 219.6 | 226.0 | 31.4 | 1.7 | 1,454.3 |
| 1962 | 0.0 | 20.0 | 43.5 | 36.4 | 179.3 | 117.9 | 125.5 | 223.5 | 464.5 | 164.6 | 1.5 | 0.0 | 1,376.8 |
| 1963 | 0.0 | 10.0 | 40.5 | 55.5 | 83.8 | 122.0 | 132.4 | 318.3 | 386.3 | 333.4 | 56.0 | 2.3 | 1,540.5 |
| 1964 | 4.6 | 107.4 | 15.0 | 45.9 | 554.1 | 100.2 | 279.6 | 243.9 | 403.2 | 100.2 | 10.0 | 2.7 | 1,866.8 |
| 1965 | 0.4 | 125.4 | 2.6 | 66.2 | 264.7 | 96.0 | 83.1 | 185.1 | 543.4 | 277.5 | 26.3 | 18.3 | 1,689.0 |
| 1966 | 0.0 | 35.2 | 1.3 | 72.0 | 380.8 | 214.6 | 314.7 | 157.4 | 257.4 | 191.3 | 4.2 | 39.2 | 1,668.1 |
| 1967 | 6.3 | 0.0 | 4.2 | 67.6 | 235.9 | 28.0 | 104.7 | 121.0 | 165.1 | 96.6 | 36.2 | 0.0 | 865.6 |
| 1968 | 4.6 | 51.2 | 0.4 | 124.7 | 124.4 | 180.1 | 114.7 | 269.7 | 293.7 | 166.4 | 31.5 | 0.0 | 1,361.4 |
| 1969 | 38.5 | 0.1 | 0.4 | 12.0 | 68.5 | 280.0 | 78.0 | 95.6 | 292.8 | 159.0 | 93.6 | 1.6 | 1,348.1 |
| 1970 | 1.2 | 68.2 | 44.6 | 157.5 | 283.0 | 307.7 | 152.8 | 144.3 | 355.2 | 187.3 | 50.4 | 103.2 | 1,855.4 |
| 1971 | 0.0 | 28.1 | 11.0 | 31.1 | 236.3 | 82.2 | 178.9 | 352.1 | 383.2 | 177.4 | 2.8 | 0.8 | 1,483.9 |
| 1972 | 0.0 | 19.9 | 18.8 | 146.9 | 55.1 | 127.8 | 69.5 | 157.0 | 676.3 | 237.9 | 88.4 | 54.7 | 1,652.3 |
| 1973 | 0.0 | 0.0 | 102.6 | 5.6 | 157.5 | 131.4 | 78.5 | 97.3 | 368.3 | 113.8 | 36.8 | 11.2 | 1,103.0 |
| 1974 | 0.7 | 0.0 | 10.2 | 130.2 | 179.2 | 82.3 | 130.5 | 160.9 | 219.7 | 470.2 | 134.8 | 0.0 | 1,579.3 |
| 1975 | 38.1 | 1.0 | 32.4 | 3.9 | 186.2 | 100.7 | 174.8 | 323.7 | 211.5 | 261.5 | 35.0 | 9.0 | 1,377.8 |
| Mean ($\bar{x}$) | 8.62 | 31.8 | 24.7 | 67.1 | 185.4 | 149.0 | 148.4 | 209.4 | 352.1 | 236.9 | 47.5 | 12.7 | 1,487.6 |
| S | 14.7 | 37.5 | 25.7 | 50.8 | 121.6 | 70.6 | 63.9 | 80.6 | 126.9 | 112.5 | 38.4 | 25.1 | 256.7 |
| S/$\bar{x}$ | 1.71 | 1.18 | 1.04 | 0.76 | 0.66 | 0.47 | 0.43 | 0.38 | 0.36 | 0.47 | 0.81 | 1.98 | 0.173 |

Note: S - Standard Deviation

Source: Meteorological Department

Table A. 3-13 Monthly Rainfall Record

Station: Kanchana Buri

(Unit: mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1956 | 0.0 | 0.0 | 12.0 | 55.0 | 149.8 | 149.4 | 95.4 | 186.1 | 341.7 | 294.2 | 73.4 | 0.0 | 1,357.0 |
| 1957 | 0.0 | 0.0 | 0.0 | 88.5 | 5.2 | 85.8 | 161.8 | 152.6 | 437.4 | 349.5 | 15.8 | 0.0 | 1,296.6 |
| 1958 | 0.0 | 46.1 | 56.4 | 81.8 | 80.8 | 125.1 | 63.7 | 99.9 | 193.1 | 102.8 | 21.3 | 0.0 | 871.0 |
| 1959 | 3.0 | 9.0 | 94.2 | 43.8 | 101.3 | 50.7 | 166.6 | 31.8 | 478.5 | 505.2 | 26.8 | 4.9 | 1,515.8 |
| 1960 | 10.6 | 0.2 | 6.9 | 23.6 | 173.3 | 60.9 | 86.1 | 24.2 | 126.4 | 265.1 | 82.0 | 8.3 | 867.6 |
| 1961 | 2.4 | 0.0 | 10.9 | 116.2 | 221.4 | 144.4 | 82.7 | 121.5 | 55.4 | 147.4 | 17.6 | 0.0 | 919.9 |
| 1962 | 0.0 | 0.0 | 17.4 | 88.3 | 101.7 | 79.0 | 32.1 | 121.6 | 266.2 | 193.2 | 2.1 | 0.2 | 901.8 |
| 1963 | 0.0 | 0.0 | 0.0 | 6.8 | 180.5 | 58.7 | 89.6 | 117.3 | 298.5 | 204.9 | 102.1 | 5.8 | 1,055.2 |
| 1954 | 0.0 | 12.1 | 0.0 | 119.1 | 176.8 | 45.2 | 192.7 | 29.0 | 201.7 | 182.0 | 218.7 | 1.7 | 1,179.0 |
| 1965 | 17.2 | 1.5 | 61.7 | 25.6 | 145.6 | 51.6 | 38.3 | 151.7 | 264.2 | 144.5 | 47.5 | 12.1 | 961.5 |
| 1966 | 0.0 | 3.2 | 2.5 | 28.5 | 283.1 | 100.1 | 67.1 | 107.7 | 145.2 | 216.5 | 26.5 | 51.1 | 1,031.6 |
| 1967 | 0.0 | 0.0 | 0.0 | 133.8 | 159.1 | 32.8 | 101.9 | 42.7 | 90.4 | 264.4 | 48.2 | 0.0 | 873.3 |
| 1968 | 0.0 | 2.7 | 0.0 | 110.5 | 115.0 | 142.3 | 73.4 | 9.2 | 143.7 | 161.9 | 20.9 | 0.6 | 780.2 |
| 1969 | 3.7 | 2.0 | 30.5 | 125.7 | 200.1 | 72.9 | 92.9 | 125.3 | 217.2 | 121.7 | 131.5 | 0.6 | 1,124.1 |
| 1970 | 0.0 | 89.6 | 20.4 | 103.7 | 132.4 | 107.7 | 90.7 | 179.4 | 332.0 | 265.1 | 103.7 | 75.7 | 1,500.4 |
| 1971 | 0.0 | 24.3 | 17.2 | 107.9 | 133.5 | 75.7 | 88.9 | 147.1 | 285.0 | 178.1 | 6.2 | 4.0 | 1,067.9 |
| 1972 | 0.0 | 0.0 | 44.3 | 115.0 | 58.2 | 179.3 | 64.9 | 109.9 | 413.6 | 89.2 | 99.9 | 17.9 | 1,192.2 |
| 1973 | 1.5 | 2.0 | 55.4 | 6.1 | 190.0 | 73.7 | 84.5 | 85.7 | 218.9 | 238.5 | 107.2 | 0.0 | 1,063.5 |
| 1974 | 1.5 | 0.0 | 213.0 | 146.4 | 133.0 | 64.8 | 151.8 | 198.6 | 265.1 | 366.6 | 28.9 | 12.0 | 1,581.7 |
| 1975 | 77.9 | 0.0 | 56.1 | 59.8 | 204.1 | 104.2 | 126.3 | 84.6 | 222.0 | 295.6 | 34.3 | 23.9 | 1,288.8 |
| Mean ($\bar{x}$) | 5.89 | 9.64 | 34.9 | 77.3 | 147.2 | 90.2 | 97.6 | 106.3 | 249.4 | 229.3 | 60.7 | 10.9 | 1,121.5 |
| S | 17.1 | 21.4 | 48.6 | 43.5 | 60.4 | 39.2 | 41.2 | 54.7 | 110.0 | 98.6 | 52.7 | 19.1 | 231.9 |
| S/$\bar{x}$ | 2.90 | 2.22 | 1.39 | 0.55 | 0.41 | 0.43 | 0.42 | 0.51 | 0.44 | 0.43 | 0.87 | 1.75 | 0.206 |

Note: S - Standrad Deviation

Source: Meteorological Department

Table A. 3-14 Rainfall Records in Wet Season (May - October)

(Unit: mm)

| Year | Rainfall in Wet Season: Sing Ha Nat | Rainfall in Wet Season: Lakkhon | Rainfall in Wet Season: Phraya Banlu |
|---|---|---|---|
| 1962 | 1,801.2 | 1,525.8 | |
| 1963 | 1,865.2 | 1,552.2 | |
| 1964 | 1,281.0 | 964.8 | |
| 1965 | 949.9 | 650.6 | 874.6 |
| 1966 | 1,520.9 | 1,242.8 | 1,283.1 |
| 1967 | 907.7 | 591.6 | 912.5 |
| 1968 | 917.9 | 1,122.2 | 870.9 |
| 1969 | 1,147.9 | 1,017.3 | 1,045.3 |
| 1970 | 1,356.8 | 1,458.6 | 1,243.1 |
| 1971 | 1,309.7 | 1,008.2 | 814.1 |
| 1972 | 1,162.3 | 966.5 | 1,378.7 |
| 1973 | 867.8 | 1,039.5 | 1,180.4 |
| 1974 | 1,254.9 | 1,177.4 | 1,293.3 |
| 1975 | 1,350.4 | 1,121.1 | 968.3 |
| 1976 | 1,411.5 | 795.5 | 1,250.8 |
| Mean ($\bar{x}$) | 1,273.7 | 1,082.3 | 1,092.9 |
| S.D. (S) | 292.2 | 276.3 | 191.1 |
| Variation ($S/\bar{x}$) | 0.229 | 0.255 | 0.175 |

Note: S.D. - Standard Deviation

Table A. 3-15 Probable Rainfall in Wet Season (May - October)

(Unit: mm)

| Return Period (years) | Probable Maximum Rainfall: Sing Ha Nat | Lakkhon | Phraya Banlu | Average |
|---|---|---|---|---|
| 2 | 1,227 | 1,045 | 1,076 | 1,116 |
| 5 | 1,512 | 1,324 | 1,259 | 1,365 |
| 10 | 1,697 | 1,498 | 1,367 | 1,521 |
| 15 | 1,800 | 1,593 | 1,424 | 1,606 |
| 20 | 1,871 | 1,658 | 1,463 | 1,664 |
| 25 | 1,927 | 1,709 | 1,492 | 1,709 |
| 30 | 1,971 | 1,749 | 1,516 | 1,745 |
| 40 | 2,042 | 1,812 | 1,552 | 1,802 |
| 50 | 2,096 | 1,860 | 1,579 | 1,845 |

| Return Period (years) | Probable Minimum Rainfall: Sing Ha Nat | Lakkhon | Phraya Banlu | Average |
|---|---|---|---|---|
| 2 | 1,227 | 1,071 | 1,083 | 1,105 |
| 5 | 1,013 | 836 | 922 | 913 |
| 10 | 923 | 720 | 843 | 833 |
| 15 | 883 | 664 | 805 | 797 |
| 20 | 859 | 628 | 781 | 775 |
| 25 | 841 | 601 | 761 | 734 |
| 30 | 828 | 581 | 747 | 718 |
| 40 | 808 | 550 | 726 | 695 |
| 50 | 795 | 527 | 711 | 678 |

Note: Data Source: Table A. 3-14

Table A. 3-16 Rainfall Records in Dry Season (November-March & November-April)

| | Stations | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sing Ha Nat Regulator | | Lakkhon Regulator | | Phraya Banlu Regulator | | Lop Buri | | Suphan Buri | | Bang Kapi (Bangkok) | | Kanchana Buri | |
| Year | Nov-Mar | Nov-Apr | Nov-Mar | Nov-Apr | Nov-Mar | Nov-Apr | Nov-Mar | Nov-Apr | Nov-Mar | Nov-Apr | Nov-Mar | Nov-Apr | Nov-Mar | Nov-Apr |
| 1952 | 201.1 | 201.1 | | | | | | | | | | | | |
| 1953 | 0.0 | 14.3 | | | | | | | | | | | | |
| 1954 | 40.8 | 139.0 | | | | | | | | | | | | |
| 1955 | 39.9 | 186.5 | | | | | 137.0 | 232.0 | 126.5 | 187.8 | 49.5 | 133.2 | 104.0 | 159.1 |
| 1956 | 0.0 | 31.7 | | | | | 31.4 | 123.2 | 82.4 | 172.1 | 165.7 | 316.4 | 73.4 | 161.9 |
| 1957 | 79.7 | - | | | | | 382.4 | 473.8 | 71.2 | 164.0 | 147.1 | 149.8 | 118.3 | 200.1 |
| 1958 | - | - | | | | | 138.8 | 231.2 | 20.8 | 62.2 | 71.7 | 132.3 | 128.0 | 171.8 |
| 1959 | 92.7 | 112.9 | | | | | 76.4 | 84.9 | 115.5 | 139.9 | 55.3 | 57.1 | 49.4 | 73.0 |
| 1960 | 116.5 | 279.4 | | | | | 128.0 | 281.7 | 151.0 | 345.0 | 219.9 | 378.1 | 103.6 | 219.8 |
| 1961 | 144.5 | 202.1 | | | | | 15.7 | 63.2 | 9.9 | 32.7 | 96.6 | 133.0 | 35.0 | 123.3 |
| 1962 | 59.2 | 61.2 | 8.4 | 8.4 | | | 4.1 | 79.3 | 56.4 | 90.8 | 52.0 | 107.5 | 2.3 | 9.4 |
| 1963 | 60.0 | 198.0 | 11.2 | 113.1 | | | 135.6 | 317.7 | 60.0 | 135.3 | 185.3 | 231.2 | 120.0 | 239.1 |
| 1964 | 178.8 | 197.2 | 95.0 | 96.4 | 88.7 | 157.2 | 70.2 | 98.6 | 55.1 | 192.2 | 141.1 | 207.3 | 300.8 | 326.4 |
| 1965 | 52.5 | 83.2 | 69.2 | 69.2 | 170.5 | 186.2 | 237.0 | 327.9 | 110.0 | 203.2 | 81.1 | 153.1 | 55.3 | 93.8 |
| 1966 | 127.7 | 168.2 | 170.6 | 183.2 | 80.0 | 85.6 | 84.1 | 213.8 | 35.7 | 170.5 | 53.9 | 121.5 | 77.7 | 211.5 |
| 1967 | 95.1 | 144.3 | 9.2 | 121.3 | 22.6 | 52.3 | 92.5 | 138.0 | 45.4 | 108.3 | 92.4 | 217.1 | 50.9 | 161.4 |
| 1968 | 49.8 | 67.8 | 183.5 | 197.4 | 142.3 | 147.8 | 143.0 | 147.1 | 92.8 | 219.0 | 70.5 | 82.5 | 57.7 | 183.4 |
| 1969 | 97.3 | 279.4 | 73.7 | 137.1 | 163.2 | 180.0 | 168.6 | 239.3 | 74.0 | 112.8 | 209.2 | 366.7 | 242.1 | 345.8 |
| 1970 | 157.2 | 215.7 | 88.8 | 146.3 | 97.7 | 224.4 | 129.0 | 197.1 | 183.6 | 322.5 | 192.7 | 223.8 | 220.9 | 328.8 |
| 1971 | 29.4 | 192.9 | 43.2 | 140.8 | 11.3 | 191.4 | 33.9 | 125.7 | 26.9 | 98.6 | 42.3 | 189.2 | 54.5 | 159.5 |
| 1972 | 209.9 | 217.4 | 197.0 | 197.0 | 307.4 | 307.4 | 188.9 | 188.9 | 195.9 | 201.7 | 245.7 | 251.3 | 176.7 | 182.8 |
| 1973 | 80.1 | 195.0 | 7.4 | 103.7 | 2.3 | 193.7 | 79.3 | 188.0 | 125.3 | 352.5 | 58.9 | 189.1 | 321.7 | 458.1 |
| 1974 | 113.2 | 121.2 | 90.2 | 90.2 | 176.0 | 176.0 | 125.8 | 156.8 | 136.8 | 147.4 | 206.3 | 210.2 | 174.9 | 234.7 |
| 1975 | 82.4 | 106.0 | 102.9 | 146.6 | 152.4 | 152.1 | | | | | | | | |
| Mean($\bar{x}$) | 91.7 | 155.2 | 82.2 | 125.1 | 117.9 | 172.0 | 120.1 | 195.4 | 89.8 | 172.9 | 125.4 | 192.5 | 123.9 | 203.2 |
| S.D.(S) | 57.0 | 71.7 | 62.0 | 49.6 | 82.9 | 61.2 | 83.3 | 98.0 | 51.2 | 84.8 | 37.7 | 84.9 | 86.9 | 101.3 |
| S/$\bar{x}$ | 0.622 | 0.462 | 0.764 | 0.397 | 0.703 | 0.356 | 0.694 | 0.502 | 0.570 | 0.491 | 0.587 | 0.441 | 0.701 | 0.499 |

Table A. 3-17 Probable Maximum Rainfall in Dry Season

(Unit: mm)

Probable Maximum Rainfall (November - March)

| Return Period (years) | Sing Ha Nat | Lakkhon | Phraya Banlu | Average of Three Stations | Lop Buri | Suphan Buri | Bangkok | Kanchana Buri | Average of Seven Stations |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 83 | * | * | 83 | 108 | 82 | 102 | 111 | 97 |
| 5 | 143 | * | * | 143 | 197 | 137 | 176 | 203 | 171 |
| 10 | 182 | * | * | 182 | 255 | 173 | 236 | 265 | 222 |
| 15 | 205 | * | * | 205 | 289 | 193 | 273 | 300 | 252 |
| 20 | 220 | * | * | 220 | 312 | 208 | 301 | 324 | 273 |
| 25 | 232 | * | * | 232 | 330 | 219 | 323 | 343 | 298 |
| 30 | 242 | * | * | 242 | 344 | 228 | 342 | 358 | 303 |
| 40 | 258 | * | * | 258 | 367 | 242 | 373 | 382 | 324 |
| 50 | 269 | * | * | 269 | 385 | 253 | 398 | 400 | 341 |

Probable Maximum Rainfall (November - April)

| Return Period (years) | Sing Ha Nat | Lakkhon | Phraya Banlu | Average of Three Stations | Lop Buri | Suphan Buri | Bangkok | Kanchana Buri | Average of Seven Stations |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 145 | * | 159 | 152 | 176 | 160 | 178 | 188 | 168 |
| 5 | 220 | * | 233 | 227 | 267 | 251 | 259 | 296 | 254 |
| 10 | 270 | * | 285 | 278 | 330 | 311 | 312 | 368 | 313 |
| 15 | 298 | * | 315 | 307 | 367 | 345 | 342 | 408 | 346 |
| 20 | 318 | * | 337 | 328 | 392 | 368 | 363 | 436 | 369 |
| 25 | 333 | * | 354 | 344 | 412 | 386 | 379 | 458 | 387 |
| 30 | 346 | * | 367 | 357 | 429 | 401 | 392 | 476 | 401 |
| 40 | 365 | * | 389 | 377 | 455 | 425 | 413 | 503 | 425 |
| 50 | 380 | * | 406 | 393 | 475 | 443 | 429 | 525 | 443 |

Note: Data Source; Table A. 3-16
* ; Data distribution on probability analysis sheet is not normal.

Table A. 3-18 Probable Minimum Rainfall in Dry Season

(Unit: mm)

Probable Minimum Rainfall (November - March)

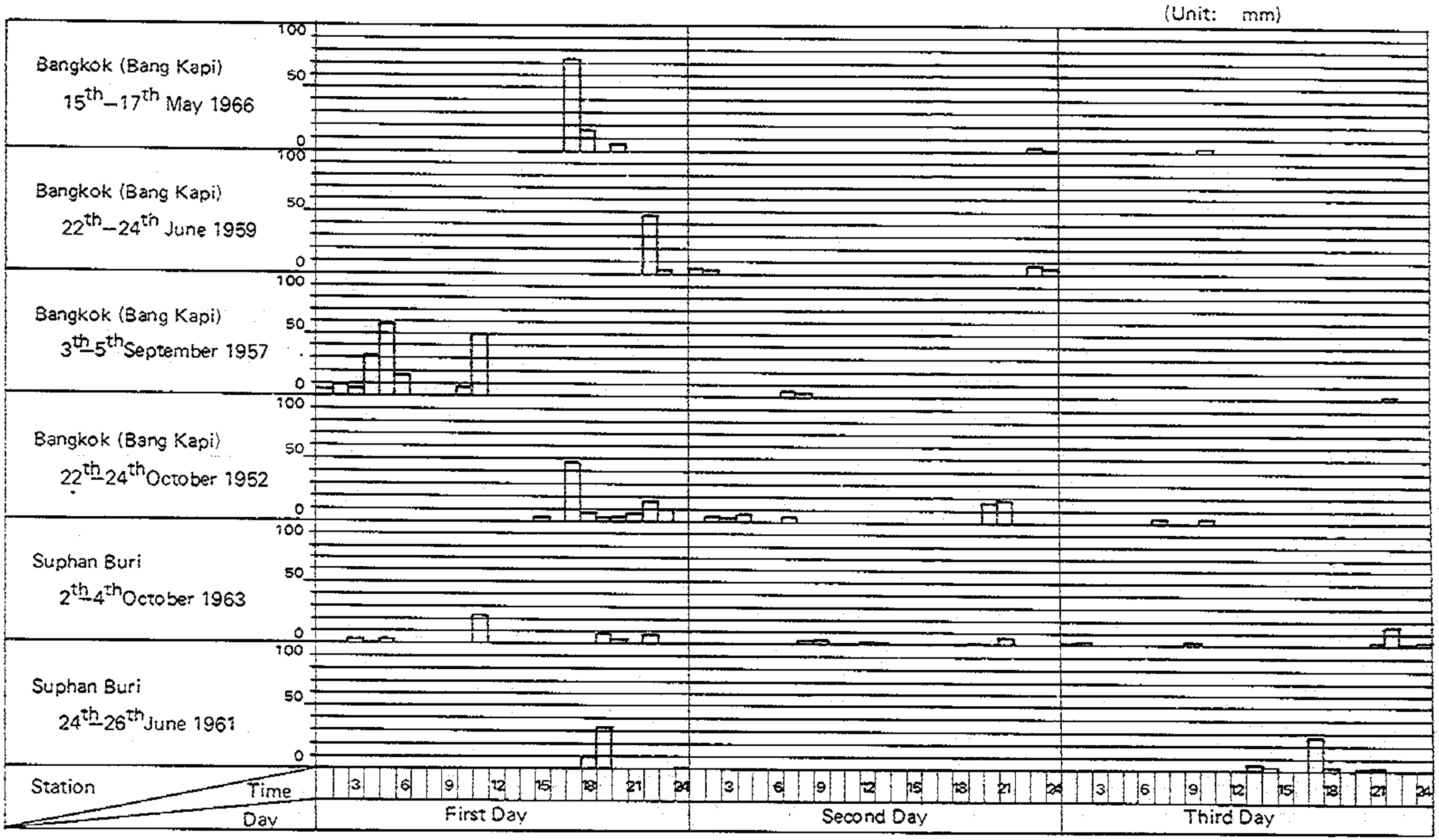
| Return Period (years) | Sing Ha Nat | Lakkhon | Phraya Banlu | Average of Three Stations | Lop Buri | Suphan Buri | Bangkok | Kanchana Buri | Average of Seven Stations |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 75.1 | 57.5 | 89.2 | 73.9 | 99.7 | 79.1 | 102.4 | 97.3 | 85.8 |
| 5 | 35.4 | 21.5 | 34.9 | 30.6 | 48.5 | 43.0 | 61.9 | 46.8 | 41.7 |
| 10 | 21.6 | 11.1 | 17.8 | 16.8 | 29.9 | 28.8 | 48.5 | 30.2 | 26.8 |
| 15 | 16.0 | 7.2 | 11.7 | 11.6 | 22.2 | 22.6 | 43.3 | 23.7 | 21.0 |
| 20 | 12.8 | 5.1 | 7.4 | 8.4 | 17.7 | 18.9 | 40.3 | 20.0 | 17.5 |
| 25 | 10.6 | 3.7 | 4.9 | 6.4 | 14.5 | 16.4 | 38.2 | 17.5 | 15.1 |
| 30 | 8.9 | 2.7 | 3.1 | 4.9 | 12.2 | 14.4 | 36.7 | 15.6 | 13.4 |
| 40 | 6.6 | 1.3 | 0.5 | 2.8 | 8.9 | 11.6 | 34.6 | 13.0 | 10.9 |
| 50 | 5.0 | 0.3 | 0 | 1.8 | 6.6 | 9.6 | 33.2 | 11.2 | 9.4 |

Probable Minimum Rainfall (November - April)

| Return Period (years) | Sing Ha Nat | Lakkhon | Phraya Banlu | Average of Three Stations | Lop Buri | Suphan Buri | Bangkok | Kanchana Buri | Average of Seven Stations |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 148.8 | 105.5 | 167.0 | 140.4 | 176.0 | 158.9 | 178.2 | 185.9 | 160.0 |
| 5 | 89.6 | 54.3 | 116.1 | 86.7 | 112.7 | 98.9 | 118.6 | 110.8 | 100.1 |
| 10 | 62.1 | 38.4 | 92.2 | 64.2 | 87.8 | 74.0 | 93.9 | 79.8 | 75.5 |
| 15 | 49.2 | 32.3 | 80.9 | 54.1 | 77.1 | 62.9 | 83.6 | 66.1 | 64.6 |
| 20 | 41.0 | 28.8 | 73.8 | 47.9 | 70.6 | 56.1 | 76.3 | 57.7 | 57.8 |
| 25 | 34.9 | 26.5 | 68.5 | 43.3 | 66.0 | 51.3 | 71.5 | 51.8 | 52.9 |
| 30 | 30.4 | 24.8 | 64.5 | 39.9 | 62.6 | 47.7 | 68.0 | 47.3 | 49.3 |
| 40 | 23.6 | 22.5 | 58.5 | 34.9 | 57.7 | 42.4 | 62.7 | 40.8 | 44.0 |
| 50 | 18.7 | 20.9 | 54.2 | 31.3 | 54.2 | 38.6 | 59.0 | 36.1 | 40.2 |

Note: Data Source; Table A. 3-16

FIGURE A. 3-2 HOURLY HYETGRAPH OF OBSERVED RAINFALLS




Source: Meteorological Department

Table A. 3-19 Probable Maximum Consecutive Rainfall

(unit: mm)

| Station | Return Period 2 years | 5 years | 10 years | 15 years | 20 years | 30 years | 50 years |
|---|---|---|---|---|---|---|---|
| **Maximum 1 day rainfall** | | | | | | | |
| Lop Buri | ( 85) | (111) | | | (144) | | |
| | 84 | 111 | 128 | 138 | 145 | 155 | 167 |
| Suphan Buri | ( 92) | (115) | | | (141) | | |
| | 89 | 109 | 121 | 127 | 132 | 138 | 146 |
| Kanchana Buri | ( 90) | (121) | | | (159) | | |
| | 89 | 120 | 141 | 153 | 161 | 173 | 188 |
| Bang Kapi | ( 92) | (115) | | | (141) | | |
| (Bangkok) | 92 | 115 | 129 | 136 | 141 | 148 | 156 |
| Sing Ha Nat | 92 | 123 | 146 | 160 | 169 | 183 | 201 |
| Phraya Banlu | 90 | 119 | 143 | 159 | 172 | 191 | 216 |
| Lakkhon | 88 | 113 | 128 | 136 | 142 | 150 | 160 |
| Average | 89 | 116 | 134 | 144 | 152 | 163 | 176 |
| **Maximum 2 day rainfall** | | | | | | | |
| Lop Buri | ( 98) | (127) | | | (172) | | |
| | 98 | 126 | 147 | 159 | 169 | 182 | 199 |
| Suphan Buri | (114) | (135) | | | (156) | | |
| | 111 | 135 | 150 | 158 | 163 | 171 | 180 |
| Kanchana Buri | (113) | (152) | | | (202) | | |
| | 112 | 151 | 177 | 192 | 202 | 217 | 236 |
| Bang Kapi | (117) | (153) | | | (199) | | |
| (Bangkok) | 115 | 151 | 177 | 192 | 203 | 219 | 239 |
| Sing Ha Nat | 124 | 164 | 189 | 203 | 213 | 227 | 224 |
| Phraya Banlu | 126 | 167 | 196 | 213 | 225 | 242 | 264 |
| Lakkhon | 116 | 155 | 181 | 195 | 204 | 218 | 235 |
| Average | 115 | 150 | 174 | 187 | 197 | 211 | 228 |
| **Maximum 3 day rainfall** | | | | | | | |
| Lop Buri | (113) | (147) | | | (196) | | |
| | 112 | 146 | 171 | 185 | 196 | 211 | 230 |
| Suphan Buri | (129) | (165) | | | (209) | | |
| | 127 | 164 | 189 | 203 | 213 | 228 | 245 |
| Kanchana Buri | (134) | (181) | | | (236) | | |
| | 132 | 179 | 209 | 226 | 238 | 254 | 274 |
| Bang Kapi | (140) | (186) | | | (248) | | |
| (Bangkok) | 140 | 185 | 215 | 232 | 244 | 261 | 273 |
| Sing Ha Nat | 141 | 192 | 225 | 244 | 257 | 275 | 298 |
| Phraya Banlu | 147 | 196 | 228 | 246 | 259 | 277 | 299 |
| Lakkhon | 134 | 181 | 210 | 225 | 236 | 251 | 270 |
| Average | 133 | 178 | 207 | 223 | 235 | 251 | 270 |

Note: 1. Observation Period
1952-1975 at four stations
Lop Buri, Suphan Buri, Kanchana Buri and Bang Kapi
1962-1976 at Sing Ha Nat and Lakkhon
1962-1976 (except 1963) at Phraya Banlu

2. Numbers indicated in ( ) are estimated by Harzen Method in Royal Irrigation Department.

Table A. 3-20 Monthly Mean Rainy Days

(Unit: day)

| Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monthly Mean Rainy Days | | | | | | | | | | | | |
| (1) Sing Ha Nat | 0.7 | 1.1 | 1.5 | 4.6 | 10.5 | 11.1 | 13.1 | 14.7 | 16.3 | 11.5 | 3.6 | 1.4 | 90.1 |
| (2) Lakkhon | 0.2 | 0.4 | 0.9 | 2.2 | 6.9 | 8.3 | 8.3 | 10.0 | 13.2 | 9.4 | 2.3 | 0.6 | 62.7 |
| (3) Phraya Banlu | 0.5 | 0.5 | 1.1 | 3.0 | 8.4 | 8.4 | 8.1 | 10.3 | 14.9 | 10.9 | 3.4 | 1.0 | 70.5 |
| (4) Lop Buri | 0.9 | 1.7 | 3.0 | 6.6 | 13.0 | 14.2 | 16.4 | 17.0 | 18.7 | 13.3 | 4.3 | 1.6 | 110.7 |
| (5) Suphan Buri | 0.7 | 1.2 | 2.2 | 5.7 | 12.4 | 11.9 | 14.2 | 16.0 | 19.2 | 13.6 | 3.9 | 1.3 | 102.3 |
| (6) Bangkok | 1.5 | 2.9 | 3.5 | 6.8 | 16.4 | 16.2 | 18.5 | 20.9 | 21.6 | 17.4 | 5.5 | 1.8 | 133.0 |
| (7) Kanchana Buri | 0.9 | 1.2 | 2.7 | 6.5 | 13.5 | 12.9 | 15.5 | 17.3 | 17.9 | 15.2 | 5.2 | 2.0 | 110.8 |
| Mean (1) | 0.5 | 0.7 | 1.2 | 3.3 | 8.7 | 9.3 | 9.8 | 11.7 | 14.8 | 10.6 | 3.1 | 1.0 | 74.7 |
| Mean (2) | 0.8 | 1.3 | 2.1 | 5.1 | 11.6 | 11.9 | 13.4 | 15.2 | 17.4 | 13.0 | 4.0 | 1.4 | 97.2 |

Note: Mean (1): Average of Sing Ha Nat, Lakkhon and Phraya Banlu
Mean (2): Average of Seven Stations

Source: (1)-(3) Royal Irrigation Department
Sing Ha Nat : 14 years (1962 - 1975)
Lakkhon : 13 years (1963 - 1975)
Phraya Banlu: 11 years (1965 - 1975)

(4)-(7) Meteorological Department: 20 years (1956 - 1975)

Table A. 3-21 Monthly Rainy Days in the Vicinity of Project Area

Station: Sing Ha Nat Regulator

(Unit: days)

| Year | Monthly Rainy Days | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
| 1962 | 0 | 1 | 1 | 5 | 11 | 6 | 14 | 15 | 21 | 11 | 2 | 0 | 87 |
| 1963 | 0 | 0 | 1 | 1 | 4 | 11 | 10 | 15 | 20 | 16 | 3 | 0 | 96 |
| 1964 | 0 | 1 | 1 | 6 | 18 | 14 | 16 | 13 | 11 | 7 | 2 | 1 | 90 |
| 1965 | 0 | 2 | 3 | 4 | 12 | 11 | 8 | 11 | 22 | 12 | 3 | 1 | 89 |
| 1966 | 1 | 1 | 0 | 4 | 17 | 13 | 18 | 19 | 14 | 12 | 4 | 4 | 107 |
| 1967 | 1 | 0 | 1 | 9 | 8 | 9 | 18 | 12 | 17 | 12 | 3 | 0 | 90 |
| 1968 | 0 | 4 | 1 | 12 | 10 | 7 | 11 | 13 | 11 | 6 | 3 | 0 | 78 |
| 1969 | 2 | 0 | 1 | 2 | 3 | 14 | 13 | 18 | 14 | 12 | 4 | 0 | 83 |
| 1970 | 0 | 2 | 2 | 4 | 13 | 14 | 13 | 14 | 18 | 14 | 1 | 6 | 101 |
| 1971 | 0 | 2 | 1 | 4 | 10 | 13 | 8 | 20 | 14 | 11 | 0 | 1 | 84 |
| 1972 | 0 | 1 | 2 | 6 | 3 | 12 | 8 | 8 | 17 | 9 | 10 | 3 | 79 |
| 1973 | 0 | 0 | 3 | 1 | 10 | 14 | 15 | 16 | 18 | 7 | 5 | 1 | 90 |
| 1974 | 1 | 0 | 1 | 7 | 11 | 7 | 14 | 12 | 15 | 19 | 6 | 0 | 93 |
| 1975 | 5 | 0 | 2 | 1 | 11 | 13 | 12 | 15 | 18 | 13 | 5 | 2 | 97 |
| 1976 | 0 | 2 | 2 | 3 | 16 | 9 | 18 | 19 | 15 | 12 | | | |
| Mean ($\bar{x}$) | 0.667 | 1.07 | 1.47 | 4.60 | 10.5 | 11.1 | 13.1 | 14.7 | 16.3 | 11.5 | 3.60 | 1.36 | 90.3 |
| S | 1.30 | 1.12 | 0.806 | 2.98 | 4.47 | 2.75 | 3.45 | 3.24 | 3.20 | 3.30 | 2.35 | 1.76 | 7.85 |
| S/$\bar{x}$ | 1.948 | 1.05 | 0.548 | 0.649 | 0.426 | 0.248 | 0.264 | 0.220 | 0.196 | 0.287 | 0.652 | 1.29 | 0.087 |

Note: S - Standard Deviation

Source: Sing Ha Nat and Phraya Banlu Project Offices, RID

Table A. 3-22 Monthly Rainy Days in the Vicinity of Project Area

Station: Lakkhon Regulator

(Unit: days)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1963 | 0 | 0 | 0 | 0 | 2 | 8 | 9 | 13 | 18 | 15 | 1 | 0 | 66 |
| 1964 | 0 | 0 | 0 | 2 | 13 | 10 | 10 | 10 | 10 | 5 | 0 | 1 | 61 |
| 1965 | 0 | 1 | 2 | 1 | 9 | 6 | 1 | 8 | 16 | 6 | 1 | 0 | 51 |
| 1966 | 0 | 3 | 1 | 0 | 10 | 8 | 12 | 11 | 9 | 11 | 4 | 3 | 72 |
| 1967 | 1 | 0 | 1 | 1 | 8 | 6 | 13 | 5 | 13 | 9 | 0 | 0 | 56 |
| 1968 | 0 | 1 | 1 | 5 | 10 | 5 | 7 | 10 | 12 | 9 | 3 | 0 | 63 |
| 1969 | 1 | 0 | 2 | 1 | 3 | 9 | 7 | 13 | 11 | 8 | 4 | 0 | 59 |
| 1970 | 0 | 0 | 1 | 3 | 9 | 13 | 11 | 11 | 8 | 12 | 1 | 2 | 71 |
| 1971 | 0 | 0 | 2 | 4 | 6 | 5 | 7 | 16 | 16 | 6 | 0 | 0 | 62 |
| 1972 | 0 | 0 | 1 | 6 | 1 | 9 | 4 | 5 | 14 | 10 | 6 | 2 | 58 |
| 1973 | 0 | 0 | 0 | 0 | 6 | 11 | 7 | 9 | 13 | 7 | 1 | 0 | 54 |
| 1974 | 0 | 0 | 0 | 6 | 3 | 7 | 11 | 8 | 18 | 17 | 6 | 0 | 76 |
| 1975 | 1 | 0 | 1 | 0 | 9 | 9 | 9 | 11 | 13 | 7 | 3 | 0 | 63 |
| Mean($\bar{x}$) | 0.231 | 0.385 | 0.923 | 2.23 | 6.85 | 8.25 | 8.31 | 10.0 | 13.2 | 9.38 | 2.31 | 0.615 | 62.5 |
| S | 0.421 | 0.836 | 0.730 | 2.22 | 3.53 | 2.28 | 3.20 | 2.99 | 3.08 | 3.45 | 2.09 | 1.00 | 7.01 |
| S/$\bar{x}$ | 1.82 | 2.17 | 0.79 | 1.00 | 0.52 | 0.28 | 0.39 | 0.30 | 0.23 | 0.37 | 0.90 | 1.63 | 0.11 |

Station: Phraya Banlu Regulator

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1965 | 0 | 2 | 0 | 5 | 12 | 10 | 8 | 10 | 16 | 9 | 2 | 3 | 77 |
| 1966 | 0 | 0 | 1 | 1 | 13 | 4 | 8 | 17 | 12 | 10 | 3 | 2 | 71 |
| 1967 | 0 | 0 | 0 | 1 | 10 | 4 | 10 | 6 | 16 | 7 | 2 | 0 | 56 |
| 1968 | 0 | 2 | 1 | 4 | 8 | 7 | 5 | 8 | 12 | 6 | 3 | 0 | 56 |
| 1969 | 1 | 0 | 2 | 1 | 6 | 8 | 8 | 12 | 12 | 11 | 3 | 0 | 64 |
| 1970 | 0 | 0 | 1 | 2 | 9 | 15 | 10 | 11 | 15 | 10 | 1 | 4 | 78 |
| 1971 | 0 | 0 | 1 | 5 | 2 | 4 | 6 | 14 | 14 | 11 | 0 | 0 | 57 |
| 1972 | 0 | 0 | 2 | 4 | 4 | 10 | 8 | 7 | 19 | 14 | 10 | 2 | 84 |
| 1973 | 0 | 1 | 3 | [illegible] | 10 | 13 | 11 | 10 | 16 | 7 | 0 | 0 | 71 |
| 1974 | 0 | 0 | 1 | 6 | 7 | 8 | 10 | 13 | 15 | 18 | 10 | 0 | 89 |
| 1975 | 5 | 1 | 0 | 0 | 11 | 9 | 5 | 5 | 16 | 17 | 3 | 0 | 72 |
| Mean($\bar{x}$) | 0.545 | 0.545 | 1.09 | 3.00 | 8.36 | 8.36 | 8.09 | 10.3 | 14.9 | 10.9 | 3.36 | 1.00 | 70.5 |
| S | 1.44 | 0.782 | 0.900 | 2.59 | 3.23 | 3.44 | 1.98 | 3.47 | 2.11 | 3.78 | 3.31 | 1.41 | 10.7 |
| S/$\bar{x}$ | 2.64 | 1.43 | 0.83 | 0.86 | 0.39 | 0.41 | 0.24 | 0.34 | 0.14 | 0.35 | 0.99 | 1.41 | 0.15 |

Table A. 3-23 Monthly Rainy Days Record

Station: Lop Buri

(Unit: days)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monthly Rainy Days | | | | | | | | | | | | |
| 1956 | 0 | 3 | 4 | 13 | 15 | 13 | 17 | 16 | 19 | 8 | 2 | 0 | 110 |
| 1957 | 0 | 1 | 0 | 4 | 2 | 12 | 16 | 15 | 19 | 17 | 4 | 0 | 90 |
| 1958 | 1 | 0 | 6 | 7 | 11 | 16 | 13 | 21 | 16 | 9 | 0 | 0 | 100 |
| 1959 | 1 | 3 | 5 | 9 | 17 | 12 | 17 | 13 | 24 | 13 | 4 | 1 | 119 |
| 1960 | 0 | 1 | 3 | 2 | 12 | 11 | 13 | 16 | 18 | 14 | 9 | 1 | 100 |
| 1961 | 0 | 4 | 5 | 9 | 16 | 16 | 19 | 20 | 16 | 23 | 2 | 1 | 131 |
| 1962 | 0 | 0 | 2 | 9 | 15 | 16 | 20 | 21 | 21 | 8 | 2 | 2 | 116 |
| 1963 | 0 | 0 | 3 | 4 | 8 | 19 | 16 | 18 | 21 | 16 | 11 | 1 | 117 |
| 1964 | 2 | 3 | 1 | 7 | 21 | 11 | 12 | 18 | 20 | 18 | 3 | 2 | 118 |
| 1965 | 0 | 2 | 1 | 7 | 17 | 16 | 19 | 20 | 19 | 13 | 8 | 2 | 124 |
| 1966 | 3 | 2 | 1 | 6 | 22 | 9 | 17 | 21 | 18 | 16 | 4 | 4 | 123 |
| 1967 | 1 | 1 | 0 | 9 | 13 | 13 | 22 | 14 | 20 | 13 | 3 | 0 | 109 |
| 1968 | 0 | 4 | 2 | 7 | 12 | 18 | 20 | 15 | 19 | 10 | 1 | 1 | 109 |
| 1969 | 2 | 0 | 3 | 3 | 8 | 15 | 22 | 14 | 18 | 13 | 3 | 1 | 102 |
| 1970 | 0 | 3 | 6 | 6 | 14 | 20 | 18 | 19 | 17 | 10 | 2 | 6 | 121 |
| 1971 | 0 | 3 | 2 | 7 | 13 | 17 | 14 | 19 | 16 | 11 | 2 | 1 | 105 |
| 1972 | 0 | 2 | 3 | 9 | 3 | 14 | 13 | 16 | 18 | 13 | 12 | 5 | 108 |
| 1973 | 0 | 0 | 4 | 0 | 13 | 12 | 14 | 13 | 20 | 8 | 4 | 1 | 89 |
| 1974 | 0 | 0 | 5 | 10 | 14 | 8 | 17 | 14 | 20 | 18 | 5 | 1 | 112 |
| 1975 | 8 | 1 | 3 | 3 | 14 | 15 | 8 | 17 | 15 | 14 | 4 | 2 | 104 |
| Mean($\bar{x}$) | 0.900 | 1.650 | 2.950 | 6.550 | 13.000 | 14.150 | 16.350 | 17.000 | 18.700 | 13.250 | 4.250 | 1.600 | 110.350 |
| S | 1.841 | 1.388 | 1.802 | 3.057 | 4.868 | 3.135 | 3.482 | 2.702 | 2.076 | 3.858 | 3.176 | 1.594 | 10.795 |
| S/$\bar{x}$ | 2.046 | 0.841 | 0.611 | 0.467 | 0.374 | 0.222 | 0.213 | 0.159 | 0.111 | 0.291 | 0.747 | 0.996 | 0.098 |

Note: S - Standard Deviation
A rainy day is one with an amount of rainfall of 0.1 mm or more.

Source: Meteorological Department

Table A. 3-24 Monthly Rainy Days Record

Station: Suphan Buri (Unit: days)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monthly Rainy Days | | | | | | | | | | | | |
| 1956 | 0 | 2 | 4 | 7 | 17 | 12 | 17 | 16 | 16 | 8 | 2 | 0 | 101 |
| 1957 | 0 | 0 | 4 | 5 | 4 | 14 | 9 | 22 | 24 | 18 | 6 | 0 | 106 |
| 1958 | 0 | 2 | 0 | 5 | 9 | 11 | 12 | 15 | 18 | 11 | 0 | 0 | 83 |
| 1959 | 0 | 2 | 1 | 6 | 12 | 7 | 13 | 12 | 20 | 12 | 2 | 1 | 88 |
| 1960 | 0 | 1 | 6 | 1 | 9 | 9 | 11 | 9 | 21 | 15 | 11 | 0 | 93 |
| 1961 | 1 | 0 | 3 | 6 | 17 | 9 | 15 | 18 | 10 | 18 | 1 | 1 | 99 |
| 1962 | 0 | 1 | 0 | 8 | 12 | 11 | 11 | 12 | 22 | 12 | 1 | 0 | 90 |
| 1963 | 0 | 0 | 3 | 2 | 6 | 14 | 13 | 17 | 19 | 17 | 5 | 1 | 97 |
| 1964 | 0 | 2 | 1 | 5 | 22 | 8 | 16 | 16 | 14 | 12 | 7 | 1 | 104 |
| 1965 | 0 | 4 | 0 | 6 | 13 | 15 | 14 | 18 | 21 | 12 | 3 | 3 | 109 |
| 1966 | 2 | 0 | 0 | 6 | 21 | 11 | 13 | 18 | 17 | 11 | 0 | 4 | 103 |
| 1967 | 1 | 0 | 1 | 7 | 13 | 10 | 15 | 16 | 23 | 13 | 1 | 0 | 100 |
| 1968 | 1 | 5 | 1 | 10 | 10 | 9 | 13 | 15 | 19 | 9 | 3 | 0 | 95 |
| 1969 | 0 | 1 | 3 | 7 | 7 | 12 | 18 | 12 | 22 | 13 | 4 | 0 | 99 |
| 1970 | 1 | 1 | 2 | 7 | 18 | 19 | 18 | 22 | 21 | 16 | 2 | 5 | 132 |
| 1971 | 1 | 2 | 1 | 8 | 24 | 12 | 15 | 17 | 17 | 13 | 2 | 3 | 105 |
| 1972 | 0 | 1 | 4 | 6 | 3 | 11 | 15 | 14 | 19 | 15 | 10 | 3 | 101 |
| 1973 | 0 | 0 | 3 | 2 | 13 | 16 | 15 | 16 | 22 | 7 | 5 | 1 | 100 |
| 1974 | 1 | 0 | 4 | 8 | 13 | 15 | 21 | 18 | 22 | 21 | 6 | 0 | 129 |
| 1975 | 6 | 0 | 2 | 2 | 15 | 12 | 10 | 16 | 17 | 18 | 7 | 3 | 108 |
| Mean($\bar{x}$) | 0.700 | 1.200 | 2.150 | 5.700 | 12.400 | 11.850 | 14.200 | 15.950 | 19.200 | 13.550 | 3.900 | 1.300 | 102.100 |
| S | 1.345 | 1.364 | 1.682 | 2.304 | 5.044 | 2.886 | 2.874 | 3.106 | 3.295 | 3.570 | 3.081 | 1.552 | 11.463 |
| S/$\bar{x}$ | 1.921 | 1.137 | 0.782 | 0.404 | 0.407 | 0.244 | 0.202 | 0.195 | 0.172 | 0.263 | 0.790 | 1.194 | 0.112 |

Note: S - Standard Deviation
A rainy day is one with an amount of rainfall of 0.1 mm or more.

Source: Meteorological Department

Table A. 3-25 Monthly Rainy Days Record

Station: Bangkok

(Unit: days)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monthly Rainy Days | | | | | | | | | | | | |
| 1956 | 2 | 1 | 0 | 14 | 20 | 17 | 16 | 23 | 25 | 13 | 4 | 0 | 135 |
| 1957 | 2 | 2 | 7 | 7 | 8 | 17 | 16 | 25 | 25 | 18 | 6 | 0 | 133 |
| 1958 | 4 | 5 | 3 | 4 | 10 | 16 | 20 | 22 | 20 | 20 | 1 | 0 | 125 |
| 1959 | 0 | 2 | 4 | 3 | 14 | 11 | 23 | 18 | 21 | 19 | 3 | 0 | 118 |
| 1960 | 0 | 0 | 4 | 1 | 13 | 13 | 16 | 21 | 26 | 17 | 10 | 2 | 123 |
| 1961 | 1 | 8 | 8 | 6 | 18 | 17 | 18 | 21 | 17 | 16 | 3 | 1 | 134 |
| 1962 | 0 | 2 | 3 | 7 | 12 | 14 | 19 | 20 | 25 | 14 | 5 | 0 | 121 |
| 1963 | 0 | 3 | 1 | 2 | 8 | 18 | 19 | 23 | 22 | 23 | 11 | 1 | 131 |
| 1964 | 3 | 3 | 2 | 9 | 25 | 15 | 19 | 25 | 22 | 19 | 7 | 2 | 151 |
| 1965 | 1 | 7 | 2 | 5 | 20 | 15 | 15 | 22 | 28 | 22 | 3 | 3 | 143 |
| 1966 | 0 | 3 | 1 | 4 | 22 | 22 | 22 | 24 | 20 | 15 | 3 | 5 | 141 |
| 1967 | 3 | 0 | 2 | 12 | 21 | 9 | 19 | 18 | 20 | 13 | 5 | 0 | 122 |
| 1968 | 2 | 8 | 2 | 10 | 11 | 17 | 19 | 15 | 16 | 16 | 7 | 0 | 123 |
| 1969 | 2 | 1 | 2 | 4 | 18 | 19 | 19 | 17 | 20 | 15 | 4 | 1 | 122 |
| 1970 | 3 | 3 | 4 | 10 | 17 | 19 | 23 | 23 | 21 | 15 | 2 | 10 | 150 |
| 1971 | 0 | 5 | 4 | 5 | 22 | 16 | 18 | 24 | 20 | 15 | 1 | 2 | 132 |
| 1972 | 0 | 2 | 4 | 15 | 17 | 20 | 19 | 17 | 21 | 20 | 16 | 5 | 156 |
| 1973 | 0 | 0 | 9 | 2 | 18 | 16 | 14 | 20 | 25 | 15 | 5 | 1 | 125 |
| 1974 | 1 | 0 | 4 | 13 | 17 | 13 | 18 | 22 | 19 | 23 | 9 | 0 | 139 |
| 1975 | 6 | 2 | 3 | 2 | 17 | 19 | 18 | 18 | 19 | 20 | 4 | 2 | 130 |
| Mean($\bar{x}$) | 1.500 | 2.850 | 3.450 | 6.750 | 16.400 | 16.150 | 18.500 | 20.900 | 21.600 | 17.400 | 5.450 | 1.750 | 132.700 |
| S | 1.628 | 2.475 | 2.247 | 4.229 | 4.695 | 3.038 | 2.335 | 2.844 | 3.056 | 3.105 | 3.626 | 2.426 | 10.720 |
| S/$\bar{x}$ | 1.085 | 0.868 | 0.651 | 0.627 | 0.286 | 0.188 | 0.126 | 0.136 | 0.141 | 0.178 | 0.665 | 1.386 | 0.081 |

Note: S - Standard Deviation
A rainy day is one with an amount of rainfall of 0.1 mm or more

Source: Meteorological Department

Table A. 3-26 Monthly Rainy Days Record

Station: Kanchana Buri

(Unit: days)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monthly Rainy Days | | | | | | | | | | | | |
| 1956 | 0 | 0 | 3 | 7 | 19 | 13 | 10 | 20 | 21 | 14 | 4 | 0 | 111 |
| 1957 | 0 | 0 | 0 | 5 | 5 | 12 | 17 | 19 | 23 | 17 | 2 | 0 | 100 |
| 1958 | 0 | 2 | 5 | 3 | 13 | 13 | 18 | 16 | 21 | 19 | 1 | 0 | 111 |
| 1959 | 1 | 2 | 7 | 6 | 12 | 13 | 20 | 13 | 21 | 17 | 6 | 2 | 120 |
| 1960 | 1 | 1 | 3 | 2 | 15 | 13 | 9 | 16 | 16 | 14 | 7 | 2 | 99 |
| 1961 | 1 | 0 | 2 | 5 | 16 | 10 | 16 | 15 | 11 | 15 | 2 | 0 | 93 |
| 1962 | 0 | 0 | 1 | 6 | 7 | 13 | 13 | 14 | 12 | 10 | 1 | 1 | 78 |
| 1963 | 0 | 0 | 0 | 1 | 6 | 11 | 21 | 18 | 17 | 20 | 9 | 2 | 105 |
| 1964 | 0 | 2 | 0 | 5 | 22 | 12 | 19 | 17 | 18 | 15 | 9 | 2 | 121 |
| 1965 | 2 | 1 | 5 | 7 | 18 | 15 | 12 | 24 | 19 | 10 | 8 | 6 | 127 |
| 1966 | 0 | 3 | 1 | 6 | 20 | 8 | 14 | 21 | 20 | 15 | 5 | 3 | 116 |
| 1967 | 0 | 0 | 0 | 9 | 14 | 9 | 15 | 16 | 13 | 18 | 3 | 0 | 97 |
| 1968 | 0 | 4 | 0 | 11 | 10 | 13 | 13 | 7 | 17 | 15 | 3 | 1 | 94 |
| 1969 | 1 | 1 | 4 | 5 | 13 | 13 | 12 | 17 | 17 | 13 | 5 | 1 | 102 |
| 1970 | 0 | 3 | 3 | 8 | 13 | 13 | 22 | 21 | 20 | 13 | 2 | 7 | 125 |
| 1971 | 0 | 3 | 5 | 8 | 16 | 15 | 15 | 20 | 17 | 17 | 3 | 3 | 122 |
| 1972 | 0 | 0 | 4 | 9 | 6 | 18 | 18 | 17 | 19 | 15 | 16 | 7 | 129 |
| 1973 | 1 | 1 | 2 | 3 | 11 | 10 | 16 | 15 | 22 | 10 | 6 | 0 | 97 |
| 1974 | 1 | 0 | 5 | 16 | 16 | 19 | 16 | 19 | 21 | 16 | 5 | 1 | 135 |
| 1975 | 9 | 0 | 4 | 7 | 18 | 14 | 14 | 20 | 13 | 20 | 7 | 2 | 128 |
| Mean($\bar{x}$) | 0.850 | 1.150 | 2.700 | 6.450 | 13.500 | 12.850 | 15.500 | 17.250 | 17.900 | 15.150 | 5.200 | 2.000 | 110.500 |
| S | 1.956 | 1.276 | 2.100 | 3.263 | 4.770 | 2.594 | 3.428 | 3.548 | 3.390 | 2.937 | 3.487 | 2.191 | 14.898 |
| S/$\bar{x}$ | 2.301 | 1.110 | 0.778 | 0.506 | 0.353 | 0.202 | 0.221 | 0.206 | 0.189 | 0.194 | 0.671 | 1.096 | 0.135 |

Note: S - Standard Deviation
A rainy day is one with an amount of rainfall

Source: Meteorological Department

Table A. 3-27 Maximum Drought Days in Wet Season

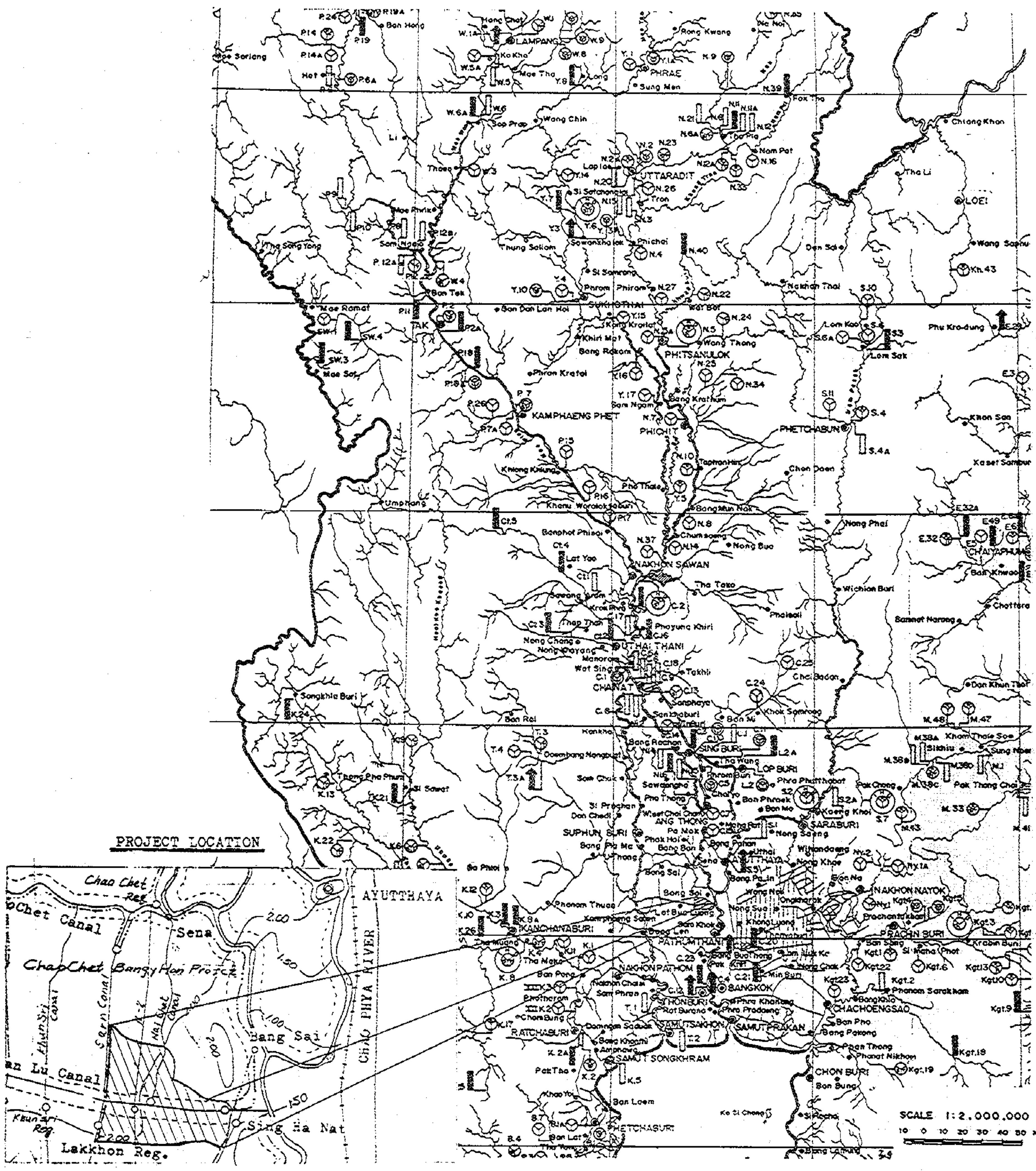
(Unit: days)

| Year | Sing Ha Nat Drought | Sing Ha Nat Period | Lakkhon Drought | Lakkhon Period | Phraya Banlu Drought | Phraya Banlu Period |
|---|---|---|---|---|---|---|
| 1962 | 15 | 6 Oct. - 30 Oct. | 13 | 12 May - 2 Jun. | | |
| 1963 | 15 | 4 May - 18 May | 15 | 4 May - 18 May | | |
| 1964 | 8 | 1 Sep. - 8 Sep. | 14 | 4 Oct. - 17 Oct. | | |
| 1965 | 16 | 29 Jun. - 14 Jul. | 34 | 25 Jun. - 25 Jul. | 13 | 9 Oct. - 22 Oct. |
| 1966 | 6 | 26 Jul. - 31 Jul. | 15 | 22 May - 5 Jun. | 12 | 22 Jun. - 2 Jul. |
| 1967 | 11 | 5 May - 15 May | 17 | 17 Aug. - 2 Sep. | 22 | 29 May - 19 Jun. |
| 1968 | 22 | 11 May - 1 Jun. | 21 | 13 May - 2 Jun. | 21 | 12 May - 1 Jun. |
| 1969 | 15 | 7 May - 21 May | 15 | 7 May - 21 May | 19 | 14 Jul. - 2 Aug. |
| 1970 | 11 | 1 May - 11 May | 15 | 27 Aug. - 10 Sep. | 10 | 3 May - 12 May |
| 1971 | 10 | 4 Jul. - 13 Jul. | 15 | 1 May - 15 May | 18 | 1 May - 18 May |
| 1972 | 22 | 21 Jun. - 13 Aug. | 30 | 1 May - 30 May | 16 | 1 May - 16 May |
| 1973 | 22 | 10 Oct. - 31 Oct. | 16 | 9 Oct. - 25 Oct. | 16 | 10 Oct. - 25 Oct. |
| 1974 | 10 | 1 May - 10 May | 13 | 13 Aug. - 25 Aug. | 12 | 3 May - 14 May |
| 1975 | 11 | 13 May - 23 May | 10 | 29 Jul. - 7 Aug. | 18 | 27 Jul. - 13 Aug. |
| 1976 | 12 | 13 Jun. - 25 Jun. | 21 | 4 Jul. - 24 Jul. | 10 | 16 Jun. - 25 Jun. |
| Mean | 13.7 | | 17.6 | | 15.6 | |

| | Sing Ha Nat | Lakkhon | Phraya Banlu |
|---|---|---|---|
| May | 7 times (46.7 %) | 7 times (46.7 %) | 6 times (50.0 %) |
| June | 3 " (20.0 ) | 1 " ( 6.7 ) | 2 " (16.7 ) |
| July | 2 " (13.3 ) | 2 " (13.3 ) | 2 " (16.7 ) |
| August | 0 " ( - ) | 3 " (20.0 ) | 0 " ( - ) |
| September | 1 " ( 6.7 ) | 0 " ( - ) | 0 " ( - ) |
| October | 2 " (13.3 ) | 2 " (13.3 ) | 2 " (16.7 ) |
| | 15 years | 15 years | 12 years |

Source: Chao-chet Bangyeehon Office and Phraya Banlu Project Office, RID

FIGURE A.3-3 LOCATIONS OF HYDROLOGIC OBSERVATION STATIONS

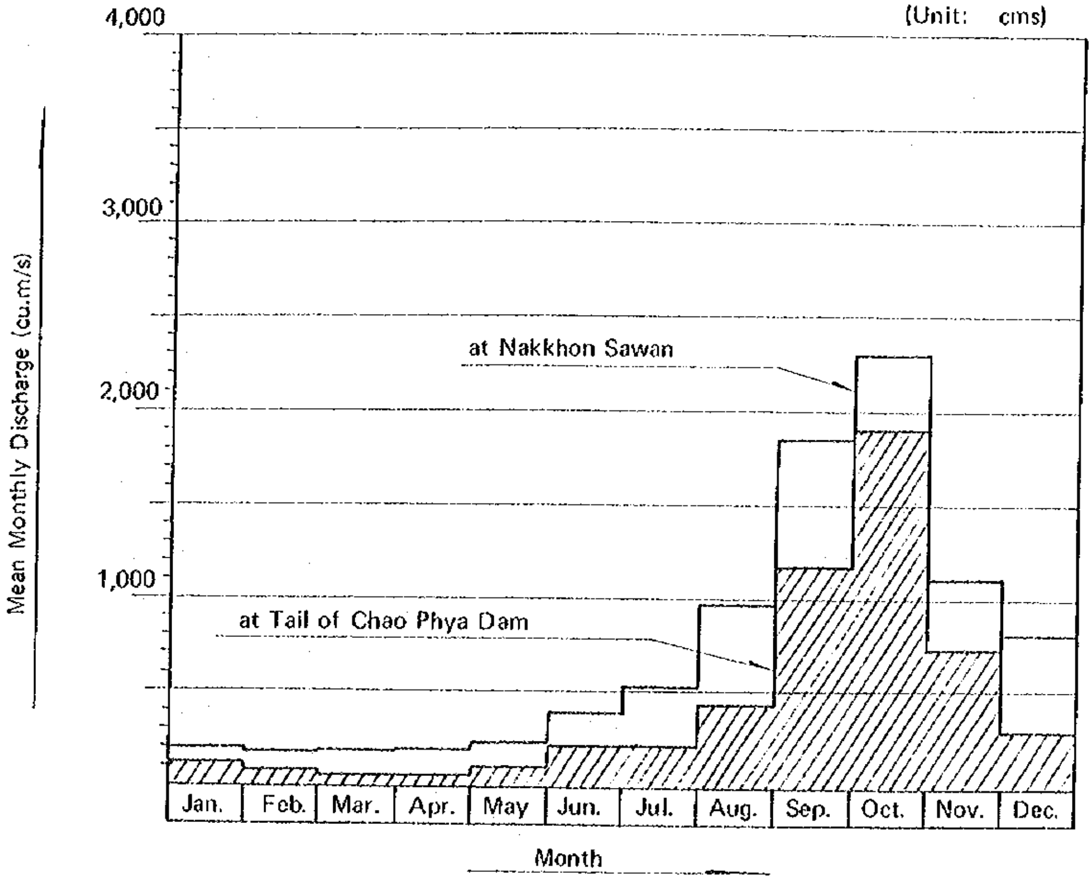



LEGENDS

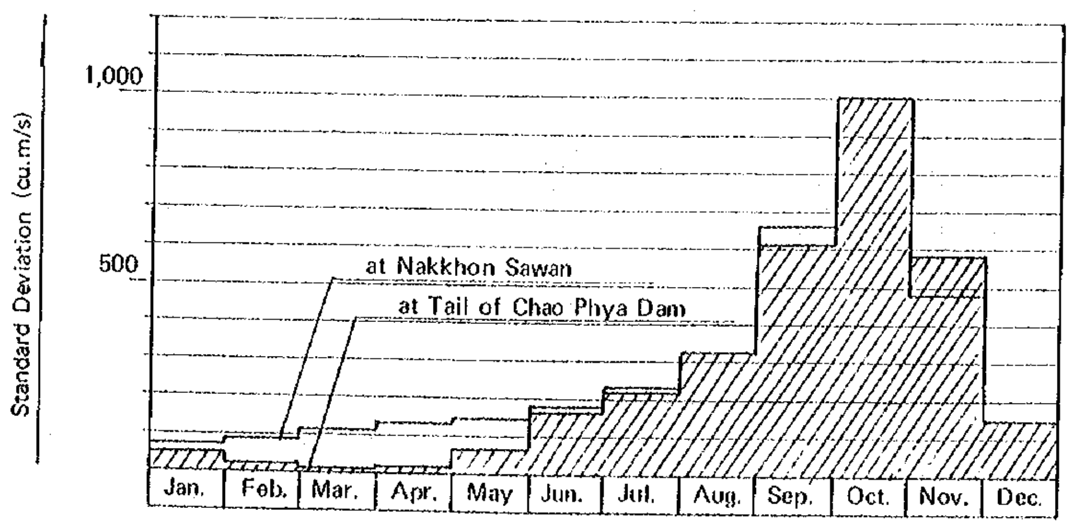
- DISCONTINUED STREAMFLOW RATING STATION
- STREAMFLOW RATING STATION WITH STAFF GAGE
- STREAMFLOW RATING STATION WITH RECORDER(R)-SEDIMENT SAMPLING (S) & TEMPERATURE (T)
- INTERNATIONAL HYDROLOGIC DECADE STATION
- DISCONTINUED STAFF GAGE
- STAFF GAGE
- RECORDING GAGE

Source: Hydrology Section, Survey Division, RID

FIGURE A. 3-4 MONTHLY MEAN DISCHARGE OF CHAO PHYA RIVER




FLUCTUATION OF MONTHLY MEAN DISCHARGE




Note: Data period 19 years (1957 -- 1976)

Table A. 3-28 Monthly and Annual Mean Discharge of Chao Phya River at Nakorn Sawan

Drainage Area: 110,569 square km
(Unit: cms)

| Year | Monthly Mean Discharge | | | | | | | | | | | | Annual Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Discharge |
| 1957 | | | | 54.3 | 61.4 | 236 | 365 | 571 | 1,789 | 2,034 | 726 | 203 | - |
| 1958 | 109 | 86.5 | 45.7 | 34.3 | 60.1 | 176 | 413 | 730 | 1,483 | 1,146 | 340 | 162 | 399 |
| 1959 | 81.5 | 51.2 | 47.3 | 33.8 | 86.5 | 267 | 357 | 1,274 | 2,245 | 3,292 | 805 | 226 | 731 |
| 1960 | 114 | 87.2 | 47.8 | 32.6 | 82.5 | 207 | 315 | 927 | 2,034 | 2,383 | 939 | 386 | 630 |
| 1961 | 144 | 90.5 | 67.1 | 62.4 | 161 | 550 | 612 | 1,163 | 2,719 | 4,336 | 2,165 | 439 | 1,042 |
| 1962 | 241 | 124 | 74.7 | 53.7 | 109 | 195 | 372 | 872 | 1,921 | 3,504 | 1,424 | 243 | 761 |
| 1963 | 87.9 | 59.1 | 54.4 | 45.2 | 42.2 | 145 | 331 | 1,511 | 1,882 | 2,382 | 1,784 | 659 | 749 |
| 1964 | 147 | 149 | 137 | 150 | 216 | 380 | 589 | 689 | 1,662 | 3,374 | 1,669 | 431 | 799 |
| 1965 | 200 | 190 | 227 | 234 | 268 | 390 | 486 | 757 | 1,340 | 1,132 | 758 | 302 | 525 |
| 1966 | 175 | 189 | 216 | 197 | 268 | 716 | 528 | 1,196 | 2,497 | 1,614 | 819 | 375 | 733 |
| 1967 | 231 | 205 | 220 | 217 | 226 | 329 | 387 | 572 | 1,169 | 2,218 | 817 | 400 | 582 |
| 1968 | 242 | 189 | 192 | 216 | 420 | 518 | 624 | 922 | 930 | 728 | 369 | 279 | 469 |
| 1969 | 204 | 178 | 144 | 158 | 155 | 324 | 580 | 938 | 1,768 | 1,974 | 922 | 378 | 644 |
| 1970 | 253 | 271 | 260 | 284 | 446 | 763 | 1,381 | 1,908 | 3,463 | 3,225 | 1,283 | 594 | 1,178 |
| 1971 | 325 | 290 | 283 | 298 | 371 | 518 | 630 | 1,183 | 1,911 | 1,929 | 1,098 | 476 | 776 |
| 1972 | 296 | 279 | 284 | 290 | 280 | 380 | 436 | 681 | 785 | 1,010 | 756 | 476 | 496 |
| 1973 | 245 | 274 | 328 | 344 | 334 | 479 | 533 | 929 | 1,557 | 2,085 | 947 | 414 | 706 |
| 1974 | 272 | 317 | 355 | 396 | 451 | 427 | 417 | 779 | 1,173 | 1,437 | 1,539 | 616 | 682 |
| 1975 | 311 | 300 | 401 | 492 | 477 | 595 | 720 | 1,057 | 2,846 | 3,890 | 1,747 | 743 | 1,132 |
| $\bar{x}$ | 204.4 | 185.0 | 188.6 | 189.1 | 237.6 | 399.7 | 530.3 | 982.1 | 1,851.3 | 2,299.6 | 1,101.0 | 410.6 | 714.9 |
| S | 74.58 | 86.06 | 113.68 | 134.07 | 142.85 | 174.4 | 231.41 | 327.63 | 664.76 | 1,014.21 | 485.68 | 155.09 | |
| S/$\bar{x}$ | 0.365 | 0.465 | 0.603 | 0.709 | 0.601 | 0.436 | 0.436 | 0.334 | 0.359 | 0.441 | 0.441 | 0.378 | |

Note: $\bar{x}$ - Mean S - Standard Deviation

Source: Hydrology Division, Royal Irrigation Department

Table A. 3-29 Monthly and Annual Mean Discharge of Chao Phya River at Chai Nat

Drainage Area: 120,693 square km
(Unit: cms)

| Year | Monthly Mean Discharge | | | | | | | | | | | | Annual Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Discharge |
| 1957 | | | | 63.2 | 66.1 | 170 | 242 | 314 | 1,429 | 2,010 | 416 | 124 | |
| 1958 | 48.7 | 60.3 | 33.7 | 35.8 | 71.7 | 93.9 | 281 | 434 | 1,256 | 1,001 | 130 | 71.6 | 292 |
| 1959 | 58.6 | 41.0 | 47.5 | 43.2 | 42.7 | 192 | 200 | 919 | 1,767 | 3,381 | 560 | 153 | 617 |
| 1960 | 82.7 | 66.8 | 47.1 | 46.9 | 46.3 | 105 | 166 | 346 | 1,252 | 1,882 | 627 | 359 | 419 |
| 1961 | 119 | 59.6 | 53.7 | 72.4 | 130.0 | 490 | 418 | 861 | 1,858 | 3,406 | 2,180 | 465 | 843 |
| 1962 | 223 | 105 | 75.9 | - | 54.9 | 84.0 | 169 | 412 | 1,533 | 3,183 | 1,212 | 202 | - |
| 1963 | 69.5 | 52.5 | - | 41.2 | 35.6 | 33.8 | 57.6 | 808 | 1,153 | 1,994 | 1,419 | 549 | - |
| 1964 | 106 | 87.2 | 71.0 | 78.4 | 106 | 231 | 296 | 153 | 941 | 3,202 | 1,518 | 391 | 598 |
| 1965 | 128 | 75.9 | 86.0 | 84 | 110 | 149 | 66 | 140 | 620 | 564 | 150 | 125 | 192 |
| 1966 | 88 | 90 | 80 | 82.9 | 159 | 534 | 143 | 591 | 1,848 | 1,357 | 357 | 264 | 466 |
| 1967 | 101 | 97.3 | 89.4 | 80.9 | 86.3 | 76.0 | 71.6 | 82.6 | 430 | 1,468 | 228 | 196 | 251 |
| 1968 | 124 | 85.5 | 80.1 | 78.2 | 274 | 238 | 115 | 180 | 159 | 136 | 83.8 | 128 | 140 |
| 1969 | 107 | 71 | 59 | 56.0 | 52.5 | 49.9 | 227 | 281 | 997 | 1,224 | 301 | 155 | 298 |
| 1970 | 119 | 91.9 | 80.5 | 91.5 | 212 | 549 | 1,054 | 1,351 | 2,417 | 3,229 | 1,007 | 464 | 889 |
| 1971 | 208 | 112 | 88.2 | 77.8 | 121 | 187 | 120 | 529 | 1,356 | 1,199 | 523 | 410 | 469 |
| 1972 | 240 | 107 | 83.3 | 97.26 | 75.45 | 96.70 | 66.29 | 93.70 | 389.46 | 597.32 | 191.33 | 371.09 | 201 |
| 1973 | 115.32 | 69.64 | 71.06 | 68.83 | 79.48 | 141.90 | 81.22 | 193.93 | 628.03 | 1,507.87 | 252.16 | 325.87 | 295 |
| 1974 | 144.22 | 80.30 | 73.70 | 79.30 | 168 | 139 | 77.6 | 209 | 509 | 1,397 | 1,312 | 524 | 393 |
| 1975 | 217 | 103 | 79.0 | 87.9 | 131 | 281 | 267 | 363 | 2,044 | 3,575 | 1,415 | 613 | 765 |
| $\bar{x}$ | 127.7 | 80.9 | 70.5 | 70.4 | 106.4 | 201.6 | 216.8 | 434.8 | 1,188.8 | 1,911.2 | 731.2 | 310.0 | 454.2 |
| S | 55.94 | 19.69 | 15.93 | 17.83 | 60.85 | 153.79 | 219.44 | 329.31 | 613.19 | 1,067.01 | 593.48 | 162.16 | |
| $S/\bar{x}$ | 0.438 | 0.243 | 0.226 | 0.253 | 0.572 | | 1.012 | 0.757 | 0.516 | 0.558 | 0.812 | 0.523 | |

Note: $\bar{x}$ - Mean S - Standard Deviation

Source: Hydrology Division, Royal Irrigation Department

Table A. 3-30 Monthly and Annual Specific Runoff of Chao Phya River at Nakorn Sawan

Drainage Area: 110,569 square km
(Unit: mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual Specific Runoff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monthly Specific Runoff | | | | | | | | | | | | |
| 1957 | | | | 1.3 | 1.5 | 5.5 | 8.8 | 13.8 | 41.9 | 49.3 | 17.0 | 4.9 | |
| 1958 | 2.7 | 1.9 | 1.1 | 0.8 | 1.5 | 4.1 | 10.0 | 17.7 | 34.8 | 27.8 | 8.0 | 3.9 | 114.3 |
| 1959 | 2.0 | 1.1 | 1.1 | 0.8 | 2.1 | 6.3 | 8.7 | 30.9 | 52.6 | 79.8 | 18.9 | 5.5 | 209.8 |
| 1960 | 2.8 | 2.0 | 1.2 | 0.8 | 2.0 | 4.8 | 7.6 | 22.5 | 47.7 | 57.7 | 22.0 | 9.4 | 180.5 |
| 1961 | 3.5 | 2.0 | 1.6 | 1.5 | 3.9 | 12.9 | 14.8 | 28.2 | 63.7 | 105.0 | 50.7 | 10.6 | 298.4 |
| 1962 | 5.9 | 2.7 | 1.8 | 1.3 | 2.6 | 4.6 | 9.0 | 21.1 | 45.0 | 84.9 | 33.4 | 5.9 | 218.2 |
| 1963 | 2.1 | 1.3 | 1.3 | 1.1 | 1.0 | 3.4 | 8.0 | 36.6 | 42.9 | 57.7 | 41.8 | 16.0 | 213.2 |
| 1964 | 3.6 | 3.4 | 3.3 | 3.5 | 5.2 | 8.9 | 14.3 | 16.7 | 39.0 | 81.7 | 39.1 | 10.4 | 229.1 |
| 1965 | 4.8 | 4.2 | 5.5 | 5.5 | 6.5 | 9.1 | 11.8 | 18.3 | 31.4 | 27.4 | 18.0 | 7.3 | 149.8 |
| 1966 | 4.3 | 4.1 | 5.2 | 4.6 | 6.5 | 16.8 | 12.8 | 29.0 | 58.5 | 39.1 | 19.2 | 9.1 | 209.2 |
| 1967 | 5.6 | 4.5 | 5.3 | 5.1 | 5.5 | 7.7 | 9.4 | 13.9 | 27.4 | 53.7 | 19.2 | 9.7 | 167.0 |
| 1968 | 5.9 | 4.3 | 4.7 | 5.1 | 10.2 | 12.0 | 15.1 | 22.3 | 21.8 | 17.6 | 8.7 | 6.8 | 134.5 |
| 1969 | 4.9 | 3.9 | 3.5 | 3.7 | 3.8 | 7.6 | 14.1 | 22.7 | 41.5 | 47.8 | 21.6 | 9.2 | 184.3 |
| 1970 | 6.1 | 5.9 | 6.3 | 6.7 | 10.8 | 17.9 | 33.5 | 46.2 | 81.2 | 78.1 | 30.0 | 14.4 | 337.1 |
| 1971 | 7.9 | 6.4 | 6.9 | 7.0 | 9.0 | 12.1 | 15.2 | 28.7 | 44.8 | 46.7 | 25.8 | 11.5 | 222.0 |
| 1972 | 7.2 | 6.3 | 6.9 | 6.8 | 6.8 | 8.9 | 10.6 | 16.5 | 18.4 | 24.5 | 17.8 | 11.1 | 141.8 |
| 1973 | 5.9 | 6.0 | 6.0 | 8.1 | 8.1 | 11.2 | 12.9 | 22.5 | 36.5 | 50.5 | 22.2 | 10.0 | 201.9 |
| 1974 | 6.6 | 6.9 | 8.8 | 9.3 | 10.9 | 10.0 | 10.1 | 18.9 | 27.5 | 34.8 | 36.0 | 14.9 | 194.7 |
| 1975 | 7.5 | 6.6 | 9.7 | 11.5 | 11.6 | 14.0 | 17.4 | 25.6 | 66.7 | 94.2 | 41.0 | 18.0 | 323.8 |
| $\bar{x}$ | 5.0 | 4.1 | 4.6 | 4.4 | 5.8 | 9.4 | 12.8 | 23.8 | 43.3 | 55.7 | 25.8 | 9.9 | 204.6 |
| S | 1.80 | 1.89 | 2.76 | 3.14 | 3.46 | 4.09 | 5.61 | 7.94 | 15.58 | 24.56 | 11.37 | 3.75 | |
| S/$\bar{x}$ | 0.360 | 0.461 | 0.600 | 0.714 | 0.596 | 0.435 | 0.438 | 0.334 | 0.360 | 0.441 | 0.441 | 0.379 | |
| Mean before 1964 | 3.2 | 1.8 | 1.4 | 1.1 | 2.1 | 5.9 | 9.6 | 24.4 | 46.9 | 66.0 | 27.4 | 8.0 | 197.8 |
| Mean after 1964 | 5.9 | 5.2 | 6.2 | 6.4 | 7.9 | 11.4 | 14.8 | 23.4 | 41.2 | 49.7 | 24.9 | 11.0 | 208.0 |

Note: $\bar{x}$ - Mean S - Standard Deviation
Source: Hydrology Division, Royal Irrigation Department

Table A. 3-31 Monthly and Annual Specific Runoff of Chao Phya River at Chai Nat

Drainage Area: 120,693 square km
(Unit: mm)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual Specific Runoff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Monthly Specific Runoff | | | | | | | | | | | | |
| 1957 | | | | 1.4 | 1.5 | 3.7 | 5.4 | 7.0 | 30.7 | 44.6 | 8.9 | 2.8 | |
| 1958 | 1.1 | 1.2 | 0.7 | 0.8 | 1.6 | 1.8 | 6.2 | 9.6 | 27.0 | 22.2 | 2.8 | 1.6 | 76.6 |
| 1959 | 1.3 | 0.8 | 1.0 | 0.9 | 0.9 | 4.1 | 6.3 | 20.4 | 38.0 | 75.0 | 12.0 | 3.4 | 164.2 |
| 1960 | 1.8 | 1.4 | 1.0 | 1.0 | 1.0 | 2.3 | 3.7 | 7.7 | 26.9 | 41.8 | 13.5 | 8.0 | 110.1 |
| 1961 | 2.6 | 1.2 | 1.2 | 1.6 | 2.9 | 10.5 | 9.3 | 19.1 | 39.9 | 75.6 | 46.8 | 10.3 | 221.0 |
| 1962 | 5.0 | 2.1 | 1.7 | - | 1.2 | 1.8 | 3.8 | 9.1 | 33.4 | 70.6 | 26.0 | 4.5 | - |
| 1963 | 1.5 | 1.1 | - | 0.9 | 0.8 | 0.7 | 1.3 | 17.9 | 24.8 | 44.3 | 30.5 | 12.2 | - |
| 1964 | 2.4 | 1.8 | 1.6 | 1.7 | 2.3 | 5.0 | 6.6 | 3.4 | 20.2 | 71.1 | 32.6 | 8.7 | 157.4 |
| 1965 | 2.8 | 1.5 | 1.9 | 1.8 | 2.4 | 3.2 | 1.5 | 3.1 | 13.3 | 12.5 | 3.4 | 2.8 | 50.2 |
| 1966 | 2.0 | 1.8 | 1.8 | 1.9 | 3.5 | 11.5 | 3.2 | 13.1 | 39.7 | 30.1 | 7.7 | 5.9 | 122.2 |
| 1967 | 2.2 | 2.0 | 2.0 | 1.7 | 1.9 | 1.6 | 1.6 | 1.8 | 9.2 | 32.6 | 4.9 | 4.4 | 65.9 |
| 1968 | 2.8 | 1.8 | 1.8 | 1.7 | 6.1 | 5.1 | 2.6 | 4.0 | 3.4 | 3.0 | 1.8 | 2.8 | 36.9 |
| 1969 | 2.4 | 1.4 | 1.3 | 1.2 | 1.2 | 1.1 | 5.1 | 6.3 | 21.4 | 27.2 | 6.5 | 3.5 | 78.6 |
| 1970 | 2.6 | 1.8 | 1.8 | 2.0 | 4.7 | 11.8 | 23.4 | 30.0 | 51.9 | 71.7 | 21.6 | 10.3 | 233.6 |
| 1971 | 4.6 | 2.2 | 2.0 | 1.7 | 2.7 | 4.0 | 2.7 | 11.7 | 28.7 | 26.6 | 11.2 | 9.1 | 107.2 |
| 1972 | 5.3 | 2.2 | 1.8 | 2.1 | 1.7 | 2.1 | 1.5 | 2.1 | 8.4 | 13.3 | 4.1 | 8.2 | 52.8 |
| 1973 | 2.6 | 1.4 | 1.6 | 1.5 | 1.8 | 3.0 | 1.8 | 4.3 | 13.5 | 33.5 | 5.4 | 7.2 | 77.6 |
| 1974 | 3.2 | 1.5 | 1.6 | 1.7 | 3.7 | 3.0 | 1.7 | 4.5 | 10.9 | 31.0 | 28.2 | 11.6 | 102.8 |
| 1975 | 4.8 | 2.1 | 1.7 | 1.9 | 2.9 | 6.0 | 5.9 | 8.1 | 43.9 | 79.3 | 30.4 | 13.6 | 200.6 |
| $\bar{x}$ | 2.8 | 1.6 | 1.6 | 1.5 | 2.4 | 4.3 | 4.9 | 9.6 | 25.5 | 42.4 | 15.7 | 6.9 | 119.2 |
| S | 1.24 | 0.40 | 0.35 | 0.39 | 1.37 | 3.30 | 4.88 | 7.31 | 13.18 | 23.68 | 12.75 | 3.59 | |
| $S/\bar{x}$ | 0.443 | 0.250 | 0.225 | 0.260 | 0.571 | 0.767 | 0.996 | 0.761 | 0.517 | 0.558 | 0.812 | 0.520 | |

Note: $\bar{x}$ - Mean S - Standard Deviation
Source: Hydrology Division, Royal Irrigation Department

Table A. 3-32 Extreme Momentary Discharge Records of the Chao Phya River

(Unit: cu.m/sec)

| Year | Stations: Nakhon Sawan C.2 Max. | | Nakhon Sawan C.2 Min. | | Chao Phya Dam C.13 Max. | | Chao Phya Dam C.13 Min. | | Wat Chulamani Max. | | Ayutthaya C.15 Min. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 2,592 | 10 Oct. | - | - | 2,670 | 12 Oct. | - | - | 438 | 7 Oct. | - | - |
| 1958 | 2,066 | 30 Sep | 28 | 6,7 Apr. | 2,295 | 30 Sep. | 25 | 7 May | 422 | 6 Oct. | 8.15 | 27 May |
| 1959 | 4,509 | 8 Oct. | 25 | 22 Apr. | 4,325 | 9 Oct. | 22 | 15 May | 572 | 19 Oct. | 13 | 7 Feb. |
| 1960 | 2,567 | 20 Oct. | 15 | 6,7 Apr. | 2,095 | 13 Oct. | 30 | 24 Apr. 11-16 May | 444 | 19 Oct. | 11 | 8,19 May |
| 1961 | 4,712 | 13 Oct. | 45 | 20 Apr. | 3,985 | 15 Oct. | 36 | 12 Feb. | 531 | 3 Nov. | 9.40 | 26 Apr. |
| 1962 | 3,812 | 17 Oct. | 39 | 17 Apr. | 3,609 | 15 Oct. | 22 | 9-12 Jul. | 537 | 24 Oct. | 8.50 | 10 Jul. |
| 1963 | 2,946 | 12 Oct. | 32 | 22,23 May | 2,628 | 11 Oct. | 25 | 1-4 Jul. | 508 | 19 Oct. | 8.50 | 6,19 Jun. |
| 1964 | 3,825 | 11 Oct. | 90 | 5,6 Feb. | 3,475 | 18 Oct. | 49 | 14-18 Aug. | 546 | 9 Oct. | 26 | 17 Aug. |
| 1965 | 1,537 | 2 Oct. | 153 | 6 Feb. | 1,071 | 3 Oct. | 44 | 14-22 Aug. | - | - | - | - |
| 1966 | 2,930 | 24 Sep. | 131 | 26,27 Jan. | 2,349 | 25 Sep. | 55 | 21,22 Feb. | 485 | 28 Sep. | 32 | 30 Apr. |
| 1967 | 2,768 | 8 Oct. | 133 | 10 Apr. | 1,985 | 7 Oct. | 53 | 9 May | 452 | 16 Oct. | 30 | 19 Jul. |
| 1968 | 1,263 | 21 Sep. | 165 | 3,4 Feb. | 588 | 13 May | 65 | 25 Apr. | 214 | 14 May | 28 | 26 Jul. |
| 1969 | 2,827 | 28 Sep. | 122 | 9 May | 2,047 | 6 Oct. | 27 | 30,31 May | 499 | 7 Oct. | 14 | 22 Jun. |
| 1970 | 4,420 | 30 Sep. | 200 | 2 Apr. | 4,049 | 7 Oct. | 59 | 5 Apr. | 558 | 16 Oct. | 36 | 22 Mar. |
| 1971 | 2,370 | 9 Oct. | 242 | 17 Apr. | 1,560 | 13 Oct. | 57 | 23,24 Apr. 1,2 Jul. | 443 | 11 Oct. | 21 | 5 Jul. |
| 1972 | 1,310 | 8 Oct. | 197 | 9 May | 1,129 | 9 Oct. | 58 | 30 Jul. | 395 | 10 Oct. | 14 | 26 May |
| 1973 | 2,600 | 5 Oct. | 183 | 5 Jan. | 1,910 | 7 Oct. | 64 | 14 Feb. 12,13 Jul. | 488 | 10 Oct. | 16 | 15 Jul. |
| 1974 | 1,930 | 9 Nov. | 186 | 5 Jan. | 2,089 | 19 Oct. | 71 | 18 Jun. | 511 | 21 Oct. | 33 | 19,20 Jul. |
| 1975 | 4,355 | 17 Oct. | 231 | 13 Feb. | 3,977 | 22 Oct. | 69 | 7-9, 13-15 Feb. | 616 | 20-23 Oct. | 24 | 10 Feb. |
| 1957-1975 | m=2,913 | S=1,059 | m=123 | S=75 | m=2,518 | S=1,076 | m=46 | S=17 | m=481 | S= 86 | m=19.6 | S=9.4 |
| 1957-1963 | m=3,315 | S= 956 | m= 30.7 | S= 9.7 | m=3,087 | S= 811 | m=27 | S= 5.0 | m=493 | S= 54 | m= 9.8 | S=1.7 |
| 1964-1975 | m=2,678 | S=1,045 | m=169 | S=44 | m=2,186 | S=1,073 | m=56 | S=11.5 | m=473 | S=100 | m=24.9 | S=7.4 |

Note : m; mean, s; standard deviation

Source: Royal Irrigation Department

## Probable Discharge and Water Level of the Chao Phya River

Study on maximum and minimum probable discharges has been conducted based on the mean monthly discharge record observed at Nakorn Sawan and Chao Phya Dam from 1964 - 1975. Its results are as shown below:

### Probable Max. Monthly Mean Discharge

(Unit: cu.m/s)

| Return Period | Nakorn Sawan | Chao Phya Dam |
|---|---|---|
| 2 years | 2,025 | 1,596 |
| 5 years | 2,940 | 2,583 |
| 10 years | 3,548 | 3,291 |
| 15 years | 4,132 | 4,007 |

### Probable Min. Monthly Mean Discharge at Nakorn Sawan

(unit: cu.m/s)

| Return Period | Discharge |
|---|---|
| 2 years | 221 |
| 5 years | 173 |
| 10 years | 149 |
| 15 years | 137 |
| 20 yerars | 129 |

Continuous maximum discharges in long term such as monthly maximum discharges have a relation with a flood duration in low-lying area, while momentary maximum discharges, which is larger than an averaged value of the maximum discharges in a long term, have relation with the highest flood level, which give a big influence on facilities such as dikes. Table A.3-33 shows momentary probable maximum discharges and maximum water levels of the Chao Phya river.

Table A. 3-33 Probable Maximum Momentary Discharges and Maximum Water Levels of the Chao Phya River

(Unit: cu.m/s)

Probable Maximum Momentary Discharges

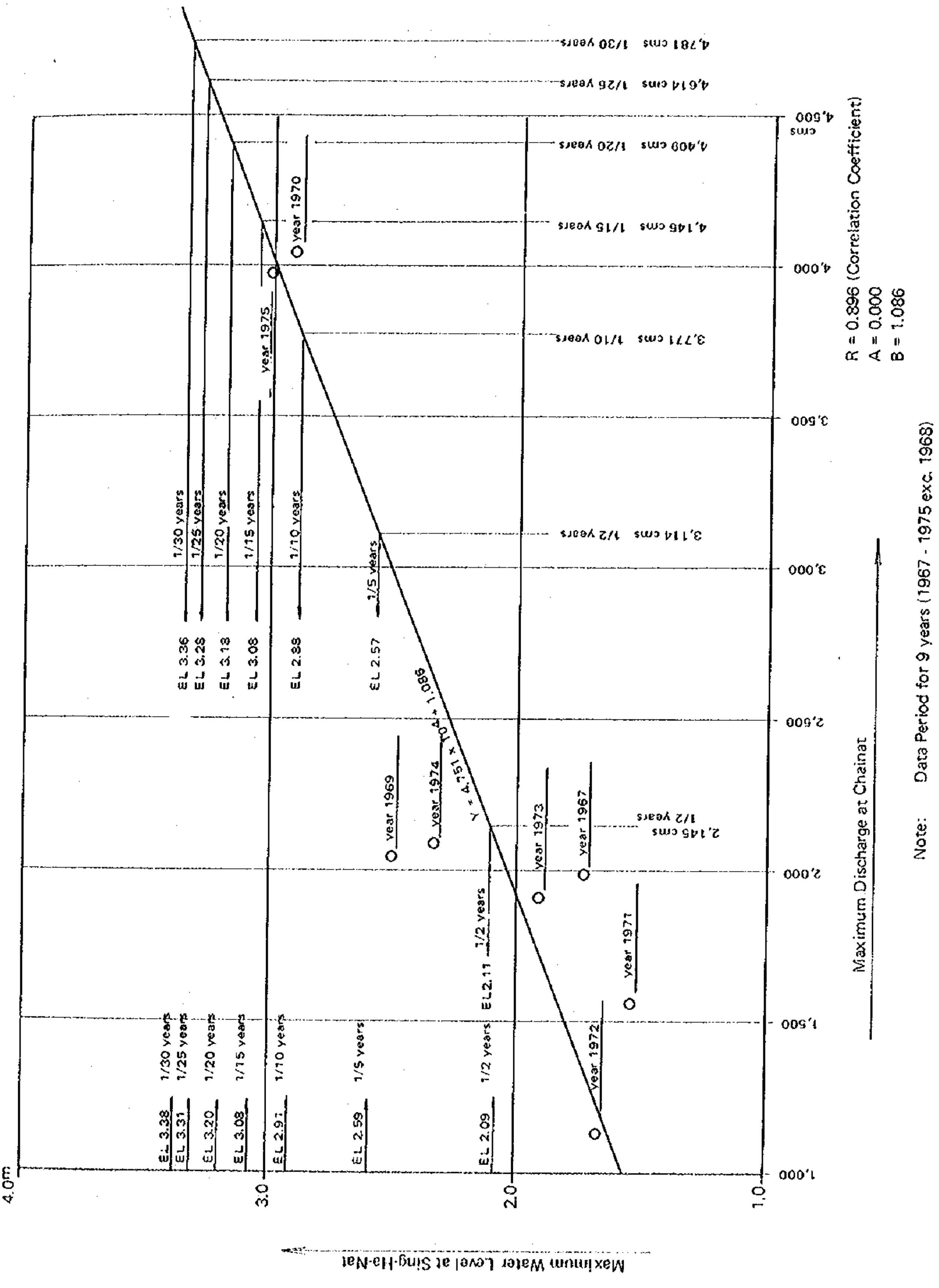
| Return Period | Nakorn Sawan 1957-1975 | Nakorn Sawan 1957-1963 | Nakorn Sawan 1964-1975 | Chai Nat Dam 1957-1975 | Chai Nat Dam 1964-1975 | Wat Chulamani 1/ 1957-1975 | Wat Chulamani 1/ 1957-1963 | Wat Chulamani 1/ 1964-1975 |
|---|---|---|---|---|---|---|---|---|
| 2 years | 2,702 | 3,207 | 2,515 | 2,425 | 2,145 | 494 | 490 | 496 |
| 5 years | 3,811 | 4,146 | 3,550 | 3,457 | 3,114 | 546 | 542 | 552 |
| 10 years | 4,583 | 4,719 | 4,218 | 4,160 | 3,771 | 575 | 571 | 583 |
| 15 years | 4,989 | 5,029 | 4,590 | 4,563 | 4,145 | 590 | 587 | 599 |
| 20 years | 5,290 | 5,241 | 4,849 | 4,847 | 4,409 | 600 | 598 | 610 |
| 25 years | 5,527 | - | - | 5,070 | - | 607 | - | 618 |
| 30 years | 5,715 | - | 5,048 | 5,249 | 4,614 | 613 | - | 624 |
| 40 years | 6,021 | - | - | 5,537 | - | 622 | - | - |
| 50 years | 6,252 | - | 5,209 | 5,757 | 4,781 | 629 | - | - |
| 100 years | 6,993 | - | - | 6,460 | - | 649 | - | - |

Probable Maximum Water Levels (Meter + Mean Sea Level)

| Return Period | Wat Chulamari 1/ 1957-75 | Wat Chulamari 1/ 1957-63 | Wat Chulamari 1/ 1964-75 | Ayutthaya 1950-75 | Ayutthaya 1957-63 | Ayutthaya 1964-75 | Sing Ha Nat 1967-1976 (exc. 1968) Outside | Sing Ha Nat 1967-1976 (exc. 1968) Inside | Phraya Banlu 1966-1976 Outside | Phraya Banlu 1966-1976 Inside | Pak Kret 1953-75 | Pak Kret 1964-75 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 years | 4.48 | 4.51 | 4.54 | 3.82 | 4.08 | 3.48 | 2.09 | 2.58 | 2.55 | 2.96 | 1.84 | 1.80 |
| 5 years | 4.75 | 4.79 | 4.85 | 4.40 | 4.40 | 4.18 | 2.59 | 2.77 | 3.12 | 3.09 | 2.01 | 2.02 |
| 10 years | 4.89 | 4.95 | 5.02 | 4.73 | 4.58 | 4.58 | 2.91 | 2.91 | 3.46 | 3.18 | 2.11 | 2.15 |
| 15 years | 4.96 | 5.03 | 5.10 | 4.90 | 4.67 | 4.79 | 3.08 | 2.99 | 3.65 | 3.23 | 2.15 | 2.22 |
| 20 years | 5.01 | 5.08 | 5.16 | 5.01 | 4.73 | 4.93 | 3.20 | 3.66 | 3.77 | 3.26 | 2.18 | 2.27 |
| 25 years | 5.06 | - | - | 5.09 | - | - | - | - | - | - | - | - |
| 30 years | 5.08 | - | 5.20 | 5.16 | 4.77 | 5.03 | 3.31 | - | 3.88 | - | 2.23 | - |
| 40 years | 5.13 | - | - | 5.26 | - | - | - | - | - | - | - | - |
| 50 years | 5.15 | - | 5.23 | 5.33 | 4.81 | 5.11 | 3.38 | - | 3.95 | - | 2.28 | - |

Note: 1/ Two years data of 1967 and 1968 are excluded.

FIGURE A. 3-5 CORRELATION BETWEEN MAXIMUM WATER LEVEL AT SING HA NAT AND MAXIMUM DISCHARGE AT CHAINAT (Chao Phya Dam)



## Influence on Lower Basin Caused by the Construction of Bhumiphol and Sirikit Dams

In order to clarify the influence on the Chao Phya river lower basin caused by the operation of Bhumiphol dam whose construction was completed in 1964, mean monthly discharges of the Chao Phya river observed at Nakorn Sawan before December 1963 and after January 1964 are tabulated as follows:

Monthly Mean Discharge at Chao Phya River at Nokorn Sawan (Dry Season)

(unit: cu.m/s)

| Period | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 - 1975 | 204 | 185 | 189 | 189 | 238 | 400 | 530 | 982 | 1,851 | 2,300 | 1,101 | 411 | 715 |
| before Dec. 1963 | 130 | 83 | 56 | 45 | 86 | 254 | 390 | 1,007 | 2,010 | 2,725 | 1,169 | 331 | 691 |
| after Jan. 1964 | 240 | 236 | 255 | 273 | 326 | 485 | 609 | 968 | 1,758 | 2,051 | 1,061 | 457 | 727 |

Fluctuation of Mean Discharge (Standard Deviation) (unit: cu.m/s)

| Period | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957-1975 | 75 | 86 | 114 | 134 | 143 | 174 | 231 | 328 | 665 | 1,014 | 486 | 155 |
| before Dec. 1963 | 54 | 24 | 11 | 11 | 37 | 126 | 93 | 303 | 360 | 980 | 598 | 163 |
| after Jan. 1964 | 52 | 55 | 79 | 96 | 102 | 138 | 251 | 341 | 775 | 949 | 401 | 129 |

As is clear in the above table, the discharges of the Chao Phya river in the dry season have been stabilized and strengthened to a considerable extent especially in April since 1964 due to the storage effect by Bhumiphol dam.

The minimum monthly mean discharges of the Chao Phya river obserbed at Nakorn Sawan and at the immediately downstream reach of Chao Phya Dam during the dry season have been picked up and tabulated as follows:

Minimum Monthly Mean Discharge of The Chao Phya River (Dry season)

| | Nakorn Sawan | | | Chai Nat (at the tail of Chao Phya Dam) | | |
|---|---|---|---|---|---|---|
| Year | Discharge | Month | Order | Discharge | Month | Order |
| 1958 | 34.3 cu.m/s | Apr. | 3 | 33.7 cu.m/s | Mar. | 1 |
| 1959 | 33.8 | Apr. | 2 | 41.0 | Feb. | 3 |
| 1960 | 32.6 | Apr. | 1 | 46.9 | Apr. | 4 |
| 1961 | 62.4 | Apr. | 6 | 53.7 | Mar. | 5 |
| 1962 | 53.7 | Apr. | 5 | 54.9 | May | 6 |
| 1963 | 45.2 | Apr. | 4 | 33.8 | Jun. | 2 |
| 1958-1963 | M=43.7 | S=11.3 | | M=44.0 | S=8.6 | |
| 1964 | 137 | Mar. | 1 | 71.0 | Mar. | 4 |
| 1965 | 190 | Feb. | 5 | 75.9 | Feb. | 7 |
| 1966 | 175 | Jan. | 3 | 80.0 | Mar. | 11 |
| 1967 | 205 | Feb. | 6 | 71.6 | Jul. | 5 |
| 1968 | 189 | Feb. | 4 | 78.2 | Apr. | 9 |
| 1969 | 144 | Mar. | 2 | 49.9 | Jun. | 1 |
| 1970 | 253 | Jan. | 8 | 80.5 | Mar. | 12 |
| 1971 | 283 | Mar. | 11 | 77.8 | Apr. | 8 |
| 1972 | 279 | Feb. | 10 | 66.3 | Jul. | 2 |
| 1973 | 245 | Jan. | 7 | 68.8 | Apr. | 3 |
| 1974 | 272 | Jan. | 9 | 73.7 | Mar. | 6 |
| 1975 | 300 | Feb. | 12 | 79.0 | Mar. | 10 |
| 1964-1975 | M=223 | S=54 | | M=72.7 | S=8.2 | |

Note: M: mean S: Standard deviation

Minimum monthly mean discharge had occurred in April every year before 1963, but it has been scattered over the three months from Jan. to Mar. since 1964.

An averaged value of the minimum monthly mean discharges observed since 1964 is about 5 times of that of the same before 1964, which clearly prove the storage effect by this dam. According the discharge data observed at the immediate downstream reaches of the Chao Phya dam the minimum monthly mean discharges have been scattered over some months and especially in 1967 and 1972 it occurred in July due to the artificial intake of the river water to cover the water requirement in the whole Central Plain. It seems that occurrance of the minimum monthly mean discharges at the downstream reaches from Chao Phya dam has a close relation with the maximum consecutive draughty days, most of which have been recorded from May to July, and the absolute volume of rainy water in the beginning of the wet season.

An averaged value of the minimum monthly mean discharges observed since 1964 at Chai Nat is 73 cu.m/sec, and the minimum monthly mean discharges are much stabilized as expressed by the standard deviation of ±8 cu.m/sec except that of 50 cu.m/sec in 1969 when the salt intrusion became a big problem.

The major objectives to stabilize the minimum discharges in the lower reaches from Chao Phya dam are to secure the discharges of 25 cu.m/sec being released at Ayutthaya to cover the water requirement in Bangkok and to prevent the salt intrusion.

On the contrary, in order to clarify the effect of flood control by Bhumiphol and Sirikit dam operation, maximum monthly mean discharges of the Chao Phya river in the dry season before 1963 and after 1964 have been tabulated below. Reduction from the averaged maximum monthly mean discharge before 1963 to that after 1964 is 586 cu.m/sec at Nakorn Sawan and 761 cu.m/sec at the immediate downstream reaches of Chao Phya dam. By the way Sirikit dam was constructed in 1973, its storage effect of this dam is not yet clear due to the data available are quite limited.

Table A. 3-34 Maximum Monthly Mean Discharge of The Chao Phy River (Wet Season)

| | Nakorn Sawan | | | Chai Nat (Tail of Chao Phy Dam) | | |
|---|---|---|---|---|---|---|
| Year | Maximum Discharge cu.m/s | Month | Order | Maximum Discharge cu.m/s | Month | Order |
| 1957 | 2,034 | Oct. | 6 | 2,010 | Oct. | 4 |
| 1958 | 1,483 | Sep. | 7 | 1,256 | Sep. | 7 |
| 1959 | 3,292 | Oct. | 3 | 3,381 | Oct. | 2 |
| 1960 | 2,382 | Oct. | 4 | 1,882 | Oct. | 6 |
| 1961 | 4,336 | Oct. | 1 | 3,406 | Oct. | 1 |
| 1962 | 3,504 | Oct. | 2 | 3,183 | Oct. | 3 |
| 1963 | 2,382 | Oct. | 4 | 1,994 | Oct. | 5 |
| 1957-1963 | M=2,773 | | S=907 | M=2,445 | S=799 | |
| 1964 | 3,374 | Oct. | 3 | 3,202 | Oct. | 3 |
| 1965 | 1,340 | Sep. | 10 | 620 | Sep. | 10 |
| 1966 | 2,497 | Sep. | 4 | 1,848 | Sep. | 4 |
| 1967 | 2,218 | Oct. | 5 | 1,468 | Oct. | 6 |
| 1968 | 930 | Sep. | 12 | 180 | Aug. | 12 |
| 1969 | 1,974 | Oct. | 7 | 1,224 | Oct. | 9 |
| 1970 | 3,463 | Sep. | 2 | 3,229 | Oct. | 2 |
| 1971 | 1,929 | Oct. | 8 | 1,356 | Sep. | 8 |
| 1972 | 1,010 | Oct. | 11 | 597 | Oct. | 11 |
| 1973 | 2,085 | Oct. | 6 | 1,508 | Oct. | 5 |
| 1974 | 1,539 | Nov. | 9 | 1,397 | Oct. | 7 |
| 1975 | 3,890 | Oct. | 1 | 3,575 | Oct. | 1 |
| 1964-1975 | M=2,187 | | S=925 | M=1,684 | S=1,055 | |

Note: M: Mean S: Standard Deviation

FIGURE A.3-6. PROFILE OF THE CHAO PHYA RIVER IN LOWER CENTRAL PLAIN

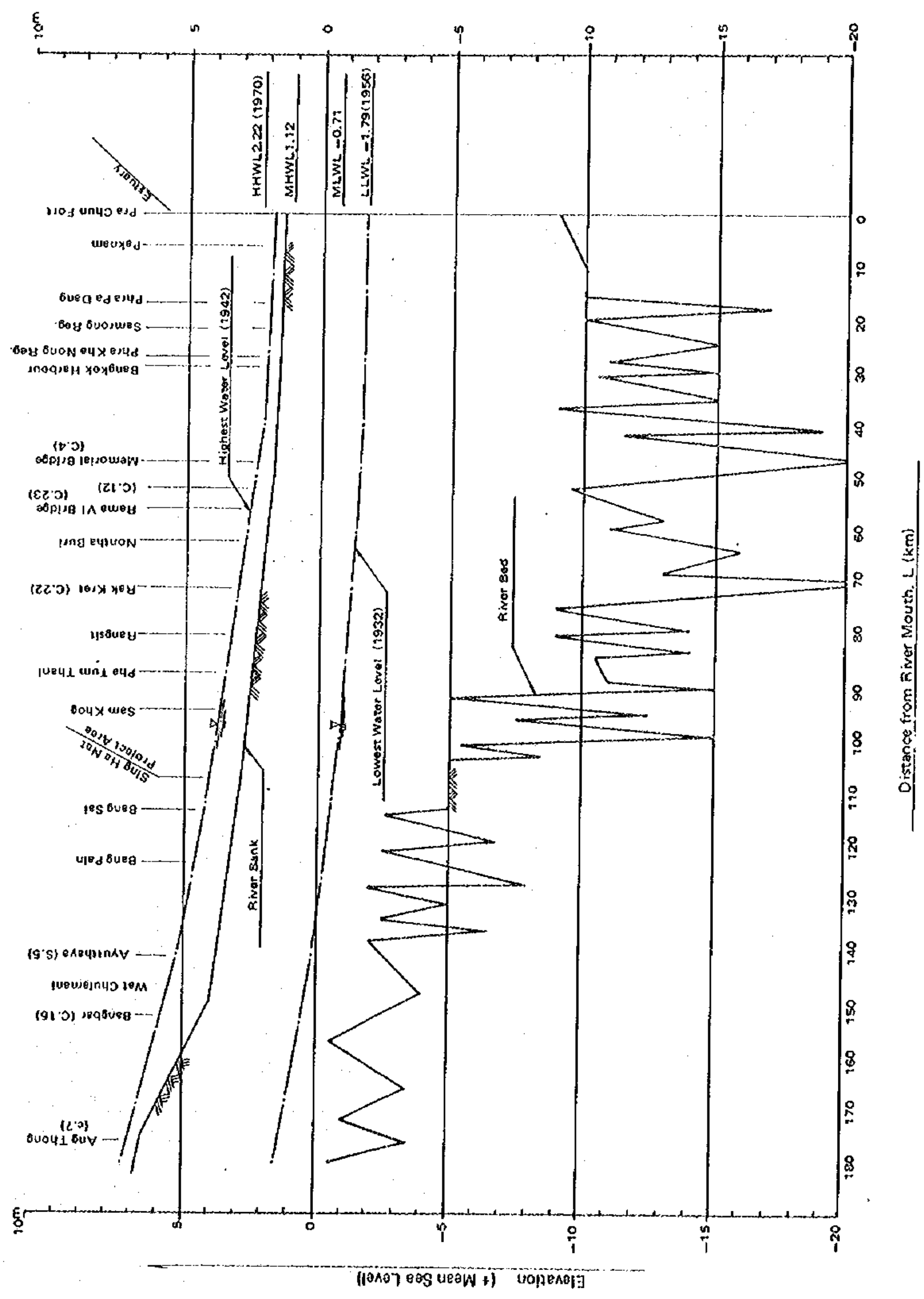
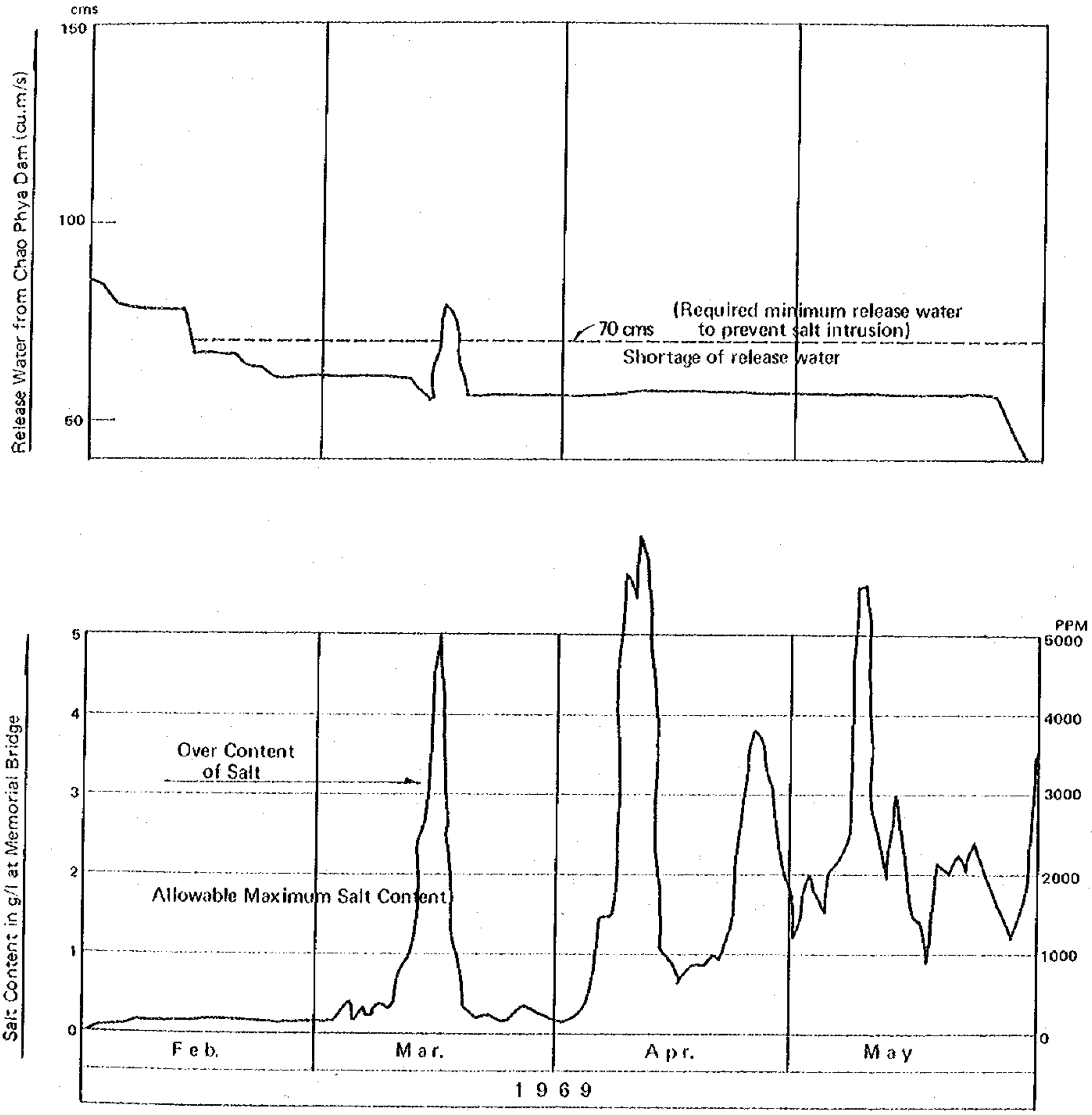


FIGURE A. 3-7

OPERATION OF SALT CONTROL AT MEMORIAL BRIDGE (observed in 1969)




Note: Observation is started from 1964

Source: Operation Center, RID

Table A. 3-35 Tides at Estuary of Chao Phya River

(Unit: m - Mean Sea Level)

| Tides | Bangkok Bar (km.-14) | Fort Phrachul (km.1) | Paknum (km.7) | Phra Pradeng (km.18) | Klong Toey Harbour (km.27) | Hydro. Dept. (km.49)a/ |
|---|---|---|---|---|---|---|
| H'est. HW | +2.28 (1970) | +2.22 (1970) | +2.04 (1970) | +1.93 (1970) | +1.89 (1970) | +2.42 (1942) |
| MHHW | +1.14 | +1.12 | +1.10 | +1.13 | +1.11 | +1.05 |
| MHWS | +1.07 | +1.07 | - | - | +1.06 | +1.03 |
| MHWN | +0.71 | +0.71 | - | - | +0.72 | +0.75 |
| MLWN | -0.65 | -0.57 | - | - | -0.38 | -0.21 |
| MLWS | -0.91 | -0.71 | - | - | -0.54 | -0.32 |
| MLLW | -1.30 | -1.07 | -1.02 | -0.90 | -0.85 | -0.61 |
| L'est LW | -2.42 (1956) | -1.79 (1956) | -1.82 (1964) | -1.78 (1967) | -1.72 (1968) | -1.74 (1964) |
| M Sp. Range | 1.98 | 1.78 | - | - | 1.60 | 1.35 |
| M Np. Range | 1.36 | 1.28 | - | - | 1.10 | 0.96 |

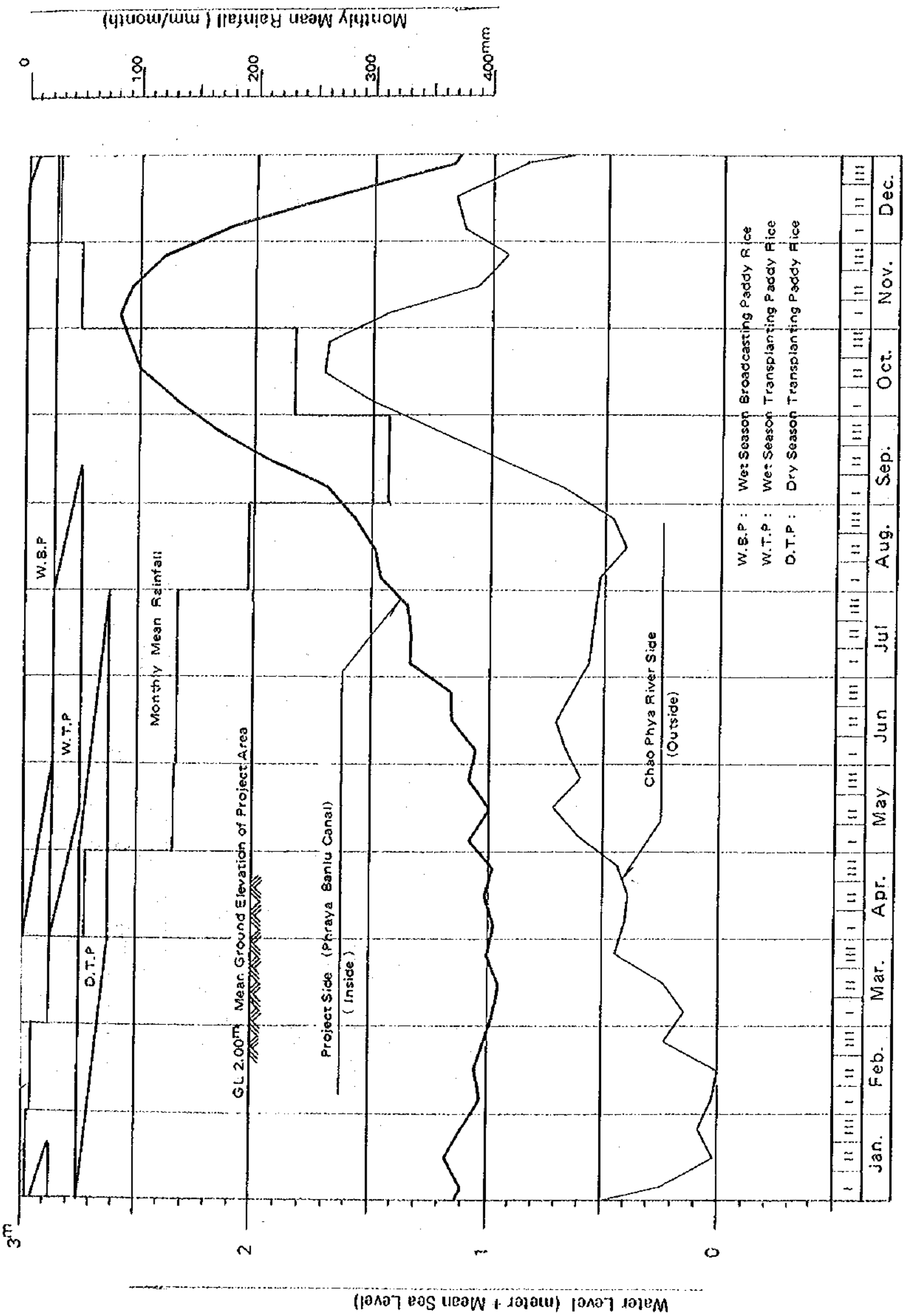
Note:

| | | |
|---|---|---|
| H'est HW | Highest High Water | 31 years (1940 - 1970) |
| MHHW | Mean Higher High Water | 10 years (1940 - 1949) |
| MHWS | Mean High Water Spring | - do - |
| MHWN | Mean High Water Neap | - do - |
| MLWN | Mean Low Water Neap | - do - |
| MLWS | Mean Low Water Spring | - do - |
| MLLW | Mean Lower Low Water | - do - |
| L'est LW | Lowest Low Water | 31 years (1940 - 1970) |

a/ : Distance from river estuary

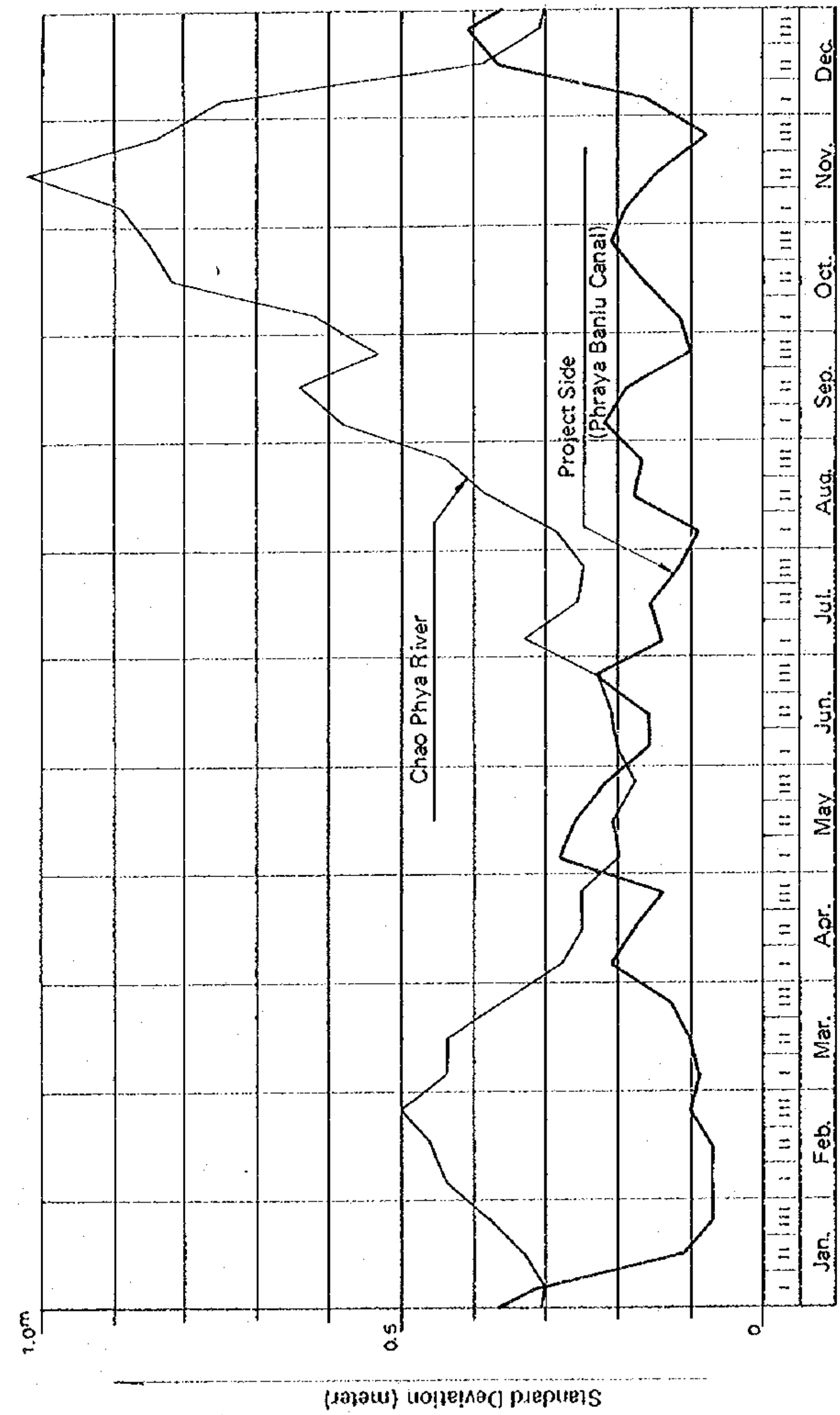
Source: RID

FIGURE A.3-8 MONTHLY MEAN WATER LEVEL AT SING HA NAT




Note: Average for 10 years (1967 - 1976)
Source: Chao-Chet Bangyeehon Project Office, RID

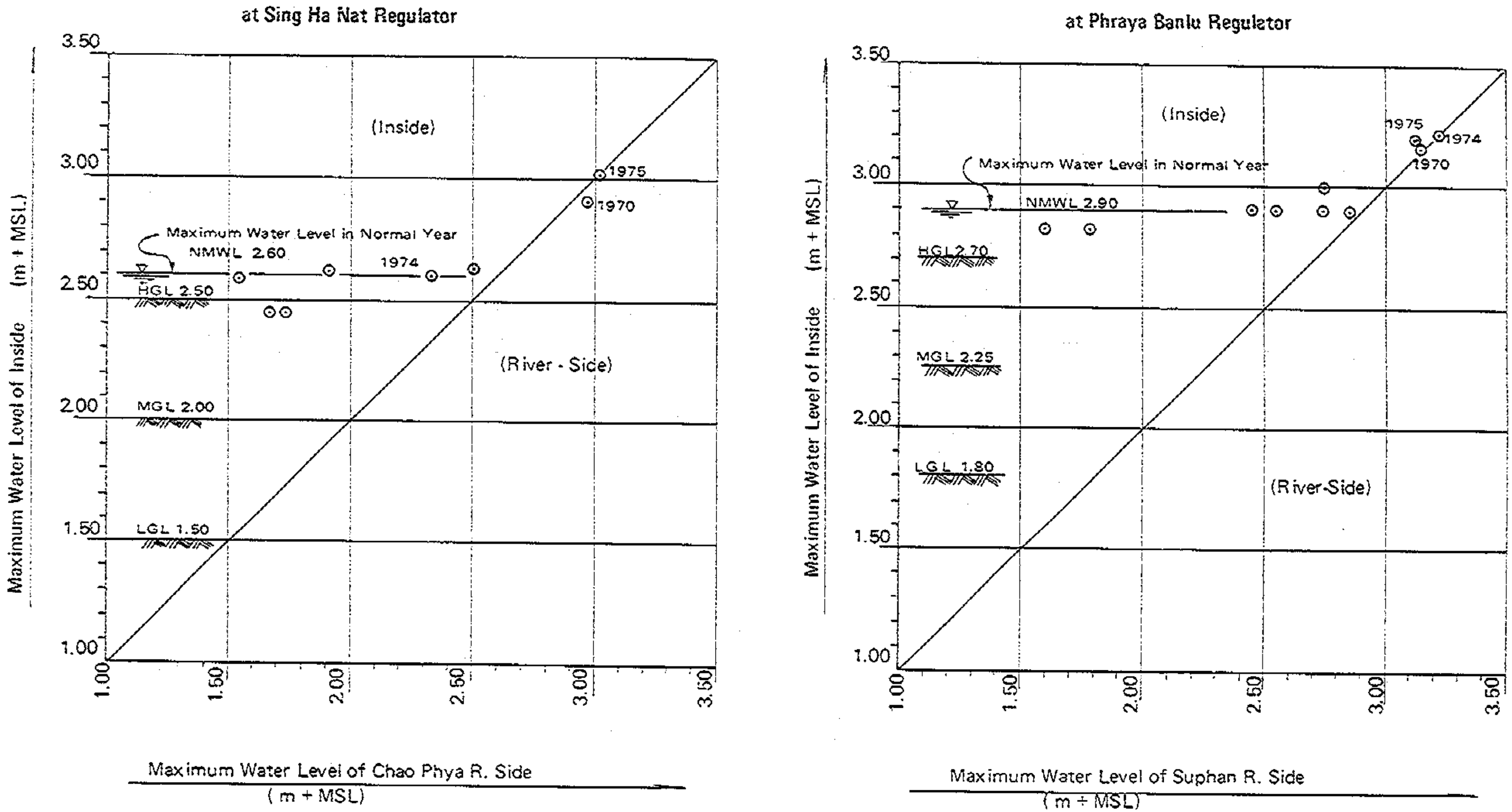
FIGURE A.3-9 FLUCTUATION OF MONTHLY MEAN WATER LEVEL AT SING HA NAT




Note: Average for 10 years (1967 – 1976)

Source: Chao-Chet Bangyeehon Project Office, RID

FIGURE A. 3-10 RELATIONSHIP BETWEEN MAXIMUM WATER LEVELS OF INSIDE OF WEST BANK TRACT AND RIVER SIDE IN THE VICINITY OF PROJECT AREA




Note: NMWL : Normal Maximum Water Level
HGL : Highest Ground Level, MGL : Mean Ground Level, LGL : Lowest Ground Level

Table A. 3-36 Maximum and Minimum Probable Water Level

(Unit: m)

| Return Period | Maximum Water Level | | | |
|---|---|---|---|---|
| | Phraya Banlu | | Sing Ha Nat | |
| | Outside (Suphan River) | Inside (Project Side) | Outside (Chao Phya River) | Inside (Project Side) |
| 2 years | 2.55 | 2.96 | 2.09 | 2.58 |
| 5 years | 3.12 | 3.09 | 2.59 | 2.77 |
| 10 years | 3.46 | 3.18 | 2.91 | 2.91 |
| 15 years | 3.65 | 3.23 | 3.08 | 2.99 |
| 20 years | 3.77 | 3.26 | 3.20 | 3.06 |

| Return Period | Minimum Water Level | | | |
|---|---|---|---|---|
| | Phraya Banlu | | Sing Ha Nat | |
| | Outside (Suphan River) | Inside (Project Side) | Outside1/ (Chao Phya River) | Inside (Project Side) |
| 2 years | 0.14 | 0.96 | -0.64 | 0.65 |
| 5 years | -0.03 | 0.80 | -0.74 | 0.55 |
| 10 years | -0.12 | 0.74 | -0.79 | 0.49 |
| 15 years | -0.16 | 0.71 | -0.82 | 0.47 |
| 20 years | -0.19 | 0.70 | -0.83 | 0.45 |

Note: Phraya Banlu: 1966 - 1975
Sing Ha Nat : 1968 - 1975

1/ : the data in 1970 is excluded.

Table A. 3-37 Extreme Water Level in the Vicinity of Project Area

| Year | Phraya Banlu Regulator: Outside (Suphan River) | | Phraya Banlu Regulator: Inside (Project Side) | | Lakkhon Regulator: Upstream (Project Side) | | Lakkhon Regulator: Outside (Chao Phra River) | | Sing Ha Nat Regulator: Inside (Project side) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| 1966 | 2.73 20 Oct. | -0.05 8 Apr. | 2.90 11 Oct. | 0.90 20 Apr. | - | - | 1.73 25 Oct. | - | 2.44 12 Nov. | 0.75 11 Apr. |
| 1967 | 1.78 1 Jan. | -0.19 24 Mar. | 2.82 31 Oct. | 1.00 12 Apr. | - | - | 1.19 18 May | -0.72 1 Feb. | 2.44 1 Nov. | 0.65 23 May |
| 1968 | 1.60 15 Jan. | 0.00 27 Mar. | 2.82 31 Oct. | 0.87 22 May | - | - | 2.50 15 Oct. | -0.80 17 Feb. | 2.63 27 Oct. | 0.47 30 Apr. |
| 1969 | 2.85 5 Nov. | 0.10 1 Apr. | 2.90 14 Nov. | 0.80 3 Apr. | - | - | 2.91 25 Oct. | -0.80 21 Feb. | 2.97 20 Oct. | 0.10 9 Jan. |
| 1970 | 3.14 5 Nov. | 0.12 4 Apr. | 3.16 31 Oct. | 1.06 19 Jan. | - | - | 1.54 7 Dec. | -0.60 26 Feb. | 2.58 30 Oct. | 0.60 30 Dec. |
| 1971 | 2.74 4 Nov. | 0.10 6 Apr. | 3.00 31 Oct. | 0.70 9 Feb. | 2.74 31 Oct. | 0.92 15 May | 1.67 13 Dec. | -0.60 15 Feb. | 2.44 20 Oct. | 0.64 13 May |
| 1972 | 2.44 14 Dec. | 0.38 11 May | 2.91 12 Oct. | 0.88 12 May | 2.64 25 Oct. | 0.92 31 May | 1.91 20 Oct. | -0.65 5 Mar. | 2.62 15 Nov. | 0.52 3 Jan. |
| 1973 | 2.54 19 Oct. | 0.24 1 Apr. | 2.90 22 Oct. | 0.99 16 May | 2.64 15 Nov. | 0.74 16 May | 2.33 21 Oct. | -0.45 27 Feb. | 2.60 1 Nov. | 0.87 6 Jun. |
| 1974 | 3.22 28 Oct. | 0.45 12 Mar. | 3.22 28 Oct. | 1.10 5 Feb. | 2.76 1 Nov. | 0.90 26 May | 3.02 30 Oct. | -0.56 12 Feb. | 3.01 30 Oct. | 0.78 16 Mar. |
| 1975 | 3.12 16 Nov. | 0.35 25 Apr. | 3.19 15 Nov. | 1.06 9 Mar. | 3.00 30 Oct. | 0.86 16 Mar. | 1.93 17 Oct. | -0.30 16 Feb. | - | - |
| 1976 | - | - | - | 1.02 2 Mar. | - | - | | | | |
| Mean | 2.61 | 0.15 | 2.98 | 0.94 | 2.76 | 0.87 | 2.01 | -0.61 | 2.63 | 0.59 |
| S | 0.52 | 0.19 | 0.14 | 0.12 | 0.13 | 0.07 | 0.57 | 0.15 | 0.20 | 0.21 |

Note: Based on the record of daily mean water level
S; Standard Deviation
Elevations of canal and river beds are EL.(-)2.00 m at the both regulator of Phraya Banlu and Sing Ha Nat

Source: Chao-chet Bangyeehon and Phraya Banlu Project Offices, RID

FIGURE A. 3-11 ANNUAL FLUCTUATION OF FREE SURFACE GROUNDWATER TABLE IN UPPER WEST BANK TRACT

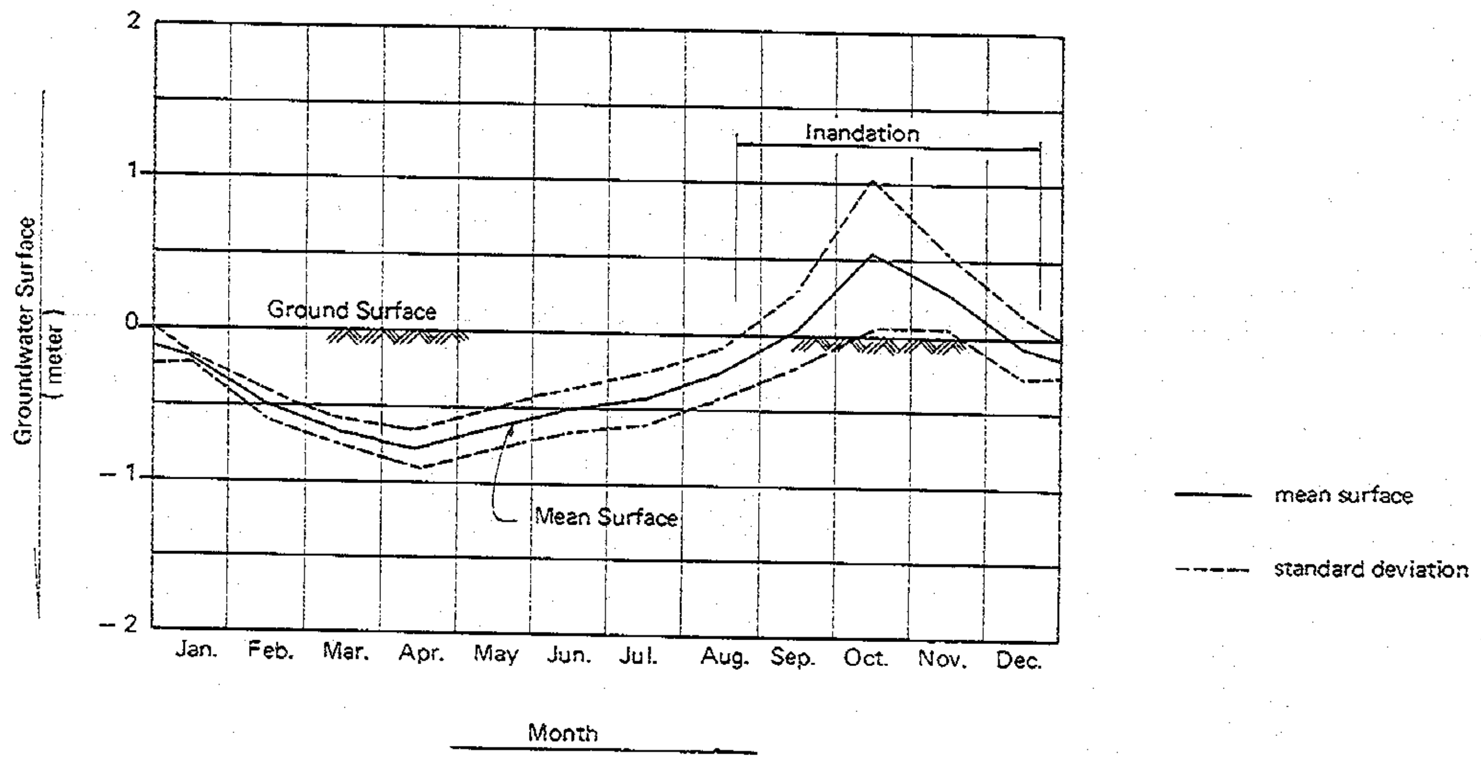


Table A. 3-38 Free Surface Ground Water Tables in Upper West Bank Tract (at Sena)

(Unit: m)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 0.164 | 0.558 | 0.793 | 0.862 | 0.473 | 0.321 | 0.272 | 0.091 | +0.405 | +1.375 | +0.645 | 0.357 |
| 1967 | 0.237 | 0.570 | 0.730 | 0.885 | 0.812 | 0.546 | 0.653 | 0.336 | 0.259 | +0.617 | +0.241 | 0.135 |
| 1968 | 0.148 | 0.329 | 0.597 | 0.654 | 0.567 | 0.588 | 0.609 | 0.494 | 0.097 | +0.215 | +0.260 | +0.102 |
| 1969 | 0.196 | 0.562 | 0.664 | 0.880 | 0.773 | 0.726 | 0.369 | 0.226 | 0.081 | 0.052 | 0.081 | 0.094 |
| 1970 | 0.187 | 0.437 | 0.557 | 0.579 | 0.552 | 0.371 | 0.203 | 0.046 | +0.270 | +0.562 | +0.452 | +0.266 |
| Mean ($\bar{x}$) | 0.186 | 0.491 | 0.668 | 0.772 | 0.635 | 0.510 | 0.421 | 0.239 | +0.048 | +0.543 | +0.303 | 0.044 |
| Standard Deviation (S) | 0.030 | 0.095 | 0.086 | 0.129 | 0.132 | 0.148 | 0.180 | 0.164 | 0.248 | 0.482 | 0.242 | 0.213 |

Note:
1. All measurements show depth in meters from ground surface to ground water table.
2. The measurements with mark of (+) are height from ground surface to inandation water surface.

Source: Technical Division, RID

Table A. 3-39 Water Quality of Canals in the West Bank Tract

PH

| Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sena | 7.2 | 7.2 | 7.2 | 7.3 | 7.4 | 7.5 | 7.4 | 7.1 | 7.3 | 7.4 | | | |
| Bang Bua Thong | | | | | | | | | 7.0 | 7.1 | 7.2 | 7.5 | |
| | 6.5 | 7.1 | 7.3 | 7.3 | 7.2 | 7.4 | 7.2 | 7.1 | 7.1 | 7.1 | | | |
| Mean | 6.9 | 7.2 | 7.3 | 7.3 | 7.3 | 7.5 | 7.3 | 7.1 | 7.1 | 7.2 | 7.2 | 7.5 | 7.2 |

Electrical Conductivity ($ECx10^6$, micromhos/cm at 20°C)

| Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sena | 230 | 300 | 295 | 300 | 260 | 280 | 260 | 240 | 240 | 220 | | | |
| Bang Bua Thong | | | | | | | | | 530 | 280 | 280 | 220 | |
| | 270 | 550 | 380 | 340 | 700 | 800 | 600 | 900 | 450 | 900 | | | |
| Mean | 250 | 425 | 338 | 320 | 480 | 540 | 430 | 570 | 407 | 467 | 280 | 220 | 394 |

Nitrate, expressed as nitrogen (PPM)

| Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sena | nil | 0.004 | 0.04 | 0.025 | nil | 0.004 | 0.012 | 0.005 | 0.010 | 0.016 | | | 0.012 |

Note: Data Period
Sena: Jan. - Oct. 1976
Bang Bua Thong: Sep. 1975 - Oct. 1976

Source: Sena Domestic Water Supply Station and Bang Bua Thong Domestic Water Supply Station

Table A. 3-40 Water Quality of the Chao Phya River

| Station | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|
| | | | | PH | | | | |
| Chai Nat | | | | 7.6 | 7.8 | | | |
| Chao Phya Dam | | | | 7.3 | 7.5 | 7.6 | 8.2 | |
| Sing Buri | 8.5 | 7.7 | 7.8 | 7.4 | 7.9 | 7.9 | 8.7 | |
| Ang Thong | 8.2 | | | 7.5 | 7.7 | 7.9 | 8.3 | |
| Ayutthaya | 8.8 | 7.5 | 8.3 | 7.4 | 7.5 | 7.7 | 8.5 | |
| Bang Sai | | 7.5 | 8.2 | | | | | |
| Pathum Thani | | | | 7.5 | 7.9 | 7.7 | 8.7 | |
| Non Tha Buri | | | | 7.3 | 8.0 | 7.6 | 8.5 | |
| Mean | 8.50 | 7.57 | 8.10 | 7.43 | 7.76 | 7.73 | 8.48 | 7.94 |
| Standard Deviation (S) | 0.24 | 0.09 | 0.22 | 0.10 | 0.18 | 0.12 | 0.19 | |

| Station | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|
| | | | | Electrical Conductivity ($ECx10^6$, micromhos/cm at 25°c) | | | | |
| Chai Nat | | | | 115 | 128 | | | |
| Chao Phya Dam | | | | 116 | 115 | 138 | 178 | |
| Sing Buri | 132 | 129 | 111 | 118 | 122 | 136 | 136 | |
| Ang Thong | 136 | | | 118 | 116 | 135 | 154 | |
| Ayutthaya | 150 | 123 | 135 | 128 | 105 | 130 | 155 | |
| Bang Sai | | 124 | 136 | | | | | |
| Pathum Thani | | | | 123 | 117 | 132 | 154 | |
| Non Tha Buri | | | | 123 | 129 | 139 | 161 | |
| Mean | 139 | 125 | 127 | 120 | 119 | 135 | 156 | 132 |
| (S) | 8 | 3 | 12 | 4 | 8 | 3 | 12 | |

| Station | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|
| | | | | Total Solids (PPM) | | | | |
| Chai Nat | | | | 368 | 165 | | | |
| Chao Phya Dam | | | | 375 | 172 | 262 | 167 | |
| Sing Buri | - | 663 | 468 | 433 | 209 | 240 | 222 | |
| Ang Thong | - | | | 467 | 241 | 219 | 258 | |
| Ayutthaya | - | 824 | 469 | 306 | 139 | 142 | 259 | |
| Bang Sai | | 341 | 522 | | | | | |
| Pathum Thani | | | | 342 | 167 | 161 | 255 | |
| Non Tha Buri | | | | 208 | 181 | 164 | 261 | |
| Mean | | 609 | 486 | 357 | 182 | 198 | 237 | 345 |
| (S) | | 201 | 25 | 79 | 31 | 45 | 34 | |

Note: Observed in 1961
S; Standard deviation

Source: Enclosed Data on Water Analysis, Greater Chao Phya Project
Refer to Lab. No.194/1962, RID

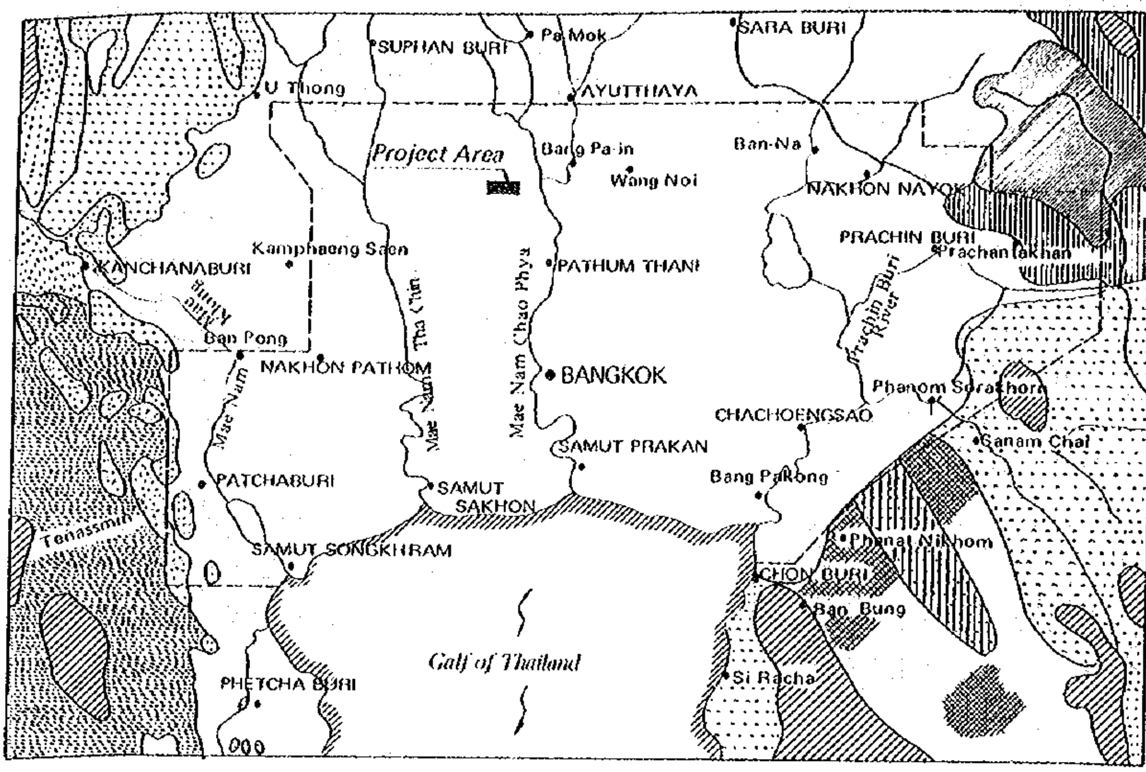
Water Quality of the Chao Phya River (cont'd)

| Station | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|
| | Total dissolved Solids (PPM) | | | | | | | |
| Chai Nat | | | | 126 | 112 | | | |
| Chao Phya Dam | | | | 115 | 113 | 131 | 143 | |
| Sing Buri | 129 | 115 | 81 | 98 | 117 | 139 | 114 | |
| Ang Thong | 106 | | | 86 | 103 | 138 | 98 | |
| Ayutthaya | 132 | 110 | 125 | 98 | 95 | 116 | 124 | |
| Bang Sai | | 126 | 146 | | | | | |
| Pathum Thani | | | | 100 | 99 | 124 | 144 | |
| Non Tha Buri | | | | 98 | 126 | 125 | 138 | |
| Mean | 122 | 117 | 117 | 103 | 110 | 129 | 127 | 118 |
| (S) | 12 | 7 | 27 | 12 | 11 | 8 | 17 | |

| Station | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|
| | Suspended Solids (PPM) | | | | | | | |
| Chai Nat | | | | 242 | 53 | | | |
| Chao Phya Dam | | | | 260 | 59 | 131 | 24 | |
| Sing Buri | - | 547 | 407 | 335 | 92 | 101 | 98 | |
| Ang Thong | - | 381 | | 381 | 138 | 81 | 160 | |
| Ayutthaya | - | 714 | 336 | 217 | 44 | 28 | 123 | |
| Bang Sai | | 268 | 377 | | | | | |
| Pathum Thani | | | | 241 | 68 | 37 | 121 | |
| Non Tha Buri | | | | 110 | 55 | 38 | 134 | |
| Mean | | 478 | 373 | 255 | 73 | 69 | 110 | 226 |
| (S) | | 169 | 29 | 80 | 30 | 38 | 43 | |

| Station | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|
| | Calcium (PPM) | | | | | | | |
| Chai Nat | | | | 14.56 | 14.59 | | | |
| Chao Phya Dam | | | | 15.10 | 13.93 | 17.32 | 18.14 | |
| Sing Buri | 16.17 | 17.35 | 15.27 | 14.89 | 14.73 | 17.29 | 16.27 | |
| Ang Thong | 14.76 | | | 16.04 | 13.02 | 14.38 | 18.50 | |
| Ayutthaya | 17.12 | 13.81 | 16.49 | 17.53 | 12.91 | 13.36 | 19.04 | |
| Bang Sai | | 15.29 | 16.93 | | | | | |
| Pathum Thani | | | | 16.69 | 15.17 | 13.36 | 18.55 | |
| Non Tha Buri | | | | 16.53 | 14.48 | 14.61 | 19.32 | |
| Mean | 16.02 | 15.48 | 16.23 | 15.91 | 14.12 | 15.05 | 18.31 | 15.87 |
| (S) | 0.97 | 1.45 | 0.70 | 1.01 | 0.80 | 1.66 | 0.99 | |

**FIGURE A. 3-12 GEOLOGICAL MAP OF THE SOUTHERN CENTRAL PLAIN**




| SEDIMENTARY AND METAMORPHIC ROCKS | | |
|---|---|---|
| | recent to old alluvium | Quarternary |
| Korat Group | PHU PHAN AND PHRA WIHAN FORMATION predominanly red to light grey sandstone and conglomerate | Jurassic |
| | PHU KRADUNG FORMATION predominanly brown micaceous shale with some siltstone | Jurassic and Triassic |
| Ratchaburi Group | RATCHABURI FORMATION light grey limestone with some shale, sandstone and conglomerate | Carboniferous and Permian |
| Tanaosi Group | KAENG KRACHAN FORMATION predominantly greywacke mudstone and siltstone with shale and sandstone | Carboniferous Devonian and Silurian |
| | KANCHANABURI FORMATION predominantly shale, sandstone, phyllite and quartzite | |

| IGNEOUS ROCKS | |
|---|---|
| basalt | Tertiary |
| granite, granodiorite | Cretaceous Triassic and Carboniferous |
| porphyry | Pre-Triassic |
| gneiss and schist | Pre-Permian |

-- -- Boundary of soil survey area

Source: Detailed Reconnaissance Soil Survey of Southern Central Plain Area
by W. Van der Kevie and Banchong Yenmanas
Report SSR-89, Bangkok, 1972

FIGURE A.3-13 LOCATION MAP OF BORING AND SAMPLING TEST

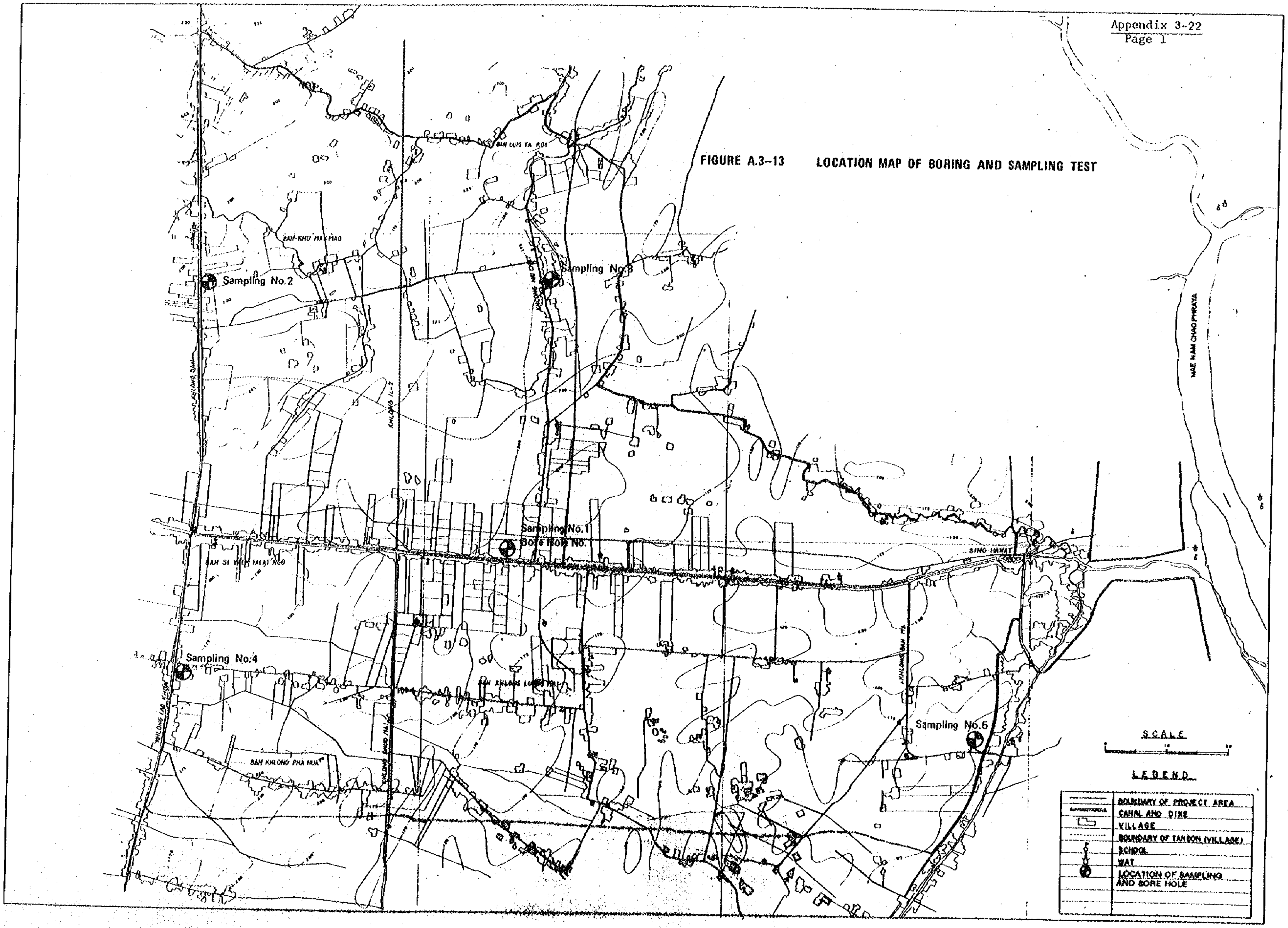


FIGURE A.3 – 14 SOIL AND MATERIAL LABORATORY BORING LOG

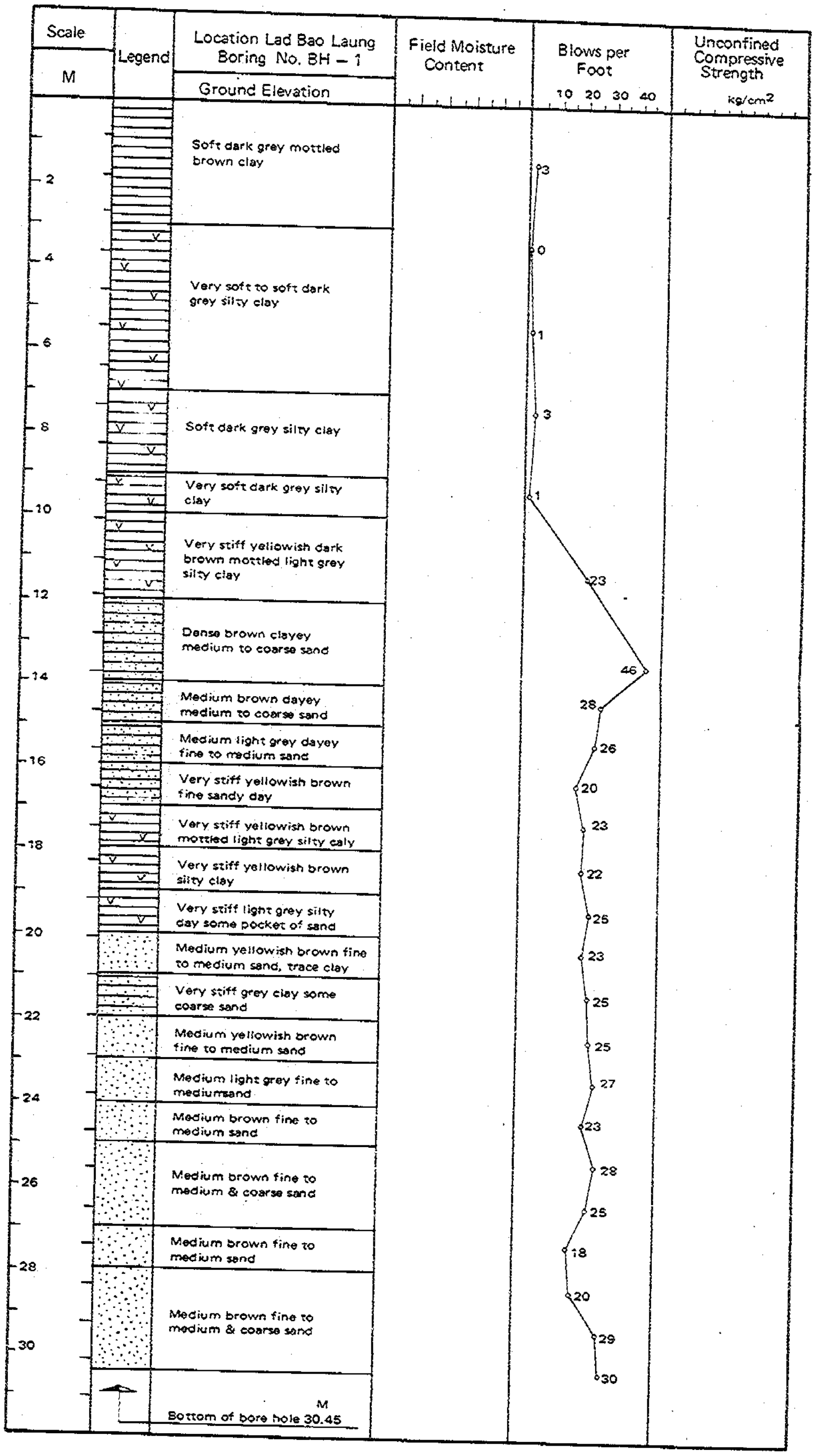
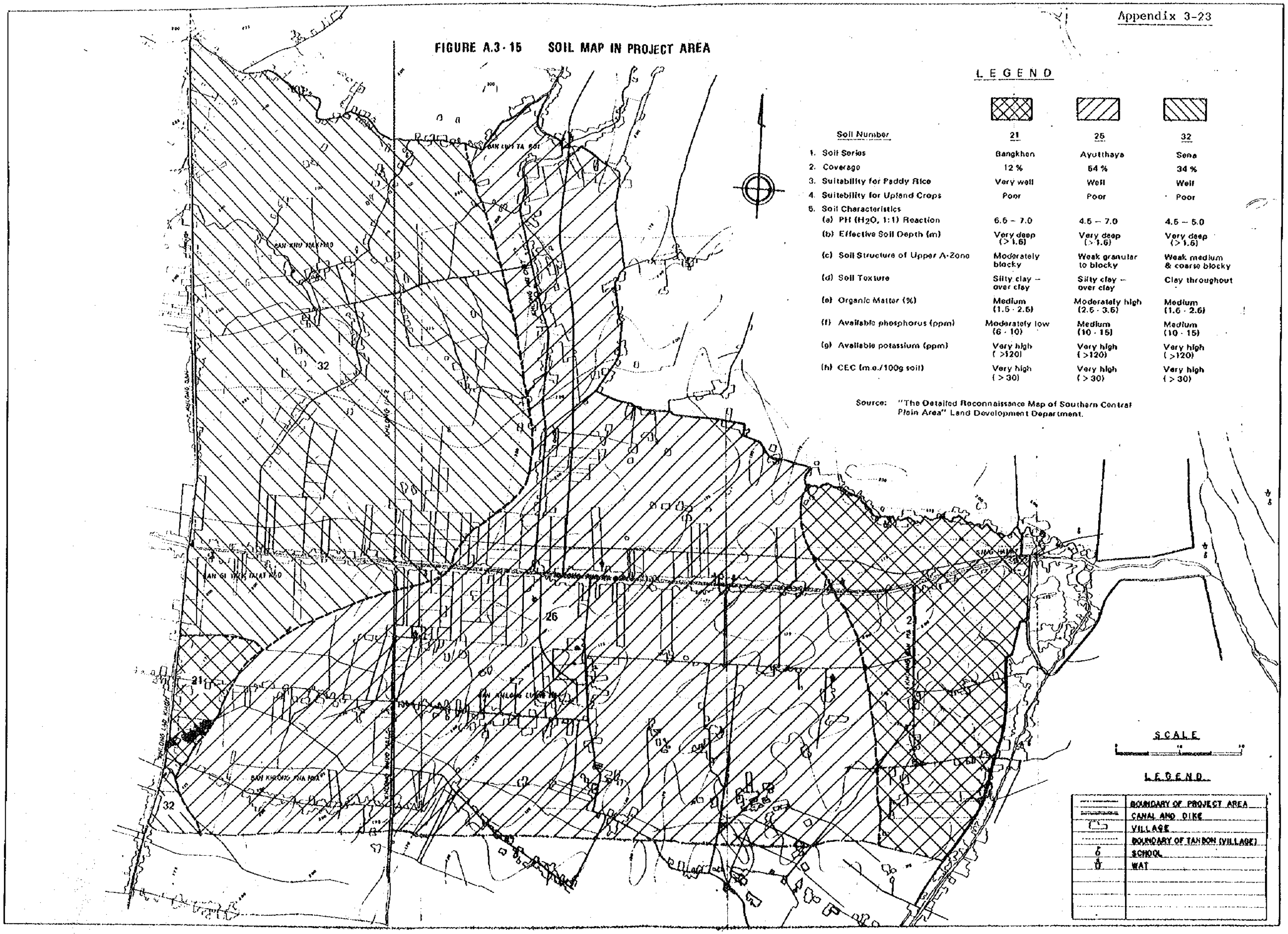


Table A. 3-41 Results of Soil Mechanical Test

| Item | | No.1 | No.2 | No.3 | No.4 | No.5 | Remarks |
|---|---|---|---|---|---|---|---|
| Natural moisture content | (%) | 78.4 | 60.2 | 54.2 | 42.0 | 22.2 | |
| Consistency | | | | | | | |
| Liquid limit | WL (%) | 84.2 | 74.0 | 92.0 | 85.2 | 71.5 | |
| Plastic limit | Wp (%) | 34.6 | 32.8 | 36.9 | 31.0 | 31.1 | |
| Shrinkage limit | Ws (%) | 28.3 | 24.0 | 23.8 | 23.8 | 28.6 | |
| Plasticity index | Ip (%) | 49.6 | 41.2 | 55.1 | 54.2 | 40.4 | Ip = Wl - Wp |
| Grain size analysis | | | | | | | |
| Gravel | (%) | 1 | - | - | - | 1 | 4.76 mm over |
| Sand | (%) | 6 | 10 | 4 | 4 | 1 | 4.76 - 0.074 mm |
| Silt and clay | (%) | 93 | 90 | 96 | 96 | 98 | 0.74 mm under |
| Specific gravity | | 2.57 | 2.58 | 2.56 | 2.54 | 2.58 | |
| Natural unit density | ($t/m^3$) | 1.64 | 1.84 | 1.39 | 1.64 | 1.82 | |
| Classification of soil | (USCS) | CH | CH | CH | CH | CH | Inorganic clays of high plasticity |
| | (USDA) | Silty clay | Silty clay | Silty clay | Silgy clay | Silty clay | |

Note: USCS: base on Unifined Soil Classification
USDA: base on U.S. Bureau of Soil Triangular Classification Chart

## FIGURE A.3-15 SOIL MAP IN PROJECT AREA




LEGEND

| Soil Number | 21 | 25 | 32 |
|---|---|---|---|
| 1. Soil Series | Bangkhen | Ayutthaya | Sena |
| 2. Coverage | 12 % | 54 % | 34 % |
| 3. Suitability for Paddy Rice | Very well | Well | Well |
| 4. Suitability for Upland Crops | Poor | Poor | Poor |
| 5. Soil Characteristics | | | |
| (a) PH ($H_2O$, 1:1) Reaction | 6.6 – 7.0 | 4.5 – 7.0 | 4.5 – 5.0 |
| (b) Effective Soil Depth (m) | Very deep (> 1.6) | Very deep (> 1.6) | Very deep (> 1.6) |
| (c) Soil Structure of Upper A-Zone | Moderately blocky | Weak granular to blocky | Weak medium & coarse blocky |
| (d) Soil Texture | Silty clay – over clay | Silty clay – over clay | Clay throughout |
| (e) Organic Matter (%) | Medium (1.5 - 2.5) | Moderately high (2.5 - 3.5) | Medium (1.5 - 2.5) |
| (f) Available phosphorus (ppm) | Moderately low (6 - 10) | Medium (10 - 15) | Medium (10 - 15) |
| (g) Available potassium (ppm) | Very high ( >120) | Very high ( >120) | Very high ( >120) |
| (h) CEC (m.e./100g soil) | Very high ( > 30) | Very high ( > 30) | Very high ( > 30) |

Source: "The Detailed Reconnaissance Map of Southern Central Plain Area" Land Development Department.

FIGURE A. 3-16 PRESENT, IRRIGATION, AND DRAINAGE SYSTEMS

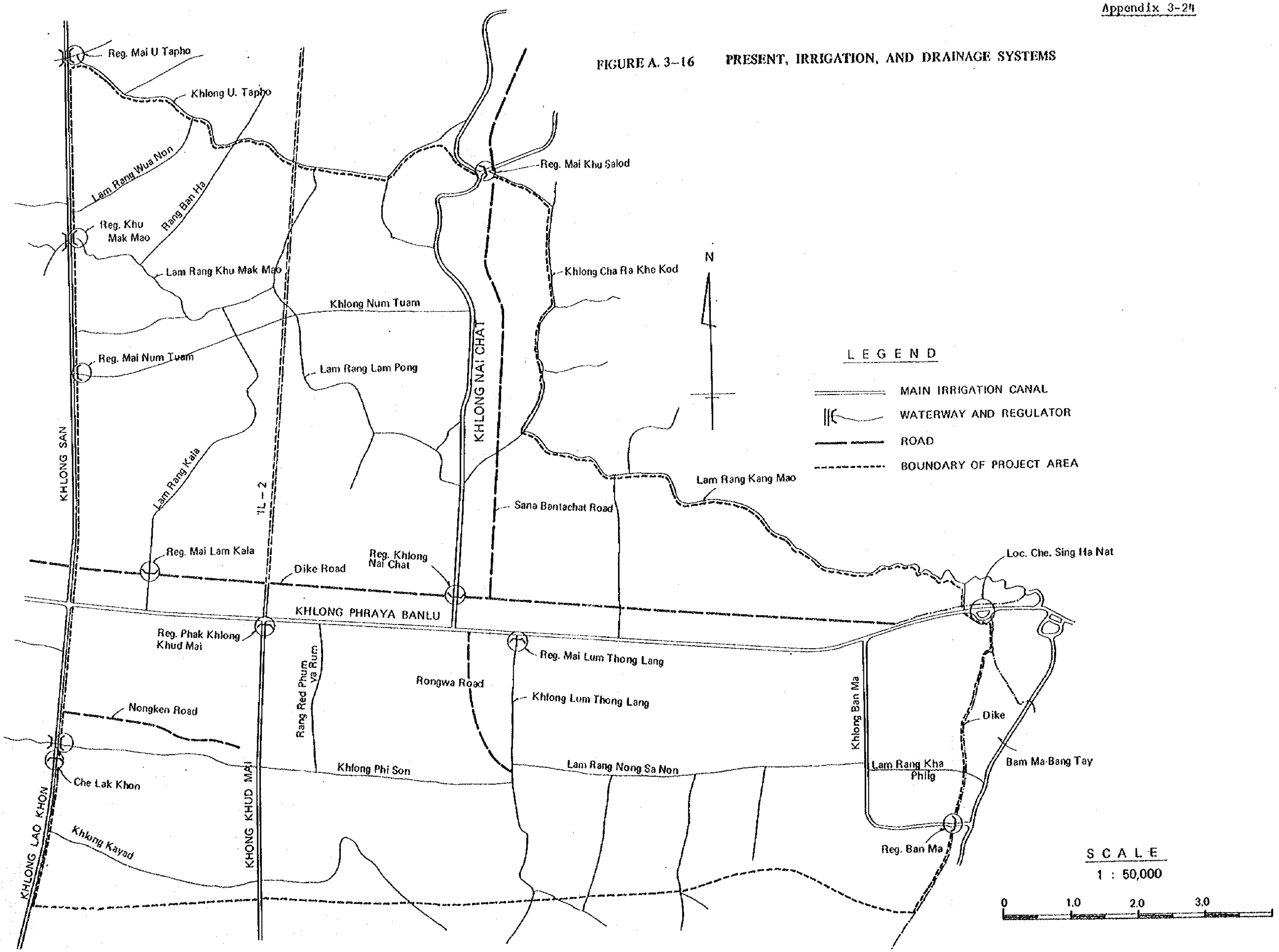
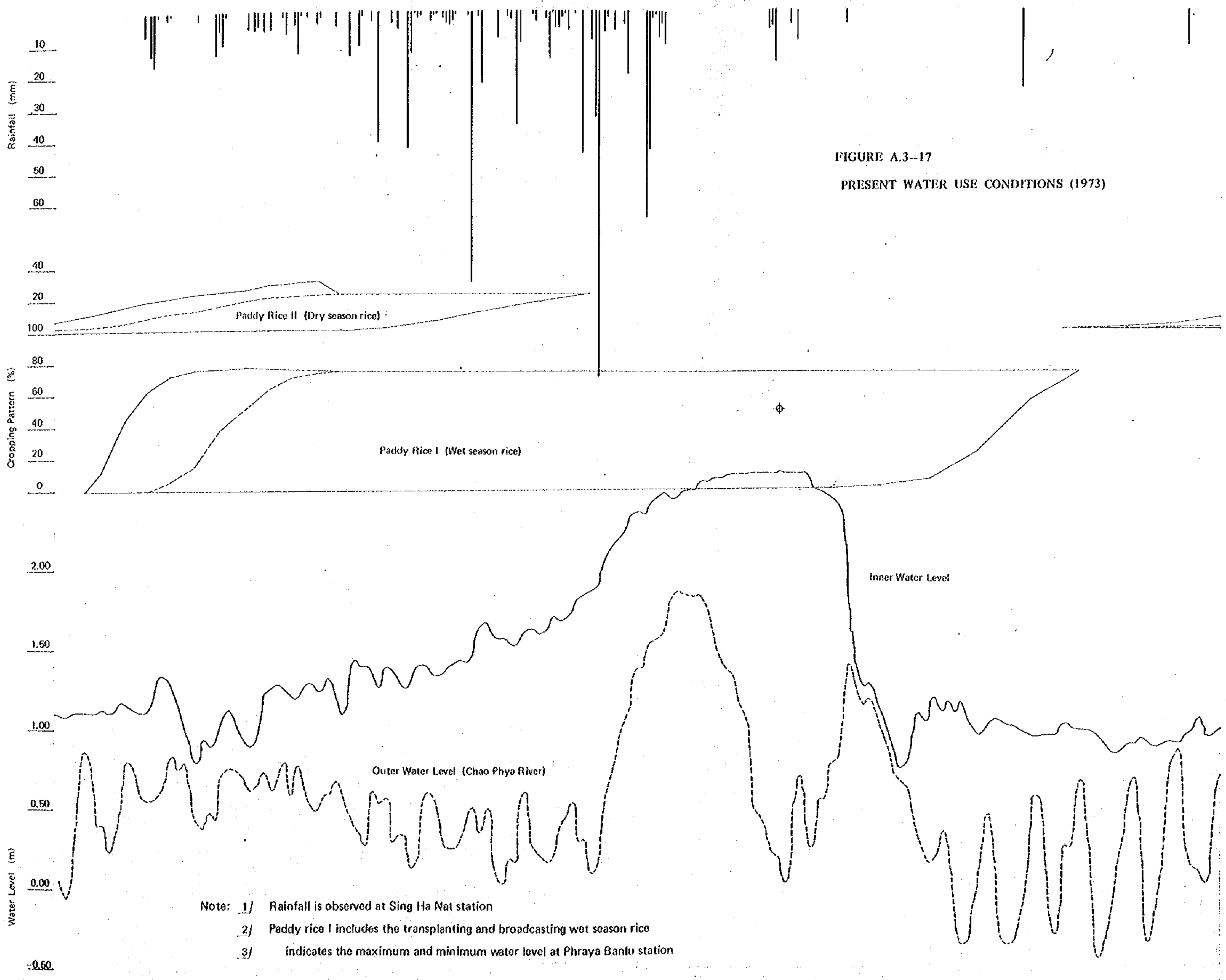


FIGURE A.3-17

PRESENT WATER USE CONDITIONS (1973)



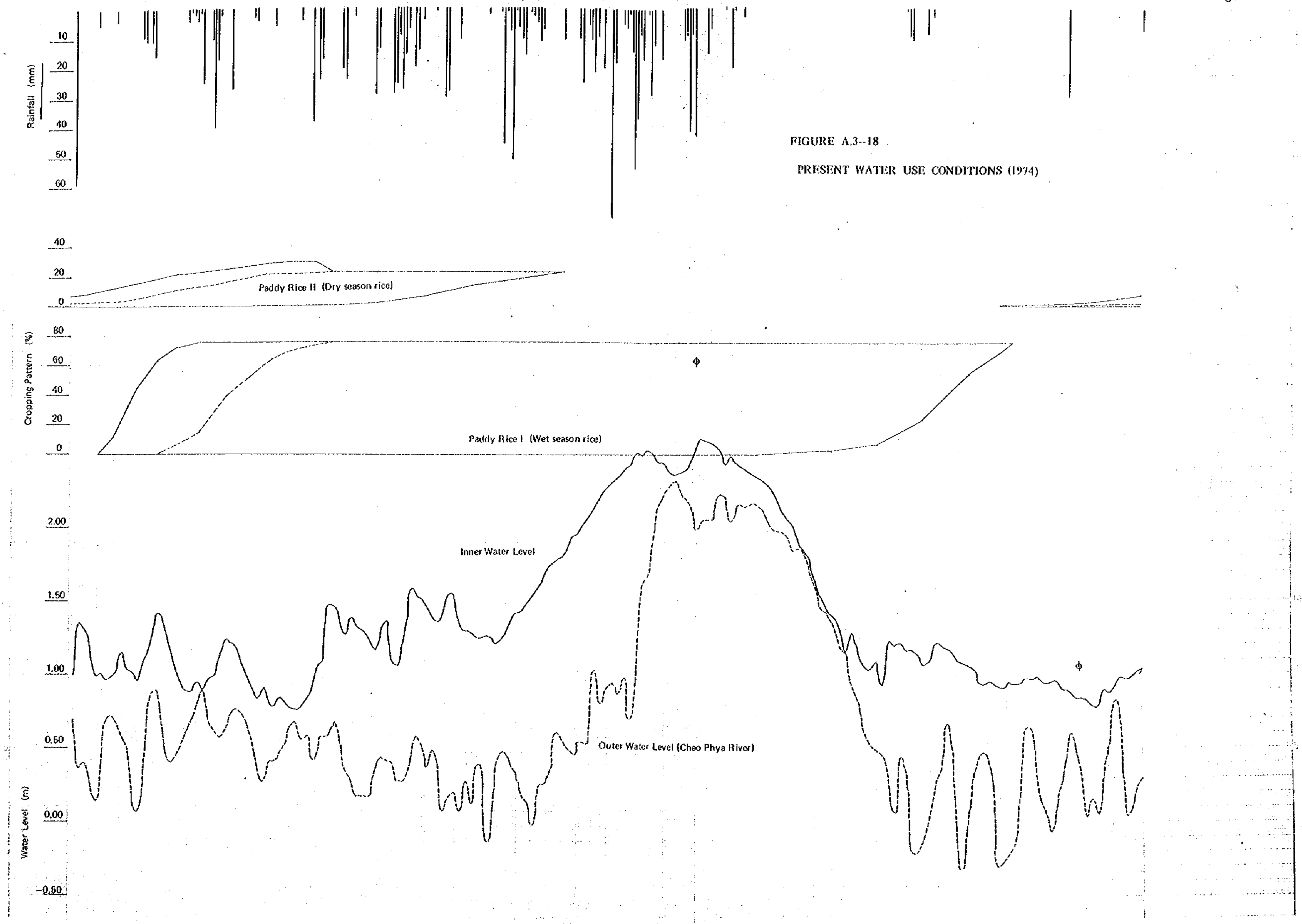

Note: 1/ Rainfall is observed at Sing Ha Nat station

2/ Paddy rice I includes the transplanting and broadcasting wet season rice

3/ indicates the maximum and minimum water level at Phraya Banlu station

FIGURE A.3-18

PRESENT WATER USE CONDITIONS (1974)



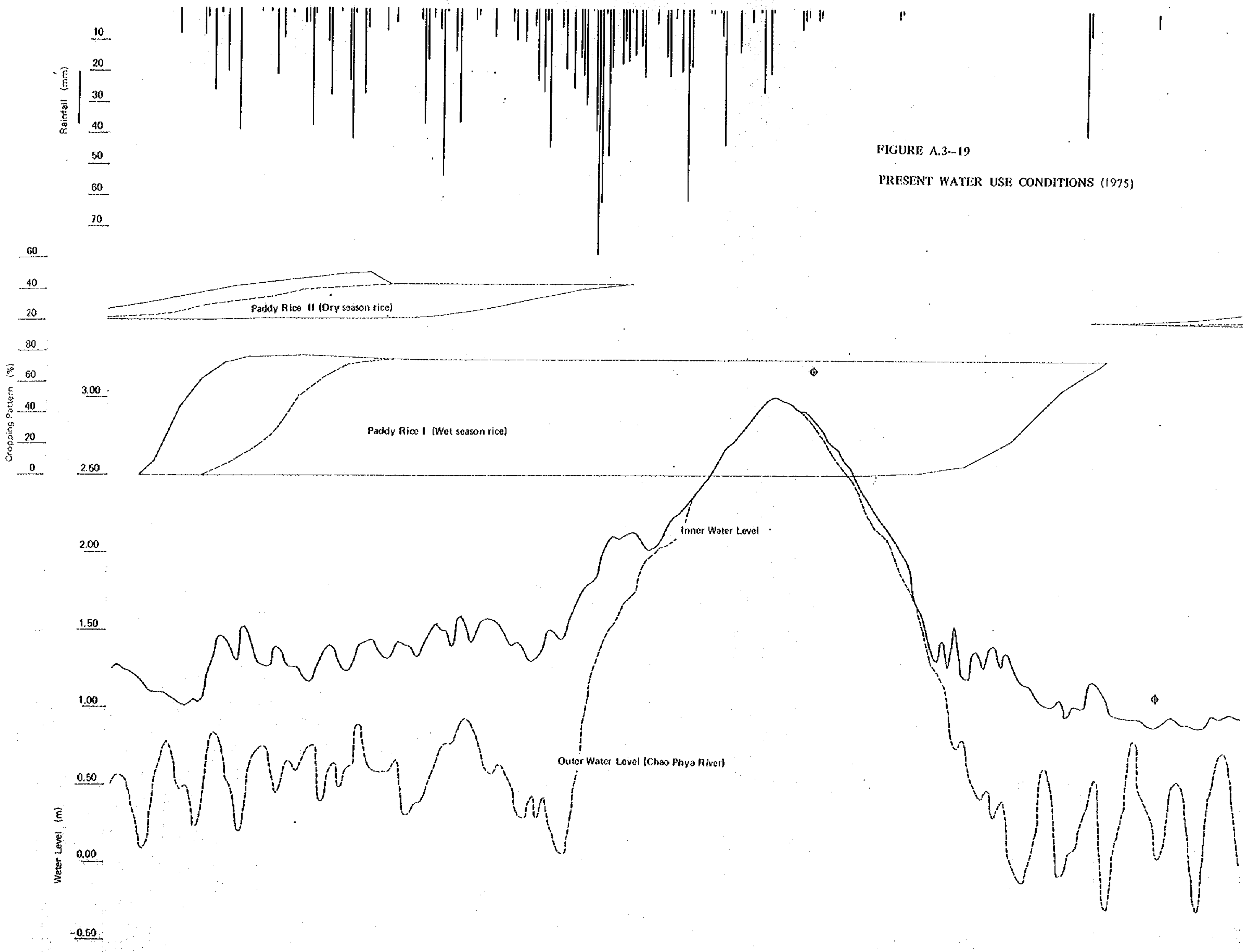



FIGURE A.3-19

PRESENT WATER USE CONDITIONS (1975)

FIGURE A.3--20

PRESENT WATER USE CONDITIONS (1976)

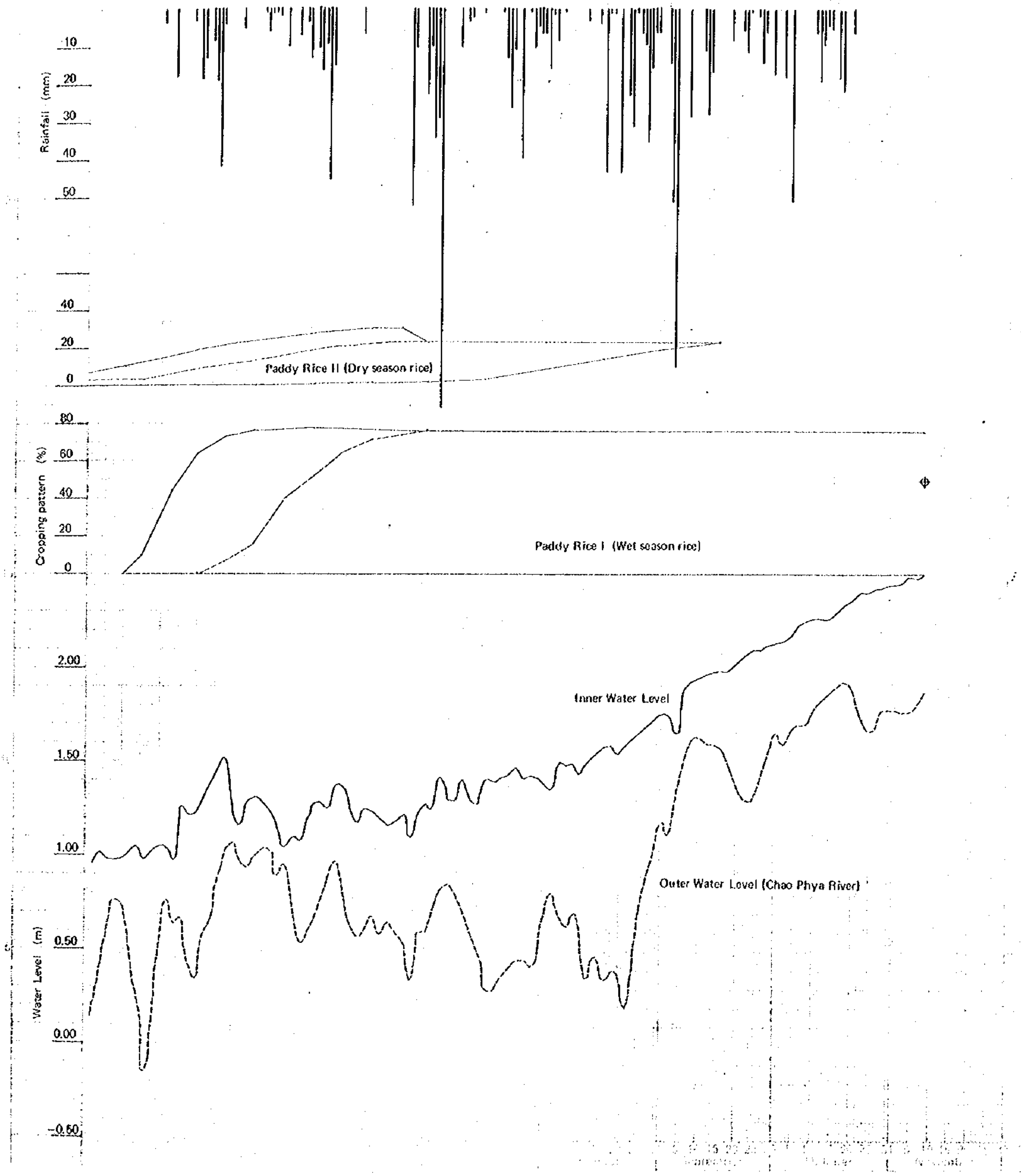
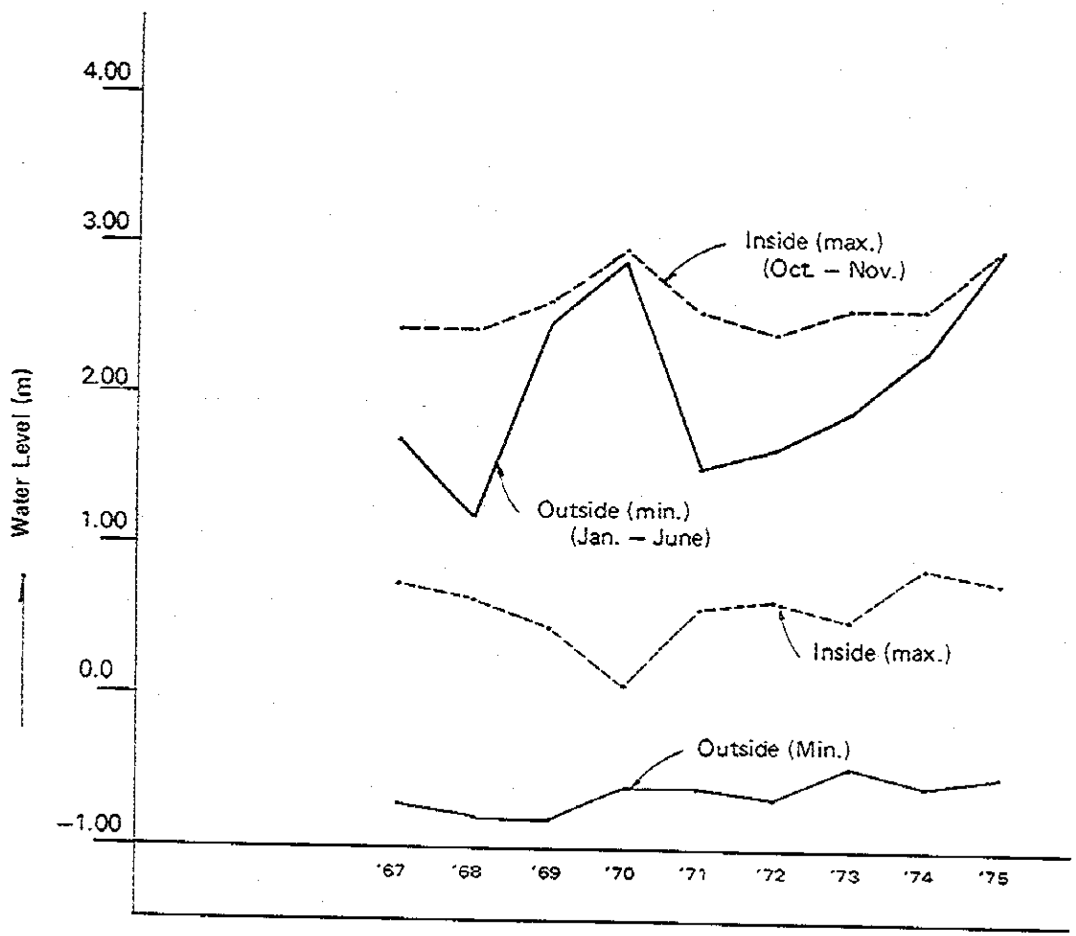


FIGURE A 3-21 MAXIMUM & MINIMUM WATER LEVEL AT SING HA NAT REG.




| Year | INSIDE Max. W.L. | INSIDE Min. W.L. | OUTSIDE Max. W.L. | OUTSIDE Min. W.L. |
|---|---|---|---|---|
| 1967 | 2.44 | 0.75 | 1.73 | –0.72 |
| 1968 | 2.44 | 0.65 | 1.19 | –0.80 |
| 1969 | 2.63 | 0.47 | 2.50 | –0.80 |
| 1970 | 2.97 | 0.10 | 2.91 | –0.60 |
| 1971 | 2.58 | 0.60 | 1.54 | –0.60 |
| 1972 | 2.44 | 0.64 | 1.67 | –0.65 |
| 1973 | 2.62 | 0.52 | 1.91 | –0.45 |
| 1974 | 2.60 | 0.87 | 2.33 | –0.56 |
| 1975 | 3.01 | 0.78 | 3.02 | –0.50 |
| Mean | 2.64 | 0.60 | 2.09 | –0.63 |

Source: Chao-ched Bangyeehon Irrigation Office
Inside: Inside of regurator
Outside: Outside of regurator (Chao Phya river)

Table A. 3-42 Proposed Land Consolidation Area and Complated Area in Thailand in 1975

| Project | Area (ha) | Implemented area (ha) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | Total |
| Suppaya | 7,200 | 124 | 162 | 346 | 213 | 439 | 368 | 1,652 |
| Channasutra (I) | 9,600 | 176 | 531 | 1,149 | 1,216 | 2,368 | 1,168 | 6,608 |
| Channasutra (II) | 56,700 | | | | | | | |
| Nong Wai | 12,000 | - | - | - | - | - | 160 | 160 |
| Total | 85,500 | 300 | 693 | 1,495 | 1,429 | 2,807 | 1,696 | 8,420 |

Source: Central Land Consolidation Office

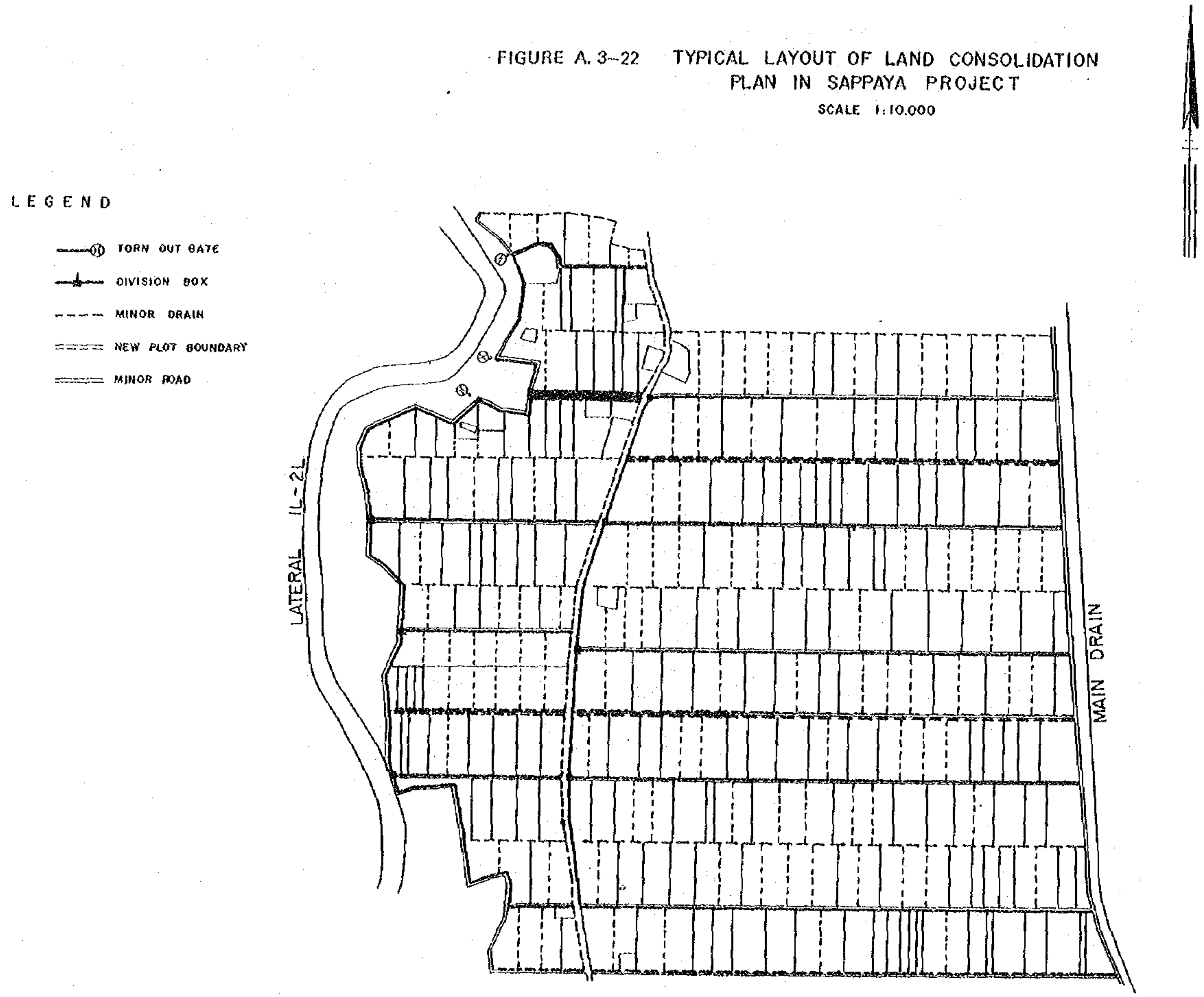
Table A. 3-43 Comparison of Major Features of Sappaya Project and Channasutra Project

| Items | Sappaya Project | Channasutra Project | Remarks |
|---|---|---|---|
| Project area (ha) | 7,200 | Stage (I) : 9,600<br>Stage (II): 56,700<br>66,300 | |
| Construction periods | 1971 - 1980 | Stage (I) : 1971-1977<br>Stage (II): 1978-1982 | |
| Implemented area (ha) | 1,652 (23 %) | 6,608 (69 %) | |
| Construction cost ($/ha) | 2,200 | 1,500 | |
| Major Features of On-Farm Cost per ha ($/ha) | 720 (2,380 ฿/rai) | 470 (1,500 ฿/rai) | Exclusive of depreciation cost of machinaries |
| size of plot (ha) | 1.0 - 0.15 | 6.0 - 0.15 | |
| length of Run (m) | 130 - 150 | 200 - 250 | |
| width of parcel (m) | 15 - 70 | 10 - 240 | |
| ratio of roads (m/ha) | 72.5 (11.6 m/rai) | 36.3 (5.8 m/rai) | |
| ratio of canal (m) | 98.1 (15.7 m/rai) | 68.1 (10.9 m/rai) | |
| Earth moving volume ($m^3$/ha) | 481 (77 $m^3$/rai) | 313 (50 $m^3$/rai) | |
| Width of road (m) | 3.0, 4.0, 6.0 | 4.0, 5.5 | |

Source: Royal Irrigation Department, Central Land Consolidation Office

FIGURE A. 3-22 TYPICAL LAYOUT OF LAND CONSOLIDATION PLAN IN SAPPAYA PROJECT

SCALE 1:10,000



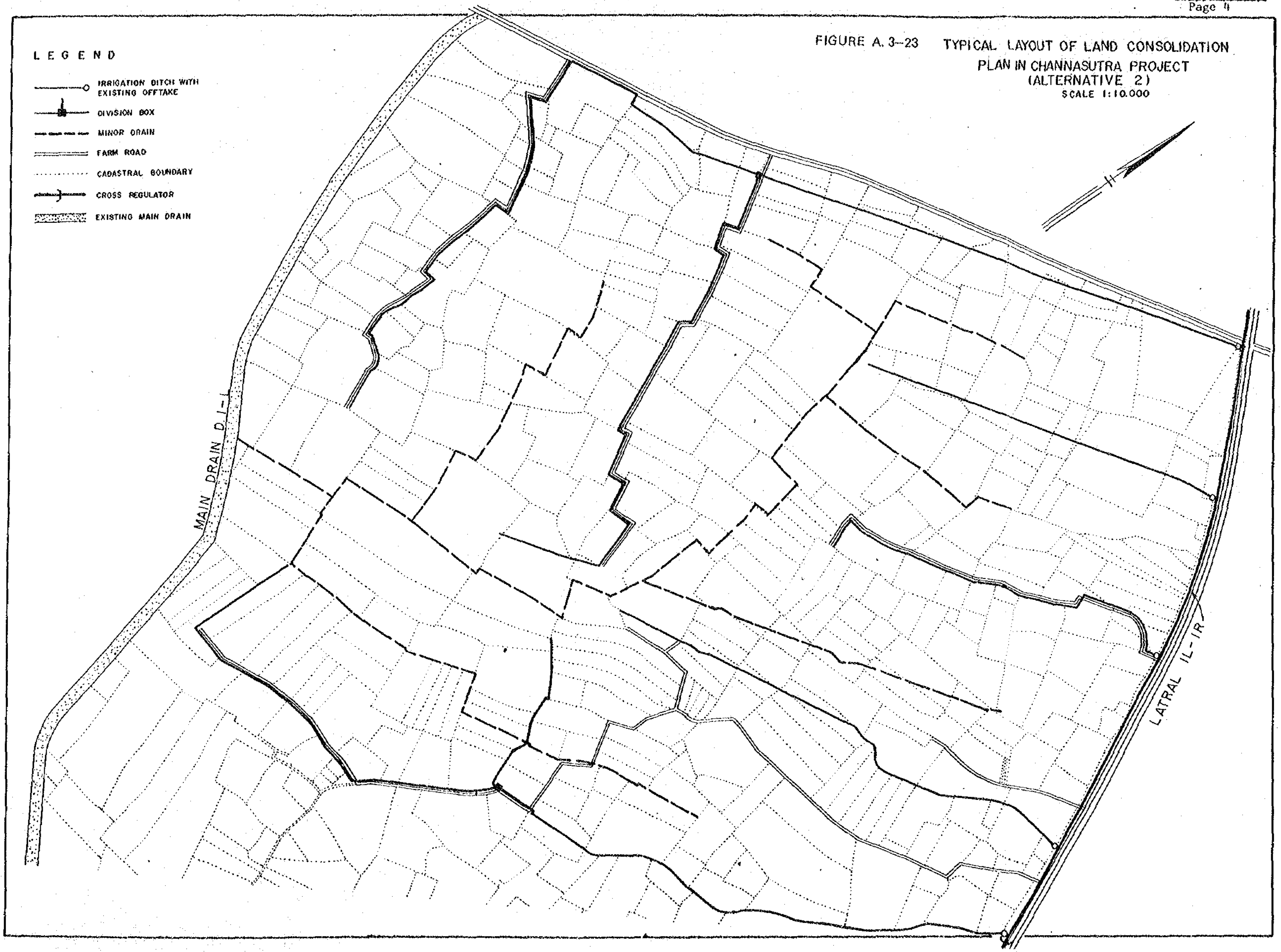



FIGURE A.3-23 TYPICAL LAYOUT OF LAND CONSOLIDATION PLAN IN CHANNASUTRA PROJECT (ALTERNATIVE 2)
SCALE 1:10.000

FIGURE A. 3-24 TYPICAL LAYOUT OF LAND CONSOLIDATION PLAN IN CHANNASUTRA PROJECT (ALTERNATIVE 4 AND 5)

SCALE 1 : 10,000

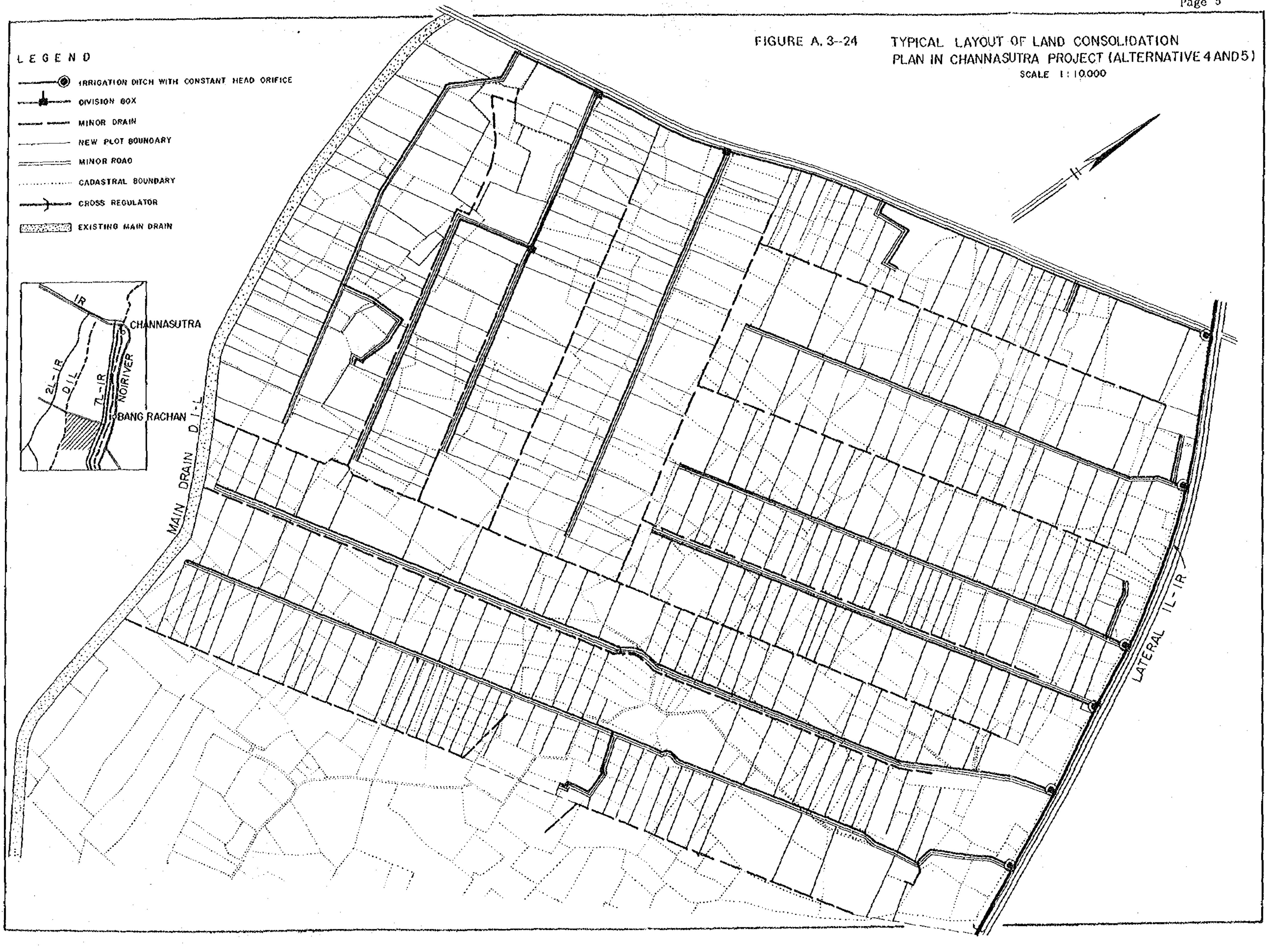


FIGURE A.3-25 PRESENT SIZE AND SHAPE OF FARM FIELD

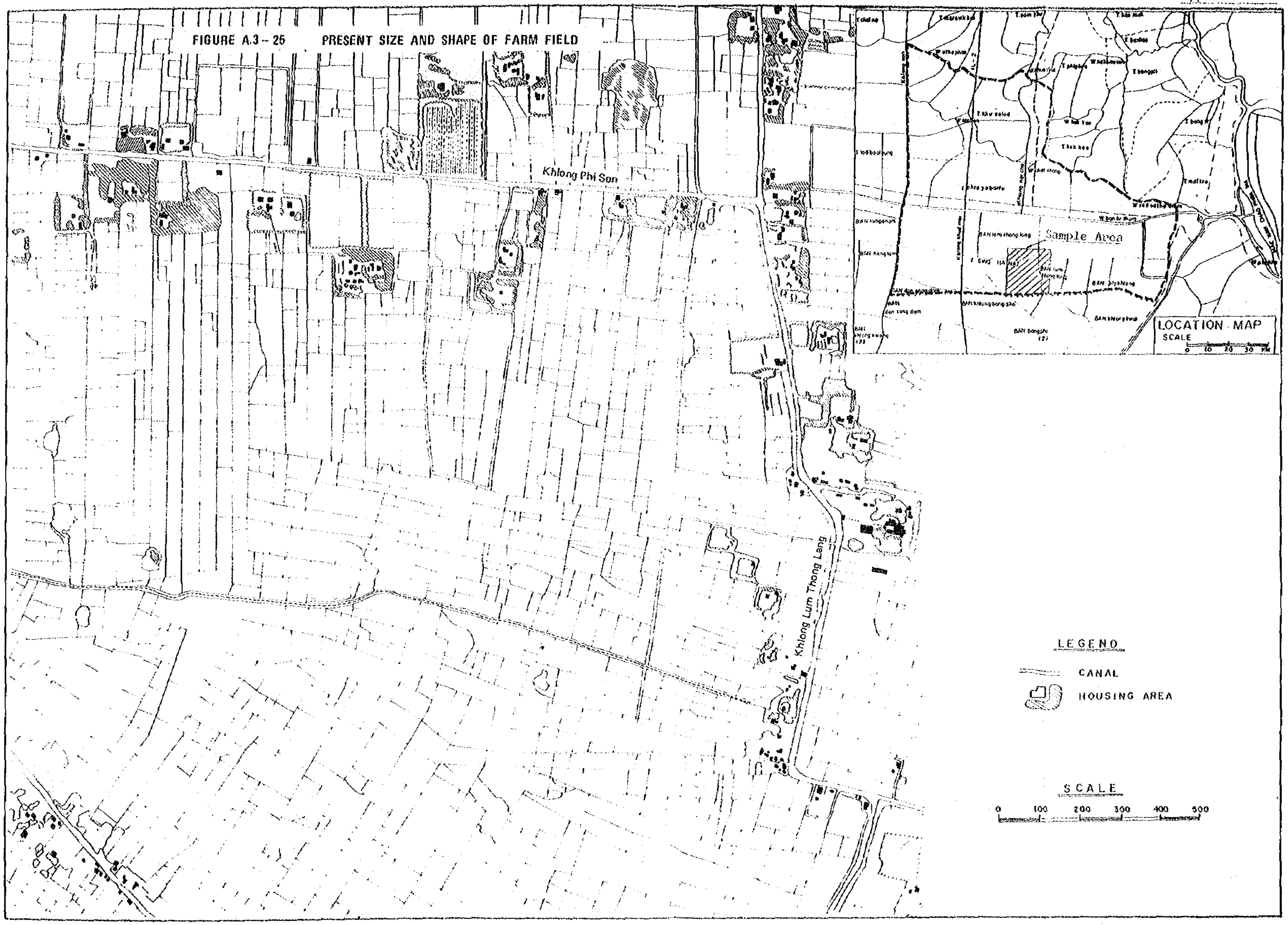
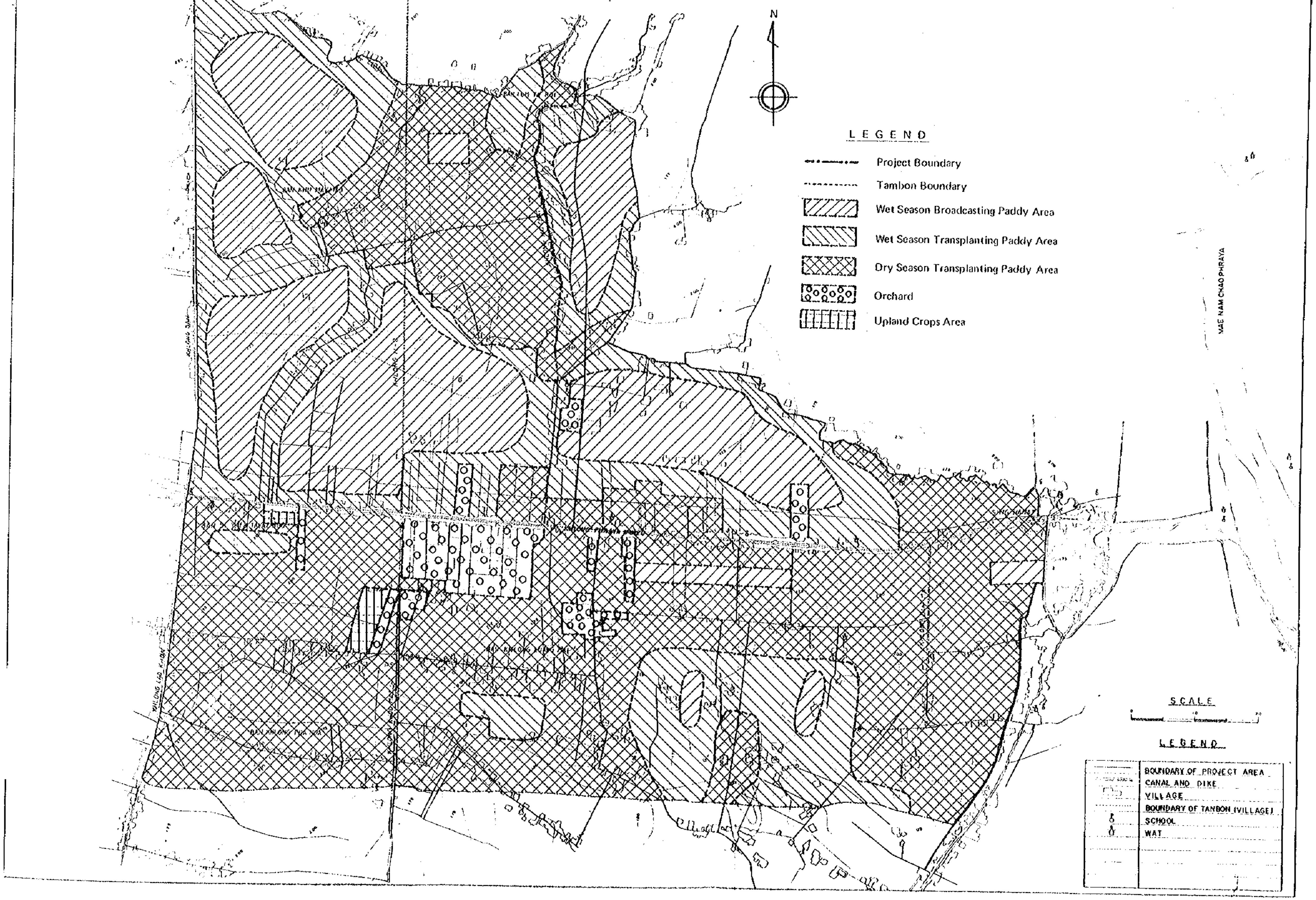


FIGURE A.3-25-1 PRESENT LAND USE MAP



Crop Yield

ld of Paddy Rice

eld in Ayutthaya Province

shown in Table A. 3-44, the Paddy Yields in the Ayutthaya is lower than those in the Central Plain as well as whole in Thailand. There are about one million hectares of paddy ilized for the floating type paddy in Thailand, and these e concentrated to the lower Chao Phya area. In the Ayutthaya especially, this type of paddy occupies about 88 per cent of e paddy cropping area, because of low-lying area with flooding on in the wet season.

yield of floating paddy rice, in general, is quite low, con- y, the average yield in the Ayutthaya Province becomes low when with those in Central Plain or Thailand.

ld in Project Area

paddy field in the Project Area is cultivated with nds of paddy cultivation, and the yield of each kind of that is as shown below, based on the collected data and field survey d by the mission.

Wet Season broadcasting paddy

ost paddy field in the Ayutthaya Province is cultivated with ting paddy, so that, it is reasonable to make assumption that ge paddy yield of about 1.6 ton/ha in Ayutthaya Province for years from 1963 to 1972 can be regarded as that in the Project l this figure is approximately same to the result of the field onducted.

transplanting paddy

he transplanting paddy field, high yielding varieties are d under the application of fertilizer and agricultural

Table A. 3-44 Statistical Data on Paddy Yield

| Statistic | Year | Planted Area (ha) | Damaged Area (ha) | Harvested Area (ha) | Production (ton) | Average Yield4/ (ton/ha) |
|---|---|---|---|---|---|---|
| Ayutthaya Province1/ | 1963 | 217,475 | 5,028 | 212,446 | 362,566 | 1.67 |
| (1963 - 1972) | 1964 | 220,754 | 99,984 | 120,770 | 149,493 | 0.68 |
| | 1965 | 220,455 | 13,966 | 206,489 | 350,190 | 1.59 |
| | 1966 | 220,200 | 11,656 | 208,544 | 374,638 | 1.70 |
| | 1967 | 219,797 | 17,245 | 202,552 | 383,583 | 1.75 |
| | 1968 | 220,856 | 16,558 | 204,299 | 331,136 | 1.50 |
| | 1969 | 220,435 | 37,742 | 182,693 | 361,788 | 1.64 |
| | 1970 | 215,839 | 33,837 | 182,002 | 385,274 | 1.79 |
| | 1971 | 219,317 | 5,452 | 213,865 | 401,398 | 1.83 |
| | 1972 | 212,819 | 13,670 | 199,149 | 351,322 | 1.65 |
| | Total | 2,187,947 | 255,138 | 1,932,809 | 3,451,388 | 16.80 |
| | Mean | 218,795 | 25,514 | 193,281 | 345,139 | 1.58 |
| Annual Rice Production in Central Plain2/ (1962 - 1975) | | 2,219,000 | N.A. | N.A. | 4,190,000 | 1.89 |
| Annual Rice Production in Thailand3/ (1962 - 1975) | | 7,342,000 | 551,000 | 6,791,000 | 12,397,000 | 1.69 |

Source: 1/ Dep. of Agricultural Extension, MOAC
("Statistical Reports of Ayutthaya Province", National Statistical Office)

2/, 3/ Div. of Agricultural Economics, MOAC
("Agricultural Statistics of Thailand, Crop Year 1975/76")

4/ Basing on planted area.

Table A. 3-45 Data on Paddy Yield in the Project Area

| Data Source | Paddy Yield | | | | Remarks |
|---|---|---|---|---|---|
| (1) The survey on socio-economic conditions of farmers in Lad Bao Laung district. (Div. of Research & Planning, ALRO, Oct.1976) | Season | No. of surveyed farm families | Planted area | Yield | |
| | Wet | 50 | 157 ha | 1.20 ton/ha | Broadcasting |
| | Dry | | 164 ha | *2.48 ton/ha | Transplanting |
| (2) Statistical survey in each village (Muban) concerned with Project Area (Statistical Office of Ayutthaya province, 1976) | Tambon | Yield | Coverage of transplanting paddy | | |
| | Khusalod | 2.9 ton/ha | 67% (31%) | | Number in parenthesis: % of dry season transplanting paddy |
| | Phraya Banlu | 2.5 ton/ha | 54% (20%) | | |
| | Sing Ha Nat | *2.9 ton/ha | 80% (60%) | | |
| (3) Agro-economy survey conducted by this Mission in Project area | Crop | No. of surveyed farmers | Planted area | Yield | |
| | Wet season broadcasting | 6 | 33.0 ha | 1.0 ton/ha | Crop year: 1975/76 |
| | Wet and dry season transplanting | 21 | 89.6 ha | *3.2 ton/ha | |
| (4) Agricultural extension office of Ayutthaya province | Tambon | Planted area | Yield | | |
| | Khusalod | 2,342 ha | 2.3 ton/ha | | Mean yield of 1974 and 1975 |
| | Phraya Banlu | 1,150 ha | 2.4 ton/ha | | |
| | Sing Ha Nat | 3,132 ha | *2.7 ton/ha | | |

Data on Paddy Yield in the Project Area (continued)

(5) Agricultural extension office of Lad Bao Laung

| Crop | Planted area | Yield | Remarks |
|---|---|---|---|
| Wet season broadcasting | 4,338 ha | 2.1 ton/ha | Mean yield from harvested area in 1971 - 1975 |
| Wet & dry season transplanting | 4,248 ha | *3.6 ton/ha | |

(6) Yield survey by quadrat sampling in Project area, which was conducted by this Mission

| Crop | Yield |
|---|---|
| Wet season broadcasting | 1.6 ton/ha |
| Dry season transplanting | 3.0 ton/ha |

chemicals in the dry season and the beginning of the wet season. The paddy cultivation in the dry season is called as the dry season transplanting paddy whish is blessed with favorate conditions of high yield in comparison with the yield of the wet season transplanting paddy.

As is seen in Table A. 3-45, yield of transplanting paddy, but if the yield marked by asterisks was regarded as the yield in the dry season transplanting paddy, 3.0 ton/ha of yield can be supposed to be an average yield of dry season transplanting paddy in the Project Area. On the other hand, the yield of wet season transplanting paddy rice is assumed at 2.2 ton/ha from the data.

2. Yield of Other Crops

Yield of Upland Crops

The cropping area of upland crops is very small in the Project Area, but many kind of crops are cultivated mainly for the farm households' self consumption. The yield of these upland crops in the Project Area and its neighbourhood are tabulated as follows:

| Crops | Yield per crop | Data Source |
|---|---|---|
| Corn | 2.3 ton/ha | Averaged yield of Upland Crops from planted area, Ayutthaya Province (1974-1976), prepared by Agricultural Extension Office of Ayutthaya province |
| Soybean | 2.6 ton/ha | |
| Sweet potato | 5.0 ton/ha | |
| Big pepper | 1.7 ton/ha | |
| Cili pepper | 1.2 ton/ha | |
| Tomato | 5.6 ton/ha | |
| Coconut | 100 fruit/tree | |
| Banana (smelling) | 60 fruit/tree | |
| Banana (cooking) | 100 fruit/tree | |
| Water melon | 5.2 ton/ha | Socio-economic conditions of farmers in Lad Boa Laung district, prepared by ALRO |

Out of these upland crops, water melon is one of the main upland crop in the Project Area, so the yield of 5.0 ton/ha is regarded as the representative of upland crops based on the above table.

Yield of Fruits

Citrus is the representative fruits in the Project Area, and the following shows the yield of citrus;

| Yield | Data Source |
|---|---|
| 12.6 ton/ha | Socio-economic conditions of farmers in Lad Boa Laung district prepared by ALRO. |
| 7.0 ton/ha | Agricultural extension office of Ayutthaya Province |
| 20.0 ton/ha (basing on harvested area) | The result of interview to some farmers growing citrus in the project area |

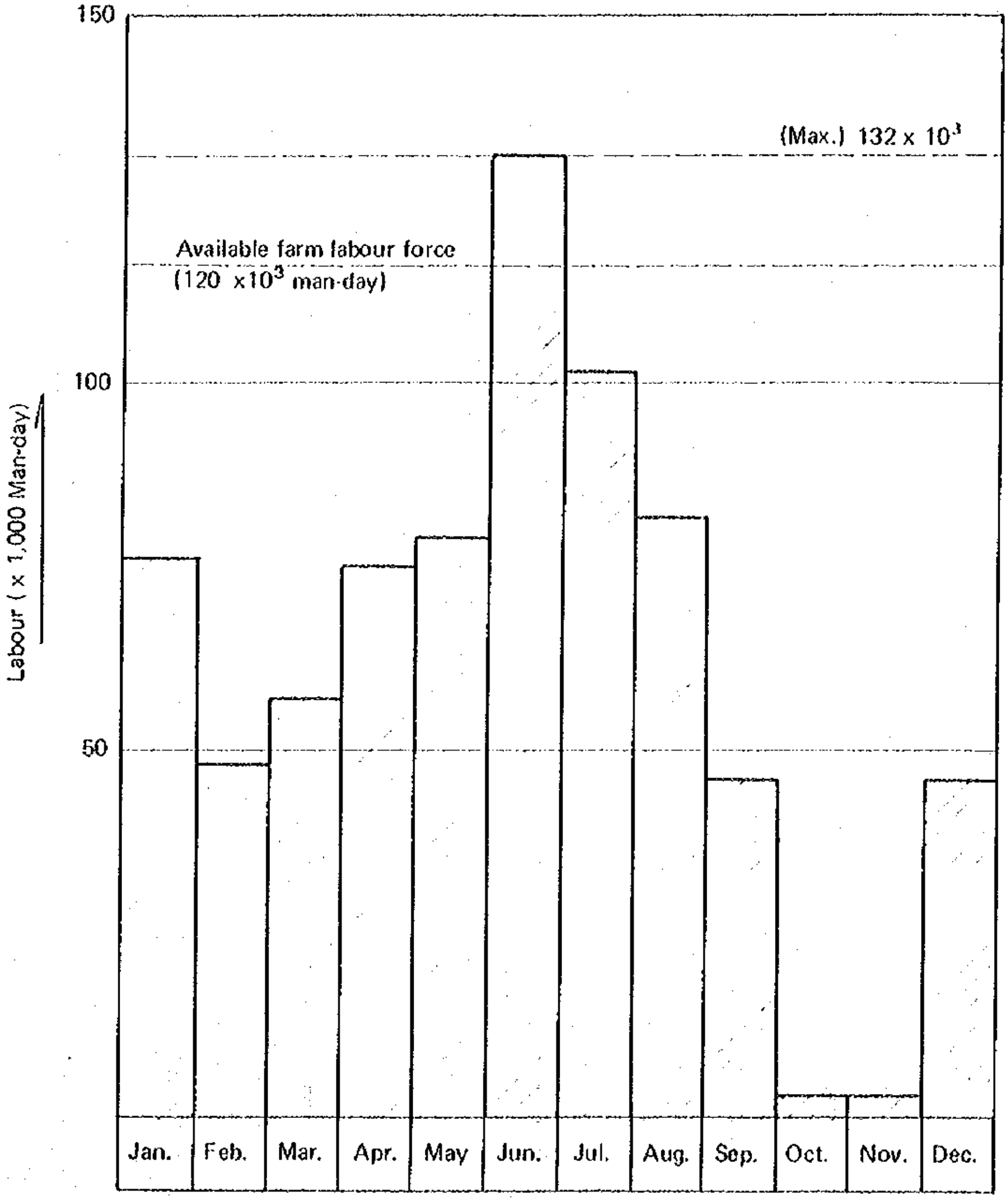
As is seen in the above table, the yield of citrus varies largely from 7.0 ton/ha to 20 ton/ha, and it is considered that these fluctuations of yields are caused by the tree age, cultivation technique and amount of input materials. In the Project, the yield of citrus is estimated at 15.0 ton/ha based on the above table.

Table A. 3-46 Number of Domestic Animals and Breeding Households in Each Tambon in the Project Area

| Animal | Tambon | No. of Domestic Animal (head) | | | | No. of Household | |
|---|---|---|---|---|---|---|---|
| | | 1973 | 1974 | 1975 | 1976 | 1976 | Proportion 1/ (%) |
| Buffalo | Khusalod | 254 | 123 | 119 | 126 | 64 | 13 |
| | Phraya Banlu | 192 | 138 | 87 | 86 | 57 | 14 |
| | Sing Ha Nat | 316 | 259 | 567 | 95 | 42 | 6 |
| | Total | 762 | 520 | 773 | 307 | 163 | 11 |
| Cattle | Khusalod | 17 | 13 | 73 | 20 | 9 | 2 |
| | Phraya Banlu | 174 | 174 | 210 | 245 | 60 | 15 |
| | Sing Ha Nat | 195 | 502 | 998 | 251 | 69 | 10 |
| | Total | 386 | 689 | 1,281 | 516 | 138 | 9 |
| Swine | Khusalod | 528 | 280 | 520 | 166 | 31 | 6 |
| | Phraya Banlu | 1,059 | 341 | 239 | 220 | 40 | 10 |
| | Sing Ha Nat | 288 | 155 | 136 | 175 | 34 | 5 |
| | Total | 1,875 | 776 | 895 | 561 | 105 | 7 |

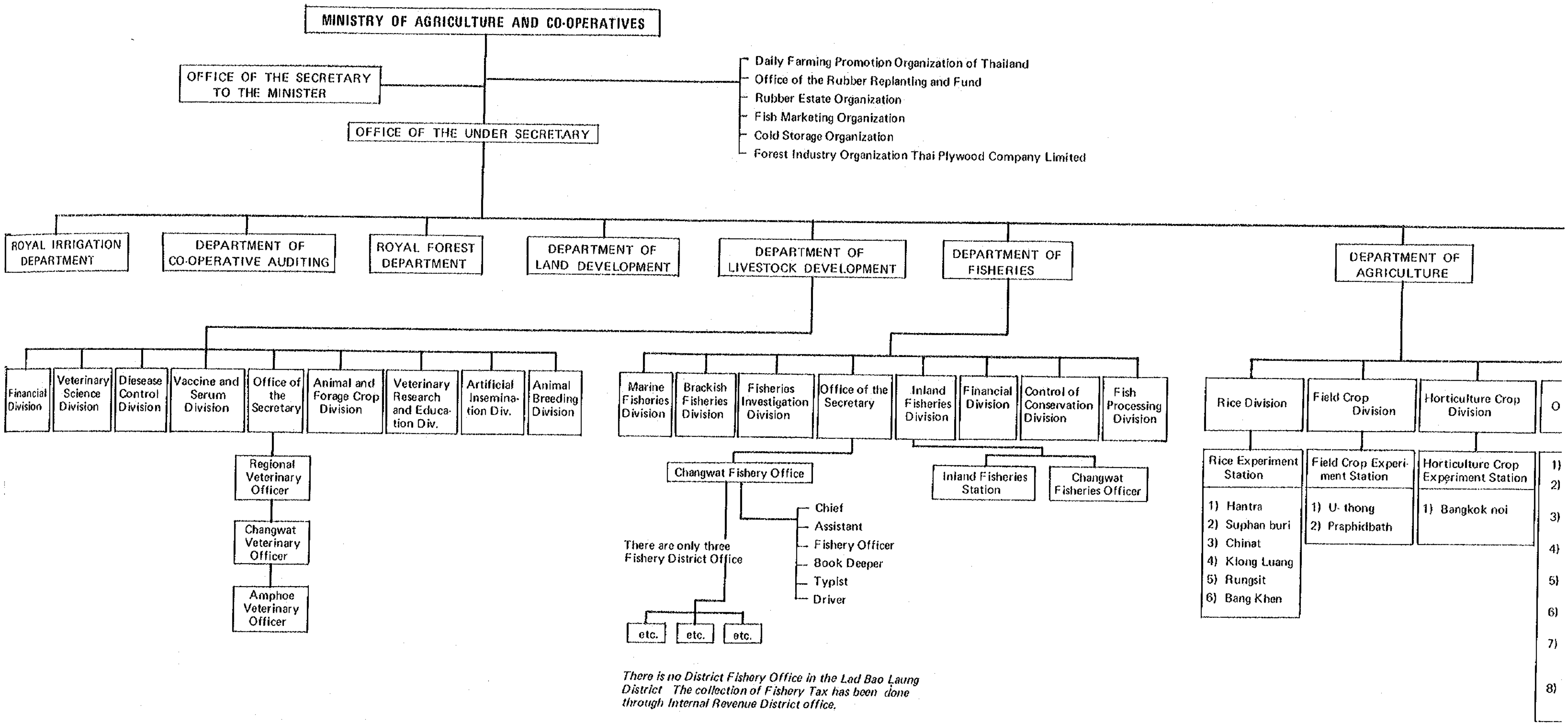
Note: 1/ Proportion of the households breeding domestic animals to total farm households (Khusalod 486 households, Phraya Banlu 396 households. Sing Ha Nat 666 households)

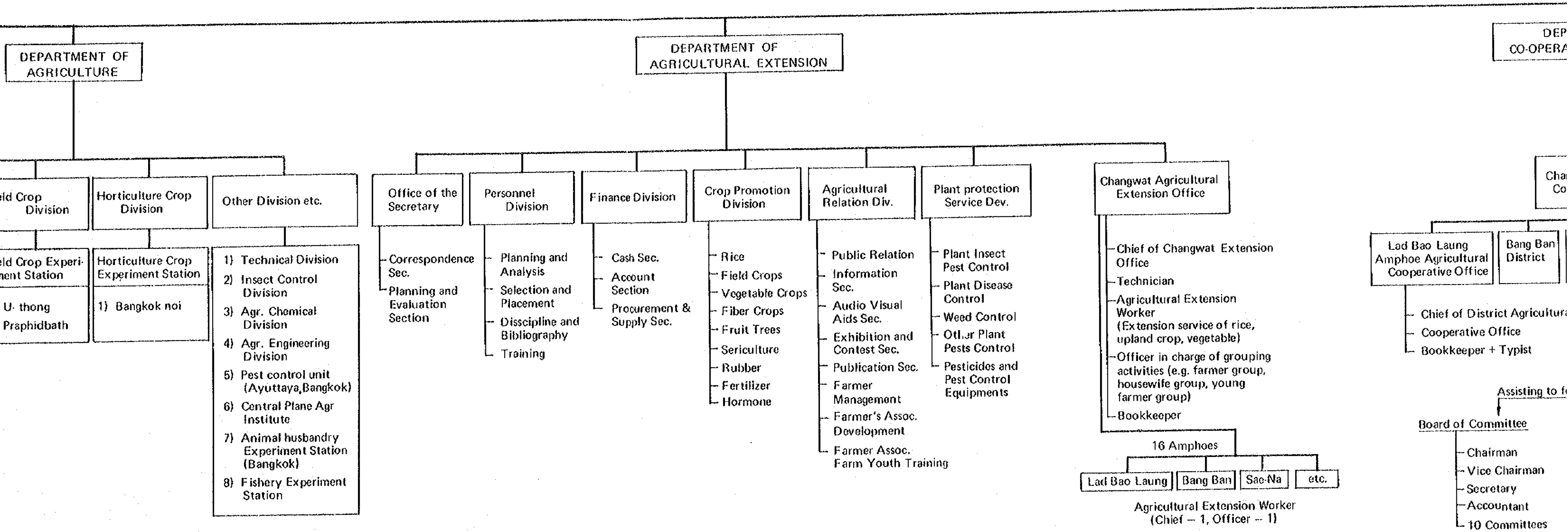
FIGURE A.3-26 FARM LABOUR BALANCE AT PRESENT




Note: Based on the calculation in Appendix 6-2

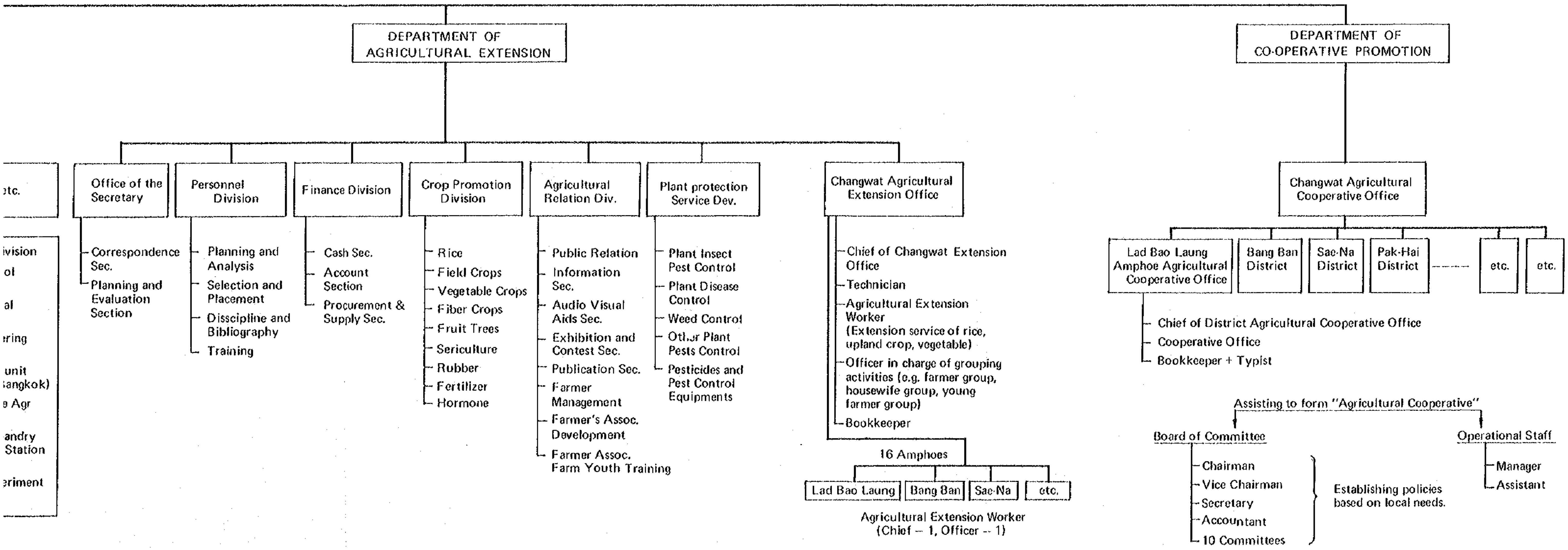
FIGURE A.3 – 27 ORGANIZATION CHART OF MINISTRY OF AGRICULTURE AND CO-OPERATIVES






*Work Load of Extension Worker in Amphoe Level*

- *50% routine work (e.g. statistical survey book keeping, etc)*
- *25% Agricultural extension servicing,*
- *25% Working for other departments in Amphur Level*




*Work Load of Extension Worker in Amphoe Level*

- *50% routine work (e.g. statistical survey book keeping, etc)*
- *25% Agricultural extension servicing,*
- *25% Working for other departments in Amphur Level*

Table A.3-47 Number of Unit and Cost of Farm Machinery and Tools per House-hold

| Tool and Machinery | Unit and Price (Unit) (1) | (฿/unit) (2) | (฿) (3) | Unit and Price per hectare (unit/ha) (4) | (฿/ha) (5) | Cost of Machinery and Tool Durable year (6) | Annual cost/ha (7) | annual cost /house-hold (8) |
|---|---|---|---|---|---|---|---|---|
| Plow | 2 | 150 | 300 | 0.50 | 75 | 5 | 15 | 60 |
| Hoe (large) | 2 | 50 | 100 | 0.50 | 25 | 5 | 5 | 20 |
| (small) | 2 | 20 | 40 | 0.50 | 10 | 5 | 2 | 8 |
| Siclke | 5 | 25 | 125 | 1.25 | 31 | 3 | 10 | 40 |
| Boat, (with engine) | 0.39 | 3,000 | 1,170 | 0.10 | 300 | 8 | 38 | 152 |
| (small) | 1 | 500 | 500 | 0.25 | 125 | 10 | 13 | 52 |
| Hand Tractor, 8HP | 0.35 | 14,500 | 5,075 | 0.09 | 1,305 | 7 | 186 | 744 |
| Water pump | 0.35 | 2,000 | 700 | 0.09 | 180 | 8 | 23 | 92 |
| Fuel and Other materials | | | | | | | 519 | 2,072 |
| Total | | | 8,010 | | 2,051 | | 811 | 3,240 |

Note: (3) = (1) x (2)
(4) = (1)/4.0 ha
average farm land holding per farm house-hold is assumed at 4.0 ha
(5) = (2) x (4)
(7) = (5)/(6)
(8) = (7) x 4.0 ha

## Proposed Cropping Pattern for Alternative Studies

Following cropping patterns are proposed for each alternative study. (see Figure A. 4-1)

### Without Dike Plan

Cropping Pattern - 1: Cropping intensity 67%

| | |
|---|---|
| Paddy Rice I: | Broadcasted floating rice in the wet season |
| Paddy Rice II: | Transplanted new variety rice in the dry season |

Cropping Pattern - 2: Cropping intensity 130%

| | |
|---|---|
| Paddy Rice I: | Transplanted floating rice in the wet season (30% of area) |
| Paddy Rice II: | Transplanted new variety rice in the dry season (100% of area) |

### With Dike Plan

Cropping Pattern - 3: Cropping intensity 200%

| | |
|---|---|
| Paddy Rice I: | Transplanted new variety rice in the wet season (100% of area) |
| Paddy Rice II: | Transplanted new variety rice in the dry season (100% of area) |

### With and without Dike Plan

Cropping Pattern - 4: Cropping intensity 180%

| | |
|---|---|
| Paddy Rice I-1: | Transplanted floating rice in the wet season (30% of Block A) |
| Paddy Rice I-2: | Transplanted new variety rice in the wet season (100% of Block B and C) |
| Paddy Rice II-1: | Transplanted new variety rice in the dry season (100% of Block A) |
| Paddy Rice II-2: | Transplanted new variety rice in the dry season (100% of Block B and C) |

FIGURE A.4 – 1. PROPOSED CROPPING PATTERN

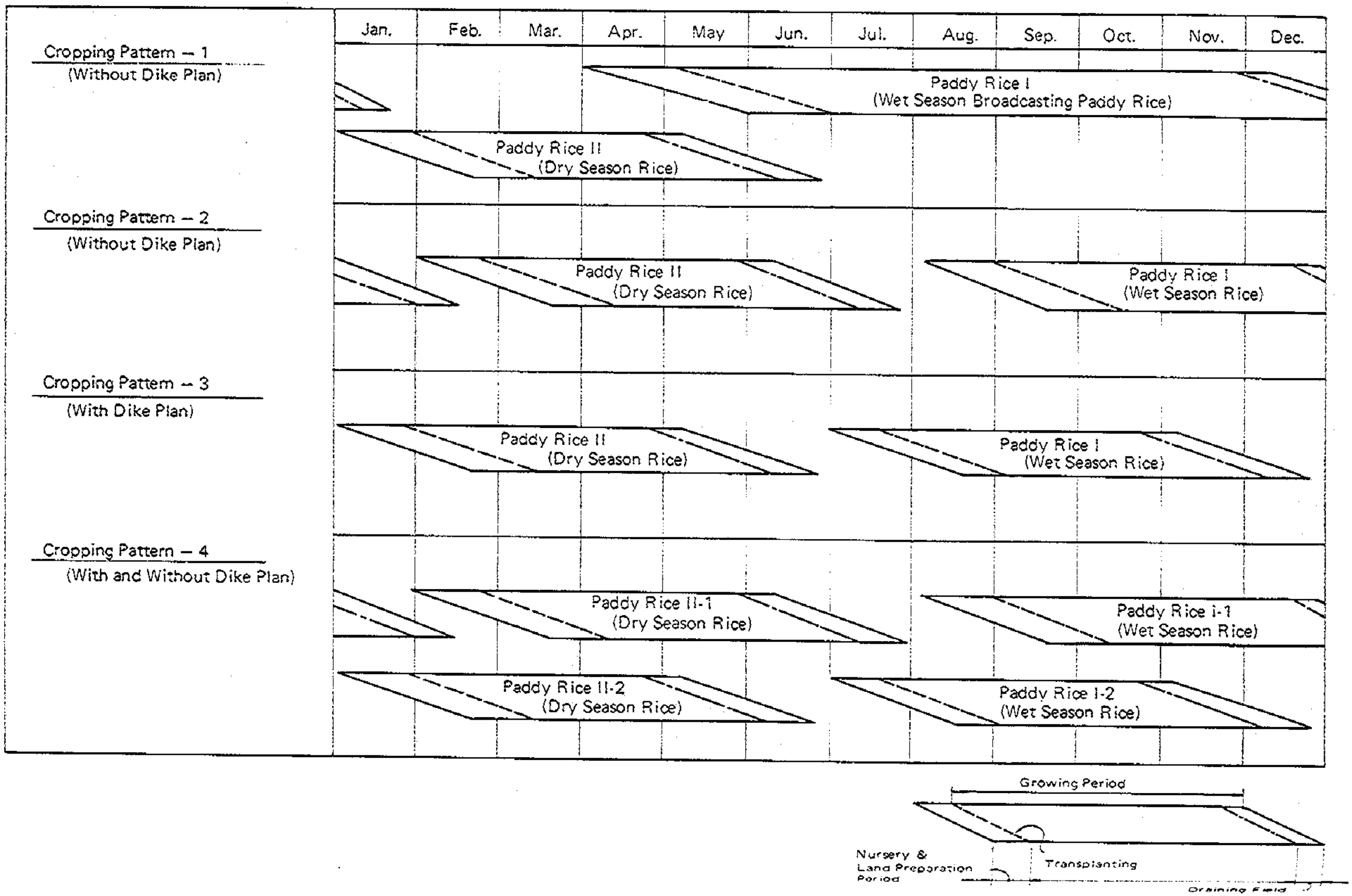


FIGURE A.4 – 2 CROPPING PATTERN OF PADDY RICE WITHOUT DIKE

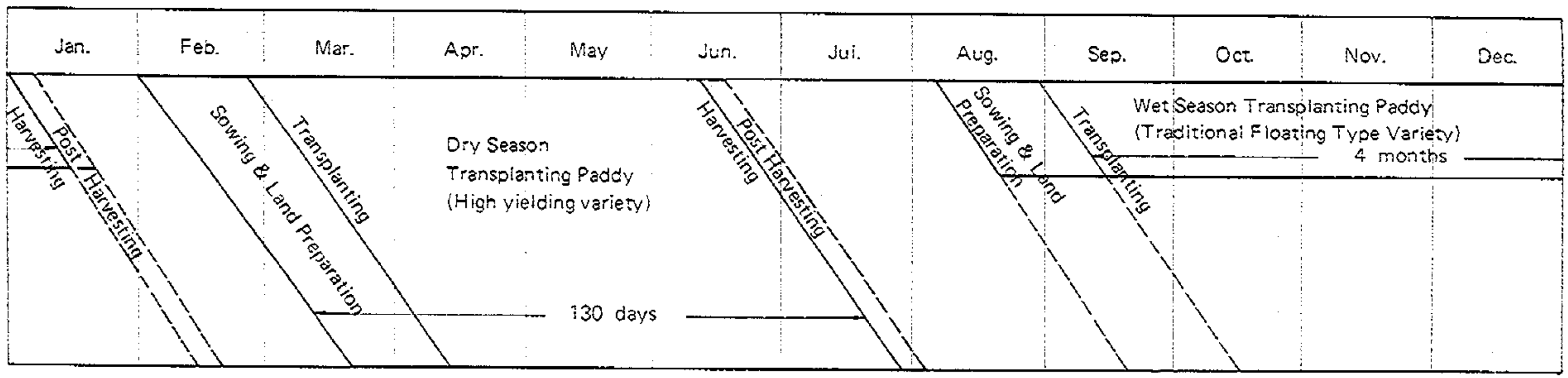


Table A. 4-1 Major Features of the Alternative Plan

| Description | Without Dike Plan | | | With Dike Plan | | | With and Without Dike Plan |
|---|---|---|---|---|---|---|---|
| | Plan I-1 | Plan I-2 | Plan I-3 | Plan II-1 | Plan II-2 | Plan II-3 | Plan III-1 |
| 1. Cropping Area (ha) | | | | | | | |
| Without Project | | | | | | | |
| Block A | 3,571 | 1,336 | 1,903 | 3,571 | 1,336 | 1,903 | 1,903 |
| B | 3,128 | 995 | 1,666 | 3,128 | 995 | 1,666 | 1,666 |
| C | - | 1,238 | 3,130 | - | 1,238 | 3,130 | 3,130 |
| D | - | 1,602 | - | - | 1,602 | - | - |
| E | - | 1,528 | - | - | 1,528 | - | - |
| Total | 6,699 | 6,699 | 6,699 | 6,699 | 6,699 | 6,699 | 6,699 |
| With Project | | | | | | | |
| Block A | 7,621 | 2,851 | 4,102 | 11,220 | 4,204 | 6,054 | 3,935 |
| B | 6,664 | 2,137 | 3,519 | 9,864 | 3,130 | 5,166 | 5,166 |
| C | - | 2,664 | 6,664 | - | 3,896 | 9,864 | 9,864 |
| D | - | 3,425 | - | - | 5,044 | - | - |
| E | - | 3,208 | - | - | 4,810 | - | - |
| Total | 14,285 | 14,285 | 14,285 | 21,084 | 21,084 | 21,084 | 18,965 |
| 2. Proposed Cropping Pattern 1/ | 2 | 2 | 2 | 3 | 3 | 3 | 4 |
| 3. Proposed Facilities | | | | | | | |
| Irrigation and drainage Canals (km) 2/ | 206 | 244 | 235 | 206 | 244 | 235 | 213 |
| Road and Dike | 153 | 153 | 153 | 241 | 260 | 268 | 237 |
| Pumping Station (Place) | 2 | 5 | 3 | 2 | 5 | 3 | 3 |

Note: 1/ : See Figure A. 4-1

2/ : No inclusive of farm ditch and drainage ditch

Table A. 4-2 Construction Cost of Alternative Plans

(Unit: US$'000)

| Works | Without Dike Plan | | | With Dike Plan | | | |
|---|---|---|---|---|---|---|---|
| | Plan I-1 | Plan I-2 | Plan I-3 | Plan II-1 | Plan II-2 | Plan II-3 | Plan III-1 |
| 1. Civil Works | | | | | | | |
| Land consolidation | 9,130 | 9,110 | 9,120 | 8,860 | 8,810 | 8,830 | 8,940 |
| Dikes, roads and canals | 2,520 | 2,350 | 2,420 | 4,010 | 3,920 | 4,080 | 3,440 |
| Pumping station | 3,020 | 4,840 | 3,720 | 8,640 | 10,150 | 9,020 | 7,600 |
| Collateral works | 1,510 | 1,380 | 1,450 | 2,400 | 2,350 | 2,650 | 2,070 |
| Sub-total | 16,180 | 17,680 | 16,710 | 23,910 | 25,230 | 24,580 | 22,050 |
| 2. Agricultural Development | 740 | 740 | 740 | 1,200 a/ | 1,200 | 1,200 | 1,070 |
| 3. Project Administration | 1,140 | 1,140 | 1,140 | 1,140 | 1,140 | 1,140 | 1,140 |
| Total | 18,060 | 19,560 | 18,590 | 26,250 | 27,570 | 26,920 | 24,260 |

Note: a/ inclusive of required cost for animal husbandry and inland fishery as shown belows;

Animal husbandry : ฿ 26,833/unit x 250 units ≒ US$335,000
Inland fishery : ฿ 10,000/unit x 250 units ≒ US$125,000

Table A. 4-3 Net Incremental Benefit of Alternative Plans

(unit: US$ '000)

| Benefits | Without Dike Plan | | | With Dike Plan | | | |
|---|---|---|---|---|---|---|---|
| | Plan I-1 | Plan I-2 | Plan I-3 | Plan II-1 | Plan II-2 | Plan II-3 | Plan III-1 |
| 1. Without Project (1) | | | | | | | |
| Crops | 730 | 730 | 730 | 730 | 730 | 730 | 730 |
| 2. With Project (2) | | | | | | | |
| Crops | 4,090 | 4,090 | 4,090 | 6,310 | 6,310 | 6,310 | 5,390 |
| Animal husbandry | - | - | - | 280 | 280 | 280 | 200 |
| Inland fishery | - | - | - | 130 | 130 | 130 | 90 |
| Sub-total | 3,230 | 3,230 | 3,230 | 6,720 | 6,720 | 6,720 | 5,680 |
| 3. Net incremental Benefit (2) - (1) | 2,500 | 2,500 | 2,500 | 5,990 | 5,990 | 5,990 | 4,950 |

Table A. 4-4 Internal Rate of Return (Plan I-1)

| Year | No. | Construction Cost | O & M Cost | Agricultural Net Incremental Benefit | Net Incremental Benefit | Rate of Return (12%) Benefit | Rate of Return (12%) Cost | Rate of Return (13%) Benefit | Rate of Return (13%) Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1978 | 1 | 1,500a/ | | | | | 1,340 | | 1,328 |
| 1979 | 2 | 3,612 | | | | | 2,870 | | 2,828 |
| 1980 | 3 | 3,612 | 54c/ | -125d/ | -71 | -51 | 2,572 | -49 | 2,503 |
| 1981 | 4 | 3,612 | 108 | -25 | 83 | 53 | 2,297 | 51 | 2,214 |
| 1982 | 5 | 3,612 | 162 | 200 | 362 | 205 | 2,048 | 197 | 1,961 |
| 1983 | 6 | 3,612 | 216 | 625 | 841 | 426 | 1,831 | 404 | 1,734 |
| 1984 | 7 | (18,060) | 903 | 1,225 | 2,128 | 962 | | 904 | |
| 1985 | 8 | | 903 | 1,700 | 2,603 | 1,052 | | 979 | |
| 1986 | 9 | | 903 | 2,150 | 3,053 | 1,102 | | 1,017 | |
| 1987 | 10 | | 903 | 2,375 | 3,278 | 1,056 | | 967 | |
| 1988 | 11 | | 903 | 2,500 | 3,403 | 980 | | 888 | |
| 1989 | 12-50 | | 903 | 2,500 | 3,403 | 8,054 | | 6,766 | |
| 2002 | 25 | 2,240b/ | | | | | 132 | | 105 |
| | | | | | | (13,839) | (13,099) | (12,124) | (12,673) |
| | | | | | | +740 | | -549 | |

$$(12 + \frac{740}{1,289}) = 12.6\%$$

Note: a/ Engineering fee is assumed at 1,500 x $10^3$US$

b/ Replacement cost of pumping facilities

c/ Operation and maintenance cost is estimated based on the following assumption:

during construction period: 1.5% of construction cost

after construction period: 5.0% of total construction cost (without dike plan)

-do- : 3.0% of total construction cost (with dike plan)

d/ Estimated by applying the annual proportion of agricultural net incremental benefit to reach target, which was obtained from the economic evaluation analyzed in Chapter VI.

Table A. 4-5 Internal Rate of Return (Plan I-2)

| Year | No. | Construction Cost | O & M Cost | Agricultural Net Incremental Benefit | Net Incremental Benefit | Rate of Return (12%) Benefit | Rate of Return (12%) Cost | Rate of Return (13%) Benefit | Rate of Return (13%) Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1978 | 1 | 1,500 | | | | | 1,340 | | 1,328 |
| 1979 | 2 | 3,912 | | | | | 3,118 | | 3,063 |
| 1980 | 3 | 3,912 | 59 | -125 | -66 | -47 | 2,785 | -46 | 2,711 |
| 1981 | 4 | 3,912 | 118 | -25 | 93 | 59 | 2,488 | 57 | 2,398 |
| 1982 | 5 | 3,912 | 177 | 200 | 377 | 213 | 2,218 | 205 | 2,124 |
| 1983 | 6 | 3,912 | 236 | 625 | 861 | 437 | 1,983 | 413 | 1,878 |
| 1984 | 7 | (19,560) | 978 | 1,225 | 2,203 | 996 | | 936 | |
| 1985 | 8 | | 978 | 1,700 | 2,678 | 1,082 | | 1,007 | |
| 1986 | 9 | | 978 | 2,150 | 3,128 | 1,129 | | 1,042 | |
| 1987 | 10 | | 978 | 2,375 | 3,353 | 1,080 | | 989 | |
| 1988 | 11 | | 978 | 2,500 | 3,478 | 1,002 | | 908 | |
| 1989 | 12-50 | | 978 | 2,500 | 3,478 | 8,231 | | 6,915 | |
| 2002 | 25 | 3,580 | | | | | 211 | | 168 |
| | | | | | | (14,182) | (14,143) | (12,426) | (13,670) |
| | | | | | | +39 | | -1,244 | |

$$\left(12 + \frac{39}{1,283}\right) = 12.0$$

Table A. 4-6 Internal Rate of Return (Plan I-3)

| Year | No. | Construction Cost | O & M Cost | Agricultural Net Incremental Benefit | Net Incremental Benefit | Rate of Return (12%) Benefit | Rate of Return (12%) Cost | Rate of Return (13%) Benefit | Rate of Return (13%) Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1978 | 1 | 1,500 | | | | | | | |
| 1979 | 2 | 3,718 | | | | | 1,340 | | 1,328 |
| 1980 | 3 | 3,718 | 56 | -125 | -69 | | 2,963 | | 2,911 |
| 1981 | 4 | 3,718 | 112 | -25 | 87 | -49 | 2,647 | -48 | 2,577 |
| 1982 | 5 | 3,718 | 168 | 200 | 368 | 55 | 2,365 | 53 | 2,279 |
| 1983 | 6 | 3,718 | 224 | 625 | 849 | 209 | 2,108 | 200 | 2,019 |
| 1984 | 7 | (18,590) | 930 | 1,225 | 2,155 | 430 | 1,885 | 408 | 1,785 |
| 1985 | 8 | | 930 | 1,700 | 2,630 | 974 | | 916 | |
| 1986 | 9 | | 930 | 2,150 | 3,080 | 1,063 | | 989 | |
| 1987 | 10 | | 930 | 2,375 | 3,305 | 1,112 | | 1,026 | |
| 1988 | 11 | | 930 | 2,500 | 3,430 | 1,064 | | 975 | |
| 1989 | 12-50 | | 930 | 2,500 | 3,430 | 988 | | 895 | |
| 2002 | 25 | 2,750 | | | | 8,118 | | 6,820 | |
| | | | | | | | 162 | | 129 |
| | | | | | | (13,964) | (13,470) | (12,234) | (13,028) |
| | | | | | | +494 | | -794 | |

$$\left(12 + \frac{494}{1,288}\right) = 12.4\%$$

Table A. 4-7 Internal Rate of Return (Plan II-1)

| Year | No. | Construction Cost | O & M Cost | Agricultural Net Incremental Benefit | Incremental Net Benefit | Rate of Return (16%) Benefit | Rate of Return (16%) Cost | Rate of Return (17%) Benefit | Rate of Return (17%) Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1978 | 1 | 1,500 | | | | | 1,293 | | 1,293 |
| 1979 | 2 | 5,250 | | | | | 3,901 | | 3,838 |
| 1980 | 3 | 5,250 | 79 | -300 | -221 | -142 | 3,365 | -138 | 3,276 |
| 1981 | 4 | 5,250 | 158 | -60 | 98 | 54 | 2,898 | 52 | 2,804 |
| 1982 | 5 | 5,250 | 237 | 479 | 716 | 341 | 2,499 | 326 | 2,394 |
| 1983 | 6 | 5,250 | 316 | 1,498 | 1,814 | 744 | 2,153 | 707 | 2,048 |
| 1984 | 7 | (26,250) | 788 | 2,935 | 3,723 | 1,318 | | 1,240 | |
| 1985 | 8 | | 788 | 4,073 | 4,861 | 1,483 | | 1,385 | |
| 1986 | 9 | | 788 | 5,151 | 5,939 | 1,562 | | 1,443 | |
| 1987 | 10 | | 788 | 5,691 | 6,479 | 1,471 | | 1,348 | |
| 1988 | 11 | | 788 | 5,990 | 6,778 | 1,322 | | 1,206 | |
| 1989 | 12-50 | | 788 | 5,990 | 6,778 | 8,254 | | 7,074 | |
| 2002 | 25 | 6,400 | | | | | 160 | | 128 |
| | | | | | | (16,407) | (16,269) | (14,643) | (15,771) |
| | | | | | | +138 | | -1,128 | |

$$\left(16 + \frac{138}{1,266}\right) = 16.1\ \%$$

Table A. 4-8 Internal Rate of Return (Plan II-2)

| Year | No. | Construction Cost | O & M Cost | Agricultural Net Incremental Benefit | Incremental Net Benefit | Rate of Return (15%) Benefit | Rate of Return (15%) Cost | Rate of Return (16%) Benefit | Rate of Return (16%) Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1978 | 1 | 1,500 | | | | | 1,305 | | 1,293 |
| 1979 | 2 | 5,514 | | | | | 4,169 | | 4,097 |
| 1980 | 3 | 5,514 | 82 | -300 | -218 | -143 | 3,628 | -140 | 3,535 |
| 1981 | 4 | 5,514 | 164 | - 60 | 104 | 59 | 3,154 | 57 | 3,044 |
| 1982 | 5 | 5,514 | 246 | 479 | 725 | 360 | 2,740 | 345 | 2,625 |
| 1983 | 6 | 5,514 | 320 | 1,498 | 1,818 | 785 | 2,382 | 745 | 2,261 |
| 1984 | 7 | (27,570) | 827 | 2,935 | 3,762 | 1,415 | | 1,332 | |
| 1985 | 8 | | 827 | 4,073 | 4,900 | 1,602 | | 1,495 | |
| 1986 | 9 | | 827 | 5,151 | 5,978 | 1,698 | | 1,572 | |
| 1987 | 10 | | 827 | 5,750 | 6,577 | 1,625 | | 1,493 | |
| 1988 | 11 | | 827 | 5,990 | 6,817 | 1,466 | | 1,329 | |
| 1989 | 12-50 | | 827 | 5,990 | 6,817 | 9,725 | | 8,301 | |
| 2002 | 25 | 7,520 | | | | | 226 | | 188 |
| | | | | | | (18,592) | (17,604) | (16,529) | (17,043) |
| | | | | | | +988 | | -514 | |

$$\left(15 + \frac{988}{1,502}\right) = 15.6\%$$

Table A. 4-9 Internal Rate of Return (Plan II-3)

| Year | No. | Construction Cost | O & M Cost | Agricultural Net Incremental Benefit | Incremental Net Benefit | Rate of Return (15%) Benefit | Rate of Return (15%) Cost | Rate of Return (16%) Benefit | Rate of Return (16%) Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1978 | 1 | 1,500 | | | | | 1,305 | | 1,293 |
| 1979 | 2 | 5,384 | | | | | 4,070 | | 4,000 |
| 1980 | 3 | 5,384 | 81 | -300 | -219 | -144 | 3,543 | -140 | 3,451 |
| 1981 | 4 | 5,384 | 162 | - 60 | 102 | 58 | 3,080 | 52 | 2,971 |
| 1982 | 5 | 5,384 | 243 | 479 | 722 | 359 | 2,676 | 344 | 2,563 |
| 1983 | 6 | 5,384 | 324 | 1,498 | 1,822 | 787 | 2,326 | 747 | 2,207 |
| 1984 | 7 | (26,920) | 807 | 2,939 | 3,746 | 1,408 | | 1,326 | |
| 1985 | 8 | | 807 | 4,073 | 4,880 | 1,596 | | 1,488 | |
| 1986 | 9 | | 807 | 5,151 | 5,958 | 1,692 | | 1,567 | |
| 1987 | 10 | | 807 | 5,691 | 6,498 | 1,605 | | 1,475 | |
| 1988 | 11 | | 807 | 5,990 | 6,797 | 1,461 | | 1,325 | |
| 1989 | 12-50 | | 807 | 5,990 | 6,797 | 9,697 | | 8,277 | |
| 2002 | 25 | 6,680 | | | | | 200 | | 167 |
| | | | | | | (18,519) | (17,200) | (16,461) | (16,652) |
| | | | | | | +1,319 | | -191 | |

$$\left(15 + \frac{1,319}{1,510}\right) = 15.9\%$$

Table A. 4-10 Internal Rate of Return (Plan III-1)

| Year | No. | Construction Cost | O & M Cost | Agricultural Net Incremental Benefit | Net Incremental Benefit | Rate of Return (14%) Benefit | Rate of Return (14%) Cost | Rate of Return (15%) Benefit | Rate of Return (15%) Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1978 | 1 | 1,500 | | | | | 1,316 | | 1,305 |
| 1979 | 2 | 4,852 | | | | | 3,736 | | 3,668 |
| 1980 | 3 | 4,852 | 73 | -248 | -175 | -118 | 3,275 | -115 | 3,193 |
| 1981 | 4 | 4,852 | 146 | -50 | 96 | 57 | 2,873 | 55 | 2,775 |
| 1982 | 5 | 4,852 | 219 | 396 | 615 | 319 | 2,518 | 306 | 2,411 |
| 1983 | 6 | 4,852 | 292 | 1,238 | 1,530 | 698 | 2,213 | 661 | 2,096 |
| 1984 | 7 | (24,260) | 728 | 2,425 | 3,135 | 1,254 | | 1,179 | |
| 1985 | 8 | | 728 | 3,366 | 4,094 | 1,437 | | 1,339 | |
| 1986 | 9 | | 728 | 4,257 | 4,985 | 1,535 | | 1,416 | |
| 1987 | 10 | | 728 | 4,703 | 5,431 | 1,466 | | 1,341 | |
| 1988 | 11 | | 728 | 4,950 | 5,678 | 1,346 | | 1,221 | |
| 1989 | 12-50 | | 728 | 4,950 | 5,678 | 9,538 | | 8,100 | |
| 2002 | 25 | 5,630 | | | | | 214 | | 169 |
| | | | | | | (17,532) | (16,145) | (15,503) | (15,617) |
| | | | | | | +1,387 | | -114 | |

$$(14 + \frac{1,387}{1,501}) = 14.9$$

Table A. 4-11 Consumptive Use of Crops

| Month | | Potential ETP (mm/day) | Paddy Rice | | | | | | | | Upland-type Crops | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Plant A | | Plant B | | Plant C | | Plant D | | Upland Crops | | | | Vegetable, Orchard | |
| | | | | | | | | | | | Plant A | | Plant B | | | |
| | | | K | C.U | K | C.U | K | C.U | K | C.U | K | C.U | K | C.U | K | C.U |
| Jan. | I | 3.9 | 0.85 | 3.3 | | | | | | | | | | | 0.80 | 3.1 |
| | II | 3.9 | 0.85 | 3.3 | 0.85 | 3.3 | | | | | | | | | 0.80 | 3.1 |
| Feb. | I | 4.7 | 0.90 | 4.2 | 0.85 | 4.0 | 0.85 | 4.0 | | | 0.30 | 1.4 | | | 0.80 | 3.7 |
| | II | 4.7 | 1.06 | 5.0 | 0.90 | 4.2 | 0.85 | 4.0 | 0.85 | 4.0 | 0.50 | 2.4 | 0.30 | 1.4 | 0.80 | 3.7 |
| Mar. | I | 5.2 | 1.17 | 6.1 | 1.06 | 5.5 | 0.90 | 4.7 | 0.85 | 4.4 | 0.85 | 4.4 | 0.50 | 2.6 | 0.80 | 4.2 |
| | II | 5.2 | 1.19 | 6.2 | 1.17 | 6.1 | 1.06 | 5.5 | 0.90 | 4.7 | 1.02 | 5.3 | 0.85 | 4.4 | 0.80 | 4.2 |
| Apr. | I | 5.7 | 1.13 | 6.4 | 1.19 | 6.7 | 1.17 | 6.8 | 1.06 | 6.0 | 0.95 | 5.4 | 1.02 | 5.9 | 0.80 | 4.6 |
| | II | 5.7 | 1.03 | 5.9 | 1.13 | 6.4 | 1.19 | 6.8 | 1.17 | 6.7 | 0.80 | 4.6 | 0.95 | 5.4 | 0.80 | 4.6 |
| May | I | 5.0 | 0.90 | 4.5 | 1.03 | 5.2 | 1.13 | 5.7 | 1.19 | 6.0 | 0.65 | 3.3 | 0.80 | 4.0 | 0.80 | 4.0 |
| | II | 5.0 | | | 0.90 | 4.5 | 1.03 | 5.2 | 1.13 | 5.7 | 0.20 | 1.0 | 0.65 | 3.3 | 0.80 | 4.0 |
| Jun. | I | 4.6 | | | | | 0.90 | 4.1 | 1.03 | 4.7 | | | 0.20 | 0.9 | 0.80 | 3.7 |
| | II | 4.6 | | | | | | | 0.90 | 4.1 | | | | | 0.80 | 3.7 |
| Jul. | I | 4.2 | 0.85 | 3.6 | | | | | | | | | | | 0.80 | 3.4 |
| | II | 4.2 | 0.85 | 3.6 | 0.85 | 3.6 | | | | | | | | | 0.80 | 3.4 |
| Aug. | I | 4.0 | 0.90 | 3.6 | 0.85 | 3.4 | 0.85 | 3.4 | | | | | | | 0.80 | 3.2 |
| | II | 4.0 | 1.06 | 4.2 | 0.90 | 3.6 | 0.85 | 3.4 | 0.85 | 3.4 | | | | | 0.80 | 3.2 |
| Sep. | I | 3.8 | 1.17 | 4.4 | 1.06 | 4.0 | 0.90 | 3.4 | 0.85 | 3.2 | | | | | 0.80 | 3.0 |
| | II | 3.8 | 1.19 | 4.5 | 1.17 | 4.4 | 1.06 | 4.0 | 0.90 | 3.4 | | | | | 0.80 | 3.0 |
| Oct. | I | 3.9 | 1.13 | 4.4 | 1.19 | 4.6 | 1.17 | 4.6 | 1.06 | 4.1 | | | | | 0.80 | 3.1 |
| | II | 3.9 | 1.03 | 4.0 | 1.13 | 4.4 | 1.19 | 4.6 | 1.17 | 4.6 | | | | | 0.80 | 3.1 |
| Nov. | I | 4.0 | 0.90 | 3.6 | 1.03 | 4.1 | 1.13 | 4.5 | 1.19 | 4.8 | | | | | 0.80 | 3.2 |
| | II | 4.0 | | | 0.90 | 3.6 | 1.03 | 4.1 | 1.13 | 4.5 | | | | | 0.80 | 3.2 |
| Dec. | I | 3.9 | | | | | 0.90 | 3.6 | 1.03 | 4.0 | | | | | 0.80 | 3.1 |
| | II | 3.9 | | | | | | | 0.90 | 3.5 | | | | | 0.80 | 3.1 |

Note: K: Coefficient
C.U: Consumptive use, in millimeter per day

## Comparison of Consumptive Use of Rice

The comparison of the consumptive use which has been authorized in the reports submitted already is made, in order to confirmed the estimated values of the consumptive use of the project. Following table indicates the monthly consumptive use of rice at the four areas inclusive of the Project Area.

Comparison of Consumptive Use of Rice
(millimeter per day)

| Month | Project Area | Northern Chao Phya Project | Sam Chook Experimental Farm | Mae-Kuang Water Use Experimental Station |
|---|---|---|---|---|
| Jan. | 4.7 a/ | 4.6 b/ | - | - |
| Feb. | 5.6 | 5.4 | 3.7 c/ | 5.9 d/ |
| Mar. | 6.3 | 6.4 | 6.8 | 6.3 |
| Apr. | 6.9 | 6.7 | 9.5 | 8.5 |
| May | 6.0 | 5.3 | 8.0 | 8.1 |
| Jun. | 5.5 | 5.0 | 3.8 | - |
| Jul. | 5.0 | 4.6 | 5.9 | - |
| Aug. | 4.8 | 4.4 | 7.0 | 4.2 |
| Sep. | 4.5 | 4.1 | 5.3 | 5.3 |
| Oct. | 4.7 | 4.4 | 5.6 | 6.5 |
| Nov. | 5.4 | 4.7 | 6.0 | 5.6 |
| Dec. | 5.0 | 4.5 | - | - |

Note: a/ Calculated by multiplying the potential evapotranspiration, ETp (see Table A.4-11) by crop coefficient of K = 1.2

b/ Prepared by NEDECO in 1970 (K = 1.2)

c/ See Table A. 4-12

d/ See Table A. 4-12

From the Table, the estimated values are almost the same to that of the Northern Chap Phya project, which is located on an adjacent upstream of the Project Area. However, the values observed at two experimental farms, Sam Chook Experimental Farm and Mae-Kuang Water Use Experimental Station, is relatively large, especially at the peak periods during the growing seasons. But those values will be varied depending upon the varieties of paddy, growing season, water management and so forth. After consideration of the facts mentioned above, the estimated values appear to be adequate for the Project.

Table A. 4-12 Observed Evapotranspiration (ETa) of Rice

| Item | Irrigation Period | Observed ETa (mm) Total | Observed ETa (mm) Daily Mean | Remarks | |
|---|---|---|---|---|---|
| Station: Sam Chook Experimental Farm | | | | | |
| Wet season rice | Jun. 25 - 30 | 22.6 | 3.76 | Variety: | Bang Phre (5 month rice) |
| (one year of | Jul. 1 - 31 | 182.9 | 5.90 | Transplanting Date: | June 25, 1964 |
| data, 1964) | Aug. 1 - 31 | 216.8 | 6.99 | Irrigation Period: | Continuously from June 26 |
| | Sep. 1 - 31 | 159.5 | 5.31 | | to November 22, 1964 |
| | Oct. 1 - 31 | 172.5 | 5.56 | Harvesting: | December 11, 1964 |
| | Nov. 1 - 22 | 130.8 | 5.95 | | |
| | Average 151 days | 885.1 | 5.86 | | |
| Dry season rice | Feb. 20 - 28 | 32.8 | 3.65 | Variety: | Leong Kamin (4 month rice) |
| (one year of | Mar. 1 - 31 | 209.8 | 6.77 | Transplanting Date: | Feb. 20, 1965 |
| data, 1965) | Apr. 1 - 30 | 283.9 | 9.46 | Irrigation Period: | Continuously from Feb. |
| | May 1 - 21 | 168.0 | 8.00 | | 21 to May 21, 1965 |
| | Average 91 days | 594.5 | 7.63 | Harvesting: | June 8, 1965 |
| Station: Mae-Kuang Water Use Experimental Station, Chieng Mai | | | | | |
| Wet season rice | Aug. 10 - 31 | 92.5 | 4.20 | Variety: | Kam Pai |
| (average two years of | Sep. 1 - 30 | 159.8 | 5.32 | Transplanting Date: | Aug. 10 |
| data, 1966 - 1967) | Oct. 1 - 31 | 200.5 | 6.47 | Irrigation Period: | Continuously from Aug. |
| | Nov. 1 - 21 | 117.2 | 5.58 | | 10 to Nov. 21 |
| | Average 104 days | 570.0 | 5.48 | | |
| Dry season rice | Feb. 24 - 28 | 29.3 | 5.86 | Variety: | Kam Pai |
| (average two years of | Mar. 1 - 31 | 194.2 | 6.26 | Transplanting Date: | Feb. 24 |
| data, 1967 - 1968) | Apr. 1 - 30 | 256.2 | 8.54 | Irrigation Period: | Continuously from Feb. |
| | May 1 - 28 | 227.9 | 8.14 | | 24 to May 28 |
| | Average 94 days | 707.6 | 7.53 | | |

Table A. 4-13 Field Water Requirements of Crops

(Unit: mm)

| | | Rice | | | | | | | | | | | | | | | | | Upland-type Crops | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant A | | | | Plant B | | | | Plant C | | | | Plant D | | | | Average Field Water Requirements | Upland Crops | | | Vegetable, Orchard |
| Month | Percolation (1) | C.U (2) | A.S (3) | Total (4) | Total (5) | C.U (2) | A.S (3) | Total (4) | Total (5) | C.U (2) | A.S (3) | Total (4) | Total (5) | C.U (2) | A.S (3) | Total (4) | Total (5) | (6) | Plant A | Plant B | Average F.W.R. | |
| Jan. I | 15 | 50 | 30 | 95 | 6.3 | | | | | | | | | | | | | 2.0 | | | | 3.1 |
| II | 16 | 53 | 160 | 229 | 14.3 | 53 | 30 | 99 | 6.2 | | | | | | | | | 6.5 | | | | 3.1 |
| Feb. I | 15 | 63 | | 78 | 5.2 | 60 | 160 | 235 | 15.7 | 60 | 30 | 105 | 7.0 | | | | | 9.0 | 1.4 | | 0.7 | 3.7 |
| II | 13 | 65 | | 78 | 5.0 | 55 | | 68 | 5.2 | 52 | 160 | 225 | 17.3 | 52 | 30 | 95 | 7.3 | 9.0 | 2.4 | 1.4 | 1.9 | 3.7 |
| Mar. I | 15 | 98 | | 113 | 7.5 | 83 | | 98 | 6.5 | 71 | | 86 | 5.7 | 66 | 160 | 241 | 16.1 | 7.0 1/ | 4.4 | 2.6 | 3.5 | 4.2 |
| II | 16 | 99 | | 115 | 7.2 | 92 | | 108 | 6.8 | 88 | | 104 | 6.5 | 75 | | 91 | 5.7 | 6.8 | 5.3 | 4.4 | 4.9 | 4.2 |
| Apr. I | 15 | 96 | | 111 | 7.4 | 101 | | 116 | 7.7 | 102 | | 117 | 7.8 | 93 | | 105 | 7.0 | 7.6 | 5.4 | 5.8 | 5.6 | 4.6 |
| II | 15 | 89 | | 104 | 6.9 | 96 | | 111 | 7.4 | 102 | | 117 | 7.8 | 101 | | 116 | 7.7 | 7.4 | 4.6 | 5.4 | 5.0 | 4.6 |
| May I | 15 | 68 | | 83 | (5.5) | 78 | | 93 | 6.2 | 86 | | 101 | 6.7 | 90 | | 105 | 7.0 | 4.6 | 3.3 | 4.0 | 3.7 | 4.0 |
| II | 16 | | | | | 72 | | 88 | (5.5) | 83 | | 99 | 6.2 | 91 | | 107 | 6.7 | 2.3 | 1.0 | 3.3 | 2.2 | 4.0 |
| Jun. I | 15 | | | | | | | | | 62 | | 77 | (5.1) | 71 | | 86 | 5.7 | 0.2 | | 0.9 | 0.5 | 3.7 |
| II | 15 | | | | | | | | | | | | | 62 | | 77 | (5.1) | - | | | | 3.7 |
| Jul. I | 15 | 54 | 15 | 84 | 5.6 | | | | | | | | | | | | | 1.8 | | | | 3.4 |
| II | 16 | 58 | 160 | 234 | 14.6 | 58 | 15 | 89 | 5.6 | | | | | | | | | 6.4 | | | | 3.4 |
| Aug. I | 15 | 54 | | 69 | 4.6 | 51 | 160 | 226 | 15.1 | 51 | 15 | 81 | 5.4 | | | | | 8.2 | | | | 3.2 |
| II | 16 | 67 | | 83 | 5.2 | 58 | | 74 | 4.6 | 51 | 160 | 227 | 14.2 | 54 | 15 | 85 | 5.3 | 7.8 | | | | 3.2 |
| Sep. I | 15 | 66 | | 81 | 5.4 | 60 | | 75 | 5.0 | 54 | | 69 | 4.6 | 48 | 160 | 223 | 14.9 | 5.4 | | | | 3.0 |
| II | 15 | 68 | | 83 | 5.5 | 66 | | 81 | 5.4 | 60 | | 75 | 5.0 | 51 | | 66 | 4.4 | 5.3 | | | | 3.0 |
| Oct. I | 15 | 66 | | 81 | 5.4 | 69 | | 84 | 5.6 | 69 | | 84 | 5.6 | 62 | | 77 | 5.1 | 5.5 | | | | 3.1 |
| II | 16 | 64 | | 80 | 5.0 | 70 | | 86 | 5.4 | 74 | | 90 | 5.6 | 74 | | 90 | 5.6 | 5.4 | | | | 3.1 |
| Nov. I | 15 | 54 | | 69 | (4.6) | 62 | | 77 | 5.1 | 68 | | 83 | 5.5 | 72 | | 87 | 5.8 | 3.7 | | | | 3.2 |
| II | 15 | | | | | 54 | | 69 | (4.6) | 62 | | 77 | 5.1 | 68 | | 83 | 5.5 | 1.8 | | | | 3.2 |
| Dec. I | 15 | | | | | | | | | 54 | | 69 | (4.6) | 60 | | 75 | 5.0 | 0.2 | | | | 3.1 |
| II | 16 | | | | | | | | | | | | | 56 | | (71) | 4.4 | - | | | | 3.1 |

Note:
(1) Percolation in paddy fields is assumed at 1.0 mm/day
(2) See Table A. 4-11
(3) Additional Water Supply (A.S.) for nursery bed and land preparation is assumed as follows:

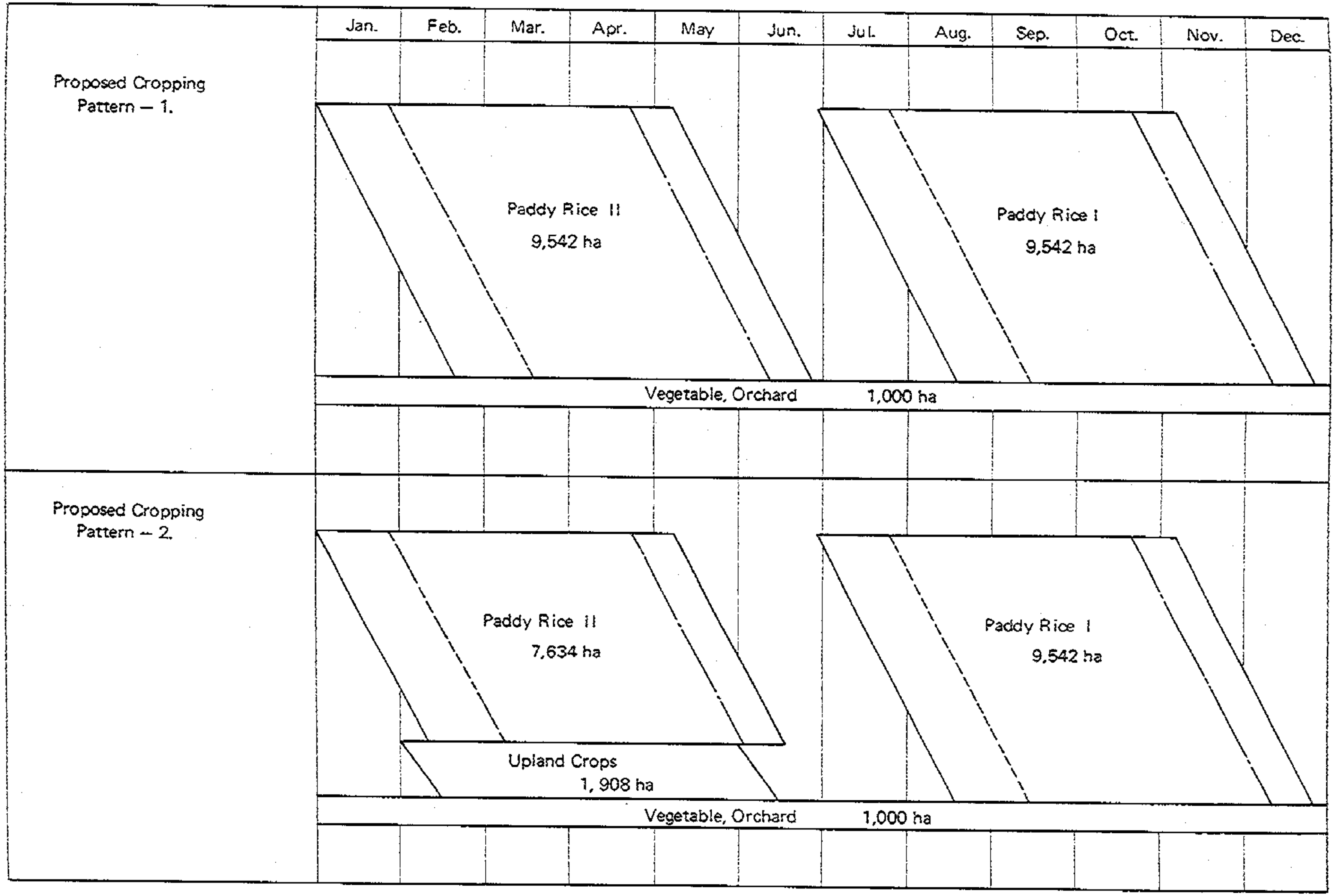
Nursery bed — Area : one-twentieth of paddy field area
Water : requirement: 300 mm
water : requirements to whole paddy area: 15 mm

Land Preparation — Pre-irrigation for plowing 15 mm (plowing depth 150 mm, increasing soil moisture from 10 per cent to 20 per cent) land preparation:
Saturation of surface soil layer: 60 mm (plowing depth 150 mm, with 40 per cent of soil prosity)
Standing water above soil surface: 100 mm

(4) Total field water requirements, in millimeter per half-month, (1)+(2)+(3)
(5) Total field water requirements, in millimeter per day
( ) shows the water requirements of rice during the period of drying field.
(6) Estimated by applying the following proportion of planting area in half month;
plant A: 31.25% plant B: 33.33% plant C: 31.25% plant D: 4.17%
Maximum average field water requirements:
7.1 x 15/48 + 6.5 x 16/48 + 5.7 x 15/48 + 5.4 x 1/48 + 160 x 1/48 = 9.6 mm/day

1/ Maximum 9.6 mm/day

FIGURE A.4-3 PROPOSED CROPPING PATTERN



## Effective Rainfall

Three rainfall data observed at Sing Ha Nat, Phraya Banlu and Lakkhon regulators are available around the Project Area for 14 years from 1962 to 1975. By using these rainfall data, Probability analysis was made to determine the design rainfall for the irrigation plan, that is, 2-years probable rainfall equivalent to once every two years and 10-years probable rainfall equivalent to once every ten years are selected as the rainfalls of normal year and the design year for the Project respectively, and they are summarized as given below;

### Probable Rainfall

(Unit: mm)

| Station | Return Period: 2-years | | Return Period: 10-years | |
|---|---|---|---|---|
| | Rainfall | Corresponding year | Rainfall | Corresponding year |
| Sing Ha Nat Reg. | 1,394 | 1971 | 1,060 | 1967 |
| Phraya Banlu Reg. | 1,222 | 1969 | 954 | 1971 |
| Lakkhon Reg. | 1,162 | 1964 | 823 | 1965 |
| Average | 1,259 | | 946 | |

As is seen in the above Table, the rainfall in the normal year and design year are estimated at 1,259 mm/annum and 946 mm/annum on average, and the corresponding year at each station to meet the average rainfall estimated above is found out respectively. The effective rainfalls for paddy fields and upland fields are computed by applying the calculation method of effective rainfalls1/ used in the irrigation Project under the Royal Irrigation Department.

1/ Paddy field:

Monthly rainfall x coefficient (K)

Coeeficient K;

| | | | |
|---|---|---|---|
| Jan.: | 0.90 | Jul.: | 0.75 |
| Feb.: | 0.90 | Aug.: | 0.75 |
| Mar.: | 0.90 | Sep.: | 0.75 |
| Apr.: | 0.75 | Oct.: | 0.65 |
| May : | 0.75 | Nov.: | 0.80 |
| Jun.: | 0.75 | Dec.: | 0.90 |

Upland field:

Based on Figure A. 4-4

Table A. 4-14 and A. 4-15 show the effective rainfalls of paddy fields and upland fields, in case of the normal year and design year.

Table A.4-14 Effective Rainfall (Return Period: 2-years)

(Unit: mm)

| Month | | Rainfall: Sing Ha Nat Reg. | Rainfall: Phraya Banlu Reg. | Rainfall: Lakkhon Reg. | Rainfall: Average (1) | Effective Rainfall, Paddy Field: Ratio of Effective Rainfall (2) | Effective Rainfall, Paddy Field: Effective Rainfall (3)=(1)x(2) | Effective Rainfall: Upland Field (4) |
|---|---|---|---|---|---|---|---|---|
| Nov. | I | - | 134.2 | - | 44.7 | 0.80 | 35.8 | 32.2 |
| | II | - | - | - | - | 0.80 | - | - |
| Dec. | I | - | - | 52.0 | 17.3 | 0.90 | 15.6 | 12.2 |
| | II | 2.0 | - | - | 0.7 | 0.90 | 0.6 | 0.4 |
| Jan. | I | - | - | - | - | 0.90 | - | - |
| | II | - | - | - | - | 0.90 | - | - |
| Feb. | I | 5.2 | - | - | 1.7 | 0.90 | 1.5 | 1.1 |
| | II | - | - | 27.4 | 9.1 | 0.90 | 8.2 | 6.2 |
| Mar. | I | - | - | 8.3 | 2.8 | 0.90 | 2.5 | 1.9 |
| | II | 22.2 | 29.0 | 7.3 | 19.5 | 0.90 | 17.6 | 13.8 |
| Apr. | I | 12.0 | 5.5 | - | 5.8 | 0.75 | 4.4 | 4.0 |
| | II | 46.5 | - | 101.9 | 49.5 | 0.75 | 37.1 | 36.0 |
| May | I | 31.4 | 27.5 | 254.7 | 104.5 | 0.75 | 78.4 | 70.0 |
| | II | 144.1 | 21.9 | 43.3 | 69.8 | 0.75 | 52.4 | 49.0 |
| Jun. | I | 120.5 | 71.0 | 70.2 | 87.2 | 0.75 | 65.4 | 59.7 |
| | II | 47.3 | 49.3 | 92.2 | 62.9 | 0.75 | 47.2 | 44.7 |
| Jul. | I | 21.1 | 135.0 | 56.0 | 70.7 | 0.75 | 53.0 | 49.6 |
| | II | 57.9 | - | 47.3 | 35.1 | 0.75 | 26.3 | 25.9 |
| Aug. | I | 68.6 | 104.9 | 35.1 | 69.5 | 0.75 | 52.1 | 48.8 |
| | II | 225.5 | 100.3 | 85.6 | 137.1 | 0.75 | 102.8 | 87.4 |
| Sep. | I | 157.3 | 145.9 | 15.0 | 106.1 | 0.75 | 79.6 | 70.9 |
| | II | 151.9 | 199.8 | 226.4 | 192.7 | 0.75 | 144.5 | 109.8 |
| Oct. | I | 72.5 | 120.5 | 19.5 | 70.8 | 0.65 | 46.0 | 49.5 |
| | II | 211.6 | 69.2 | 19.5 | 100.1 | 0.65 | 65.1 | 67.2 |
| Total | | 1,397.6 | 1,214.0 | 1,161.7 | 1,257.6 | | 936.1 | 840.3 |

Note: (4); estimated based on Figure A. 4-4

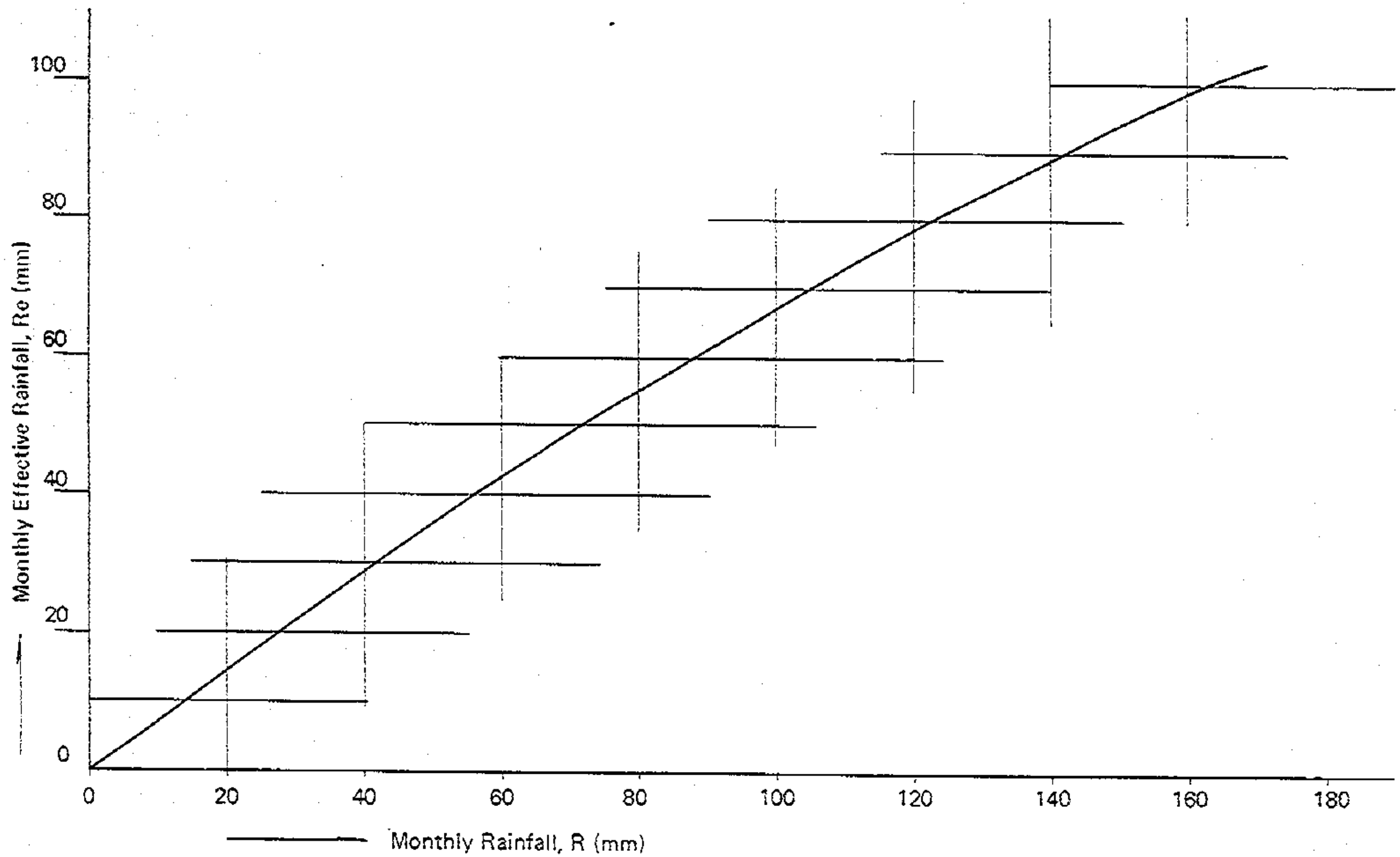
Table A.4-15 Effective Rainfall (Return Period: 10 years)

(Unit: mm)

| Month | | Rainfall: Sing Ha Nat Reg. | Phraya Banlu Reg. | Lakkhon Reg. | Average (1) | Effective Rainfall, Paddy Field: Ratio of Effecitve Rainfall (2) | Effective Rainfall (3)=(1)x(2) | Upland Field (4) |
|---|---|---|---|---|---|---|---|---|
| Nov. | I | 38.8 | - | - | 12.9 | 0.80 | 10.3 | 9.0 |
| | II | 0.8 | - | 5.2 | 2.0 | 0.80 | 1.6 | 1.3 |
| Dec. | I | - | - | - | - | 0.90 | - | - |
| | II | - | - | - | - | 0.90 | - | - |
| Jan. | I | - | - | - | - | 0.90 | - | - |
| | II | - | - | - | - | 0.90 | - | - |
| Feb. | I | - | - | 43.6 | 14.5 | 0.90 | 13.1 | 10.0 |
| | II | 34.0 | - | 16.8 | 16.9 | 0.90 | 15.2 | 12.0 |
| Mar. | I | 21.5 | - | - | 7.1 | 0.90 | 6.4 | 5.0 |
| | II | - | 11.3 | 3.6 | 5.0 | 0.90 | 4.5 | 3.5 |
| Apr. | I | 5.0 | 34.0 | 1.4 | 13.5 | 0.75 | 10.1 | 9.4 |
| | II | 35.5 | 92.7 | - | 42.7 | 0.75 | 30.0 | 31.0 |
| May | I | 3.3 | - | 7.4 | 3.6 | 0.75 | 2.7 | 2.5 |
| | II | 51.5 | 14.1 | 52.1 | 39.2 | 0.75 | 29.4 | 28.5 |
| Jun. | I | 131.2 | 34.4 | 48.6 | 71.4 | 0.75 | 53.6 | 50.0 |
| | II | 40.2 | 7.5 | 39.7 | 29.1 | 0.75 | 21.8 | 21.0 |
| Jul. | I | 89.9 | 19.5 | - | 36.1 | 0.75 | 27.1 | 26.1 |
| | II | 76.3 | 48.4 | 3.4 | 42.7 | 0.75 | 30.0 | 30.9 |
| Aug. | I | 28.8 | 23.0 | 41.0 | 30.9 | 0.75 | 23.2 | 22.1 |
| | II | 34.1 | 192.9 | 82.7 | 103.2 | 0.75 | 77.4 | 69.0 |
| Sep. | I | 129.3 | 119.0 | 89.9 | 112.7 | 0.75 | 84.5 | 74.4 |
| | II | 151.0 | 96.5 | 218.8 | 155.4 | 0.65 | 116.6 | 96.1 |
| Oct. | I | 143.0 | 46.0 | 58.2 | 82.4 | 0.65 | 53.6 | 56.8 |
| | II | 28.9 | 212.8 | 9.3 | 83.7 | 0.65 | 54.4 | 57.4 |
| Total | | 1,043.1 | 952.1 | 721.7 | 905.0 | | 665.5 | 616.0 |

Note: (4); estimated based on Figure A. 4-4

FIGURE A. 4–4 RELATION CURVE BETWEEN RAINFALL AND EFFECTIVE RAINFALL FOR UPLAND FIELDS




Note: Average monthly evapotranspiration (ETa) of crops: 100 mm (See Table A. 4–16)
Net soil water storage allowed: 75 mm

Source: Lam Pra Plerng Irrigation Project report prepared by Engineering Consultants, 1971

Table A. 4-16 Average monthly effective rainfall as related to mean monthly rainfall and average monthly crop evapotranspiration, ETa, for upland-type crop with net soil water storage allowed of 75 mm [1/]

| Mean Monthly Rainfall R (mm) | Average monthly ETa (mm) (upland-type crops) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 |
| | Average monthly effective rainfall, Re (mm) | | | | | | | | | |
| 15 | 9 | 10 | 10 | 11 | 11 | 12 | 12 | 13 | 14 | 15 |
| 20 | 12 | 13 | 14 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 30 | 18 | 19 | 21 | 22 | 22 | 23 | 24 | 26 | 28 | 30 |
| 40 | 23 | 25 | 27 | 29 | 30 | 31 | 32 | 35 | 38 | 40 |
| 50 | 25 | 32 | 34 | 35 | 36 | 38 | 40 | 43 | 46 | 49 |
| 60 | | 38 | 40 | 42 | 43 | 45 | 47 | 51 | 55 | 59 |
| 70 | | 43 | 46 | 49 | 51 | 53 | 55 | 59 | 63 | 68 |
| 80 | | 48 | 52 | 55 | 58 | 60 | 63 | 67 | 71 | 77 |
| 90 | | 50 | 57 | 61 | 64 | 67 | 70 | 75 | 79 | 85 |
| 100 | | | 63 | 67 | 71 | 74 | 78 | 82 | 87 | 94 |
| 110 | | | 68 | 73 | 78 | 80 | 84 | 89 | 95 | 102 |
| 120 | | | 73 | 78 | 84 | 86 | 91 | 97 | 102 | 110 |
| 130 | | | 75 | 83 | 89 | 92 | 98 | 104 | 110 | 118 |
| 140 | | | | 89 | 95 | 99 | 105 | 112 | 118 | 126 |
| 150 | | | | 94 | 101 | 105 | 110 | 120 | 125 | 134 |
| 160 | | | | 99 | 106 | 110 | 117 | 125 | 132 | 142 |
| 170 | | | | 100 | 111 | 116 | 123 | 131 | 138 | 149 |
| 180 | | | | | 116 | 121 | 129 | 136 | 144 | 155 |
| 190 | | | | | 121 | 126 | 134 | 142 | 150 | 161 |
| 200 | | | | | 125 | 132 | 140 | 148 | 157 | 168 |

[1/] For other net soil water storage allowed, multiply by the factor shown below:

| Net soil water storage allowed, mm | 25 | 30 | 40 | 50 | 60 | 75 | 100 | 125 | 150 | 175 |
|---|---|---|---|---|---|---|---|---|---|---|
| Factor | 0.74 | 0.82 | 0.88 | 0.93 | 0.96 | 1.00 | 1.02 | 1.04 | 1.06 | 1.07 |

Note: Average monthly effective rainfall cannot exceed average monthly rainfall or average monthly crop evapotranspiration. Where mean monthly rainfall is less than the minimum effective rainfall in the Table above it is assumed to be 100 percent effective.

Water Losses

Water losses for paddy fields consist of the following two losses;

i) Application losses

ii) Conveyance losses

The former is considered to be on-farm losses due to mostly the farmer's capacity of farm water management, and in the project, the 20 per cent of the average field irrigation water requirements is taken as the on-farm losses, based on the following assumption.

| | Application losses |
|---|---|
| Surface run-off | 10 % |
| Feeder loss | 5 |
| Operation loss | 5 |
| Total (1) | 20 |

On the other hand, the latter which is water losses during conveyance stage, furthermore, can be classified into two factors namely: physical and non-physical factors, and physical factors are composed of seepage, leakage and evaporation losses, while non-physical factors are rather related to operational factors such as over-application of irrigation water in the fields, unscheduled drainage and illegal diversion.

However, in the project area, no data on the water conveyance losses exist entirely, so that the conveyance losses for main canals and laterals are decided as shown below, although the Morits empirical formula1/ could be considered as the procedure for estimation of seepage losses of canal.

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1/ Morits Formula: Water losses (cu.m/km) = $0.038.C.(Q/V)^{1/2}$
where, Q = canal discharge (cu.m/sec), V = velocity of flow (m/sec) and C = 0.20 for sandy canal and 0.13 for clay and clayey canals.

| | Conveyance loss (%) |
|---|---|
| Water loss in main canals | |
| physical | 2.5 |
| Non-physical | 5.0 |
| Sub-total (2) | 7.5 |
| Water loss in laterals | 10.0 |
| Sub-total (3) | 10.0 |
| Total (4) = (2) + (3) | 17.5 |
| Total loss (5)1/ | 33.4 |

As a result, total water loss for paddy field irrigation are decided to be 33.4 per cent of farm turn-out requirements in the project.

On the other hand, the irrigation efficiency for upland fields is assumed to be 65 per cent, in view of irregular parcellation patterns resulting in diverse lengths of runs, non-uniform distribution of water, expected operation and percolation losses.

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1/ (5) = 100% - [100 - (1)%] x [100 - (2)%] x [100 - (3)%]

Table A. 4-17 Irrigation Water Requirements for Paddy Fields
(Return Period: 2-years)

| Month | Field Water Requirements | | Effective Rainfall | Net Water Requirements | Gross Water Requirements | | | Irrigation Water Requirements | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Farm Gate Water Requirements | Diversion Water Requirements | | Block A | Block B | Block C | Total |
| | (mm/day) | (mm/half mon) | (mm/half mon) | (mm/half mon) | (mm/half mon) | (mm/half mon) | (ℓ/sec/ha) | (cu.m/s) | (cu.m/s) | (cu.m/s) | (cu.m/s) |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Jan. I | 2.0 | 30.0 | - | 30.0 | 37.5 | 45.0 | 0.347 | 1.00 | 0.81 | 1.50 | 3.31 |
| II | 6.5 | 104.0 | - | 104.0 | 130.0 | 156.2 | 1.130 | 3.26 | 2.64 | 4.88 | 10.78 |
| Feb. I | 9.0 | 135.0 | 1.5 | 133.5 | 166.9 | 200.5 | 1.547 | 4.46 | 3.61 | 6.69 | 14.76 |
| II | 9.0 | 117.0 | 8.2 | 108.8 | 136.0 | 163.4 | 1.455 | 4.20 | 3.40 | 6.29 | 13.89 |
| Mar. I | 7.0 | 105.0 | 2.5 | 102.5 | 128.1 | 153.9 | 1.187 | 3.42 | 2.77 | 5.13 | 11.32 |
| II | 6.8 | 108.8 | 17.6 | 91.2 | 114.0 | 136.9 | 0.990 | 2.86 | 2.31 | 4.28 | 9.45 |
| Apr. I | 7.6 | 114.0 | 4.4 | 109.6 | 137.0 | 164.6 | 1.270 | 3.66 | 2.96 | 5.49 | 12.11 |
| II | 7.4 | 111.0 | 37.1 | 73.9 | 92.4 | 111.0 | 0.803 | 2.32 | 1.87 | 3.47 | 7.66 |
| May I | 4.6 | 69.0 | 78.4 | - | - | - | - | - | - | - | - |
| II | 2.3 | 36.8 | 52.4 | - | - | - | - | - | - | - | - |
| Jun. I | 0.2 | 3.0 | 65.4 | - | - | - | - | - | - | - | - |
| II | - | - | 47.2 | - | - | - | - | - | - | - | - |
| Jul. I | 1.8 | 27.0 | 53.0 | - | - | - | - | - | - | - | - |
| II | 6.4 | 102.4 | 26.3 | 76.1 | 95.1 | 114.2 | 0.826 | 2.38 | 1.93 | 3.57 | 7.88 |
| Aug. I | 8.2 | 123.0 | 52.1 | 70.9 | 88.6 | 106.4 | 0.821 | 2.37 | 1.92 | 3.55 | 7.84 |
| II | 7.8 | 104.8 | 102.8 | 2.0 | 2.5 | 3.0 | 0.022 | 0.06 | 0.05 | 0.09 | 0.20 |
| Sep. I | 5.4 | 81.0 | 79.6 | 1.4 | 1.8 | 2.2 | 0.017 | 0.05 | 0.04 | 0.07 | 0.16 |
| II | 5.3 | 84.8 | 144.5 | - | - | - | - | - | - | - | - |
| Oct. I | 5.5 | 82.5 | 46.0 | 36.5 | 45.6 | 54.8 | 0.423 | 1.22 | 0.99 | 1.83 | 4.04 |
| II | 5.4 | 86.4 | 65.1 | 21.3 | 26.6 | 32.0 | 0.231 | 0.67 | 0.54 | 1.00 | 2.21 |
| Nov. I | 3.7 | 55.5 | 35.8 | 19.7 | 24.6 | 29.5 | 0.228 | 0.66 | 0.53 | 0.99 | 2.18 |
| II | 1.8 | 27.0 | - | 27.0 | 33.8 | 40.6 | 0.313 | 0.90 | 0.73 | 1.35 | 2.98 |
| Dec. I | 0.2 | 3.0 | 15.6 | - | - | - | - | - | - | - | - |
| II | - | - | 0.6 | - | - | - | - | - | - | - | - |

Note:
(1): Average field water requirement, in millimeter per day (see Table A. 4-13)
(2): Average field water requirement, in millimeter per half month
(3): Effective rainfall in millimeter per half month (see Appendix A. 4-14)
(4): (2) - (3)
(5): (4)/(1 - 0.2)
(6): (5)/(1 - 0.075)(1 - 0.10)
(7): (6)/8.64 x n
(8): Block A; irrigable area 2,885 ha x (7)
(9): Block B; irrigable area 2,334 ha x (7)
(10): Block C; irrigable area 4,323 ha x (7)
(11): (8) + (9) + (10)

Table A. 4-18 Irrigation Water Requirements for Upland Crops
(Return Period: 2-years)

| Month | Field Water Requirements (mm/day) (1) | Field Water Requirements (mm/half mon) (2) | Effective Rainfall (mm/half mon) (3) | Net Water Requirements (mm/half mon) (4) | Gross Water Requirements: Farm Gate Water Requirements (mm/half mon) (5) | Gross Water Requirements: Diversion Water Requirements (mm/half mon) (6) | Gross Water Requirements: Diversion Water Requirements (ℓ/sec/ha) (7) | Irrigation Water Requirements: Block A (cu.m/s) (8) | Block B (cu.m/s) (9) | Block C (cu.m/s) (10) | Total (cu.m/s) (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. I | 3.1 | 46.5 | - | 46.5 | 71.5 | 85.9 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |
| II | 3.1 | 49.6 | - | 49.6 | 76.3 | 91.7 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |
| Feb. I | 3.7 | 55.6 | 1.1 | 54.5 | 83.9 | 100.8 | 0.778 | 0.11 | 0.19 | 0.47 | 0.77 |
| II | 3.7 | 48.1 | 6.2 | 41.9 | 64.5 | 77.5 | 0.690 | 0.10 | 0.17 | 0.42 | 0.69 |
| Mar. I | 4.2 | 63.0 | 1.9 | 61.1 | 94.0 | 112.9 | 0.871 | 0.12 | 0.22 | 0.53 | 0.87 |
| II | 4.2 | 67.2 | 13.8 | 53.4 | 82.2 | 98.7 | 0.714 | 0.10 | 0.18 | 0.43 | 0.71 |
| Apr. I | 4.6 | 69.0 | 4.0 | 65.0 | 100.0 | 120.1 | 0.927 | 0.13 | 0.23 | 0.56 | 0.92 |
| II | 4.6 | 69.0 | 36.0 | 33.0 | 50.8 | 61.0 | 0.471 | 0.07 | 0.12 | 0.29 | 0.48 |
| May I | 4.0 | 60.0 | 70.0 | - | - | - | - | - | - | - | - |
| II | 4.0 | 64.4 | 49.0 | 15.4 | 23.7 | 28.5 | 0.206 | 0.03 | 0.05 | 0.13 | 0.21 |
| Jun. I | 3.7 | 55.5 | 59.7 | - | - | - | - | - | - | - | - |
| II | 3.7 | 55.5 | 44.7 | 10.8 | 16.6 | 19.9 | 0.154 | 0.02 | 0.04 | 0.09 | 0.15 |
| Jul. I | 3.4 | 51.0 | 49.6 | 1.4 | 2.2 | 2.6 | - | - | - | - | - |
| II | 3.4 | 54.4 | 25.9 | 28.5 | 43.9 | 52.7 | 0.381 | 0.05 | 0.09 | 0.23 | 0.37 |
| Aug. I | 3.2 | 48.0 | 48.8 | - | - | - | - | - | - | - | - |
| II | 3.2 | 51.2 | 87.4 | - | - | - | - | - | - | - | - |
| Sep. I | 3.0 | 45.0 | 70.9 | - | - | - | - | - | - | - | - |
| II | 3.0 | 45.0 | 109.8 | - | - | - | - | - | - | - | - |
| Oct. I | 3.1 | 46.5 | 49.5 | - | - | - | - | - | - | - | - |
| II | 3.1 | 49.6 | 67.2 | - | - | - | - | - | - | - | - |
| Nov. I | 3.2 | 48.0 | 32.2 | 15.8 | 24.3 | 29.2 | 0.225 | 0.03 | 0.06 | 0.14 | 0.23 |
| II | 3.2 | 48.0 | - | 48.0 | 73.9 | 88.8 | 0.685 | 0.10 | 0.17 | 0.42 | 0.69 |
| Dec. I | 3.1 | 46.5 | 12.2 | 34.3 | 52.8 | 63.4 | 0.489 | 0.07 | 0.12 | 0.30 | 0.49 |
| II | 3.1 | 49.6 | 0.4 | 49.2 | 75.7 | 90.9 | 0.658 | 0.09 | 0.16 | 0.40 | 0.65 |

Note:
(1): Average field water requirements, in millimeter per day (see Table A. 4-13)
(2): Average field water requirements, in millimeter per half month
(3): Effective rainfall, in millimeter per half month, (see Appendix A. 4-14)
(4): (2) - (3)
(5): (4)/(1 - 0.35)
(6): (5)/(1 - 0.075)(1 - 0.10)
(7): (6)/8.64 x n
(8): Block A; irrigable area 142 ha x (7)
(9): Block B; irrigable area 249 ha x (7)
(10): Block C; irrigable area 609 ha x (7)
(11): (8) + (9) + (10)

Table A. 4-19 Irrigation Water Requirements for Paddy Fields
(Return Period: 10-years)

| Month | Field Water Requirements (mm/day) (1) | Field Water Requirements (mm/half mon) (2) | Effective Rainfall (mm/half mon) (3) | Net Water Requirements (mm/half mon) (4) | Gross Water Requirements: Farm Gate Water Requirements (mm/half mon) (5) | Gross Water Requirements: Diversion Water Requirements (mm/half mon) (6) | Gross Water Requirements: Diversion Water Requirements (ℓ/sec/ha) (7) | Irrigation Water Requirements: Block A (cu.m/s) (8) | Irrigation Water Requirements: Block B (cu.m/s) (9) | Irrigation Water Requirements: Block C (cu.m/s) (10) | Irrigation Water Requirements: Total (cu.m/s) (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. I | 2.0 | 30.0 | - | 30.0 | 37.5 | 45.0 | 0.347 | 1.00 | 0.81 | 1.50 | 3.31 |
| II | 6.5 | 104.0 | - | 104.0 | 130.0 | 156.2 | 1.130 | 3.26 | 2.64 | 4.88 | 10.78 |
| Feb. I | 9.0 | 135.0 | 13.1 | 121.9 | 152.4 | 183.1 | 1.413 | 4.08 | 3.30 | 6.11 | 13.49 |
| II | 9.0 | 117.0 | 15.2 | 101.8 | 127.3 | 152.9 | 1.362 | 3.93 | 3.18 | 5.89 | 13.00 |
| Mar. I | 7.0 | 105.0 | 6.4 | 98.6 | 123.3 | 148.1 | 1.143 | 3.30 | 2.67 | 4.94 | 10.91 |
| II | 6.8 | 108.8 | 4.5 | 104.3 | 130.4 | 156.6 | 1.133 | 3.27 | 2.64 | 4.90 | 10.81 |
| Apr. I | 7.6 | 114.0 | 10.1 | 103.9 | 130.0 | 156.2 | 1.205 | 3.48 | 2.81 | 5.21 | 11.50 |
| II | 7.4 | 111.0 | 30.0 | 81.0 | 101.3 | 121.7 | 0.939 | 2.71 | 2.19 | 4.06 | 8.96 |
| May I | 4.6 | 69.0 | 2.7 | 66.3 | 82.9 | 99.6 | 0.769 | 2.22 | 1.79 | 3.32 | 7.33 |
| II | 2.3 | 36.8 | 29.4 | 7.4 | 9.3 | 11.2 | 0.081 | 0.23 | 0.19 | 0.35 | 0.77 |
| Jun. I | 0.2 | 3.0 | 53.6 | - | - | - | - | - | - | - | - |
| II | - | - | 21.8 | - | - | - | - | - | - | - | - |
| Jul. I | 1.8 | 27.0 | 27.1 | - | - | - | - | - | - | - | - |
| II | 6.4 | 102.4 | 30.0 | 72.4 | 90.5 | 108.7 | 0.786 | 2.27 | 1.83 | 3.40 | 7.50 |
| Aug. I | 8.2 | 123.0 | 23.2 | 99.8 | 124.8 | 149.9 | 1.157 | 3.34 | 2.70 | 5.00 | 11.04 |
| II | 7.8 | 104.8 | 77.4 | 27.4 | 34.3 | 41.2 | 0.298 | 0.86 | 0.70 | 1.29 | 2.85 |
| Sep. I | 5.4 | 81.0 | 84.5 | - | - | - | - | - | - | - | - |
| II | 5.3 | 84.8 | 116.6 | - | - | - | - | - | - | - | - |
| Oct. I | 5.5 | 82.5 | 53.6 | 28.9 | 36.1 | 43.4 | 0.335 | 0.97 | 0.78 | 1.45 | 3.20 |
| II | 5.4 | 86.4 | 54.4 | 32.0 | 40.0 | 48.0 | 0.347 | 1.00 | 0.81 | 1.50 | 3.31 |
| Nov. I | 3.7 | 55.5 | 10.3 | 45.2 | 56.5 | 67.9 | 0.524 | 1.51 | 1.22 | 2.27 | 5.00 |
| II | 1.8 | 27.0 | 1.6 | 25.4 | 31.8 | 38.2 | 0.295 | 0.85 | 0.69 | 1.28 | |
| Dec. I | 0.2 | 3.0 | - | 3.0 | 3.8 | 4.6 | 0.035 | 0.10 | 0.08 | 0.15 | 0.33 |
| II | - | - | - | - | - | - | - | - | - | - | - |

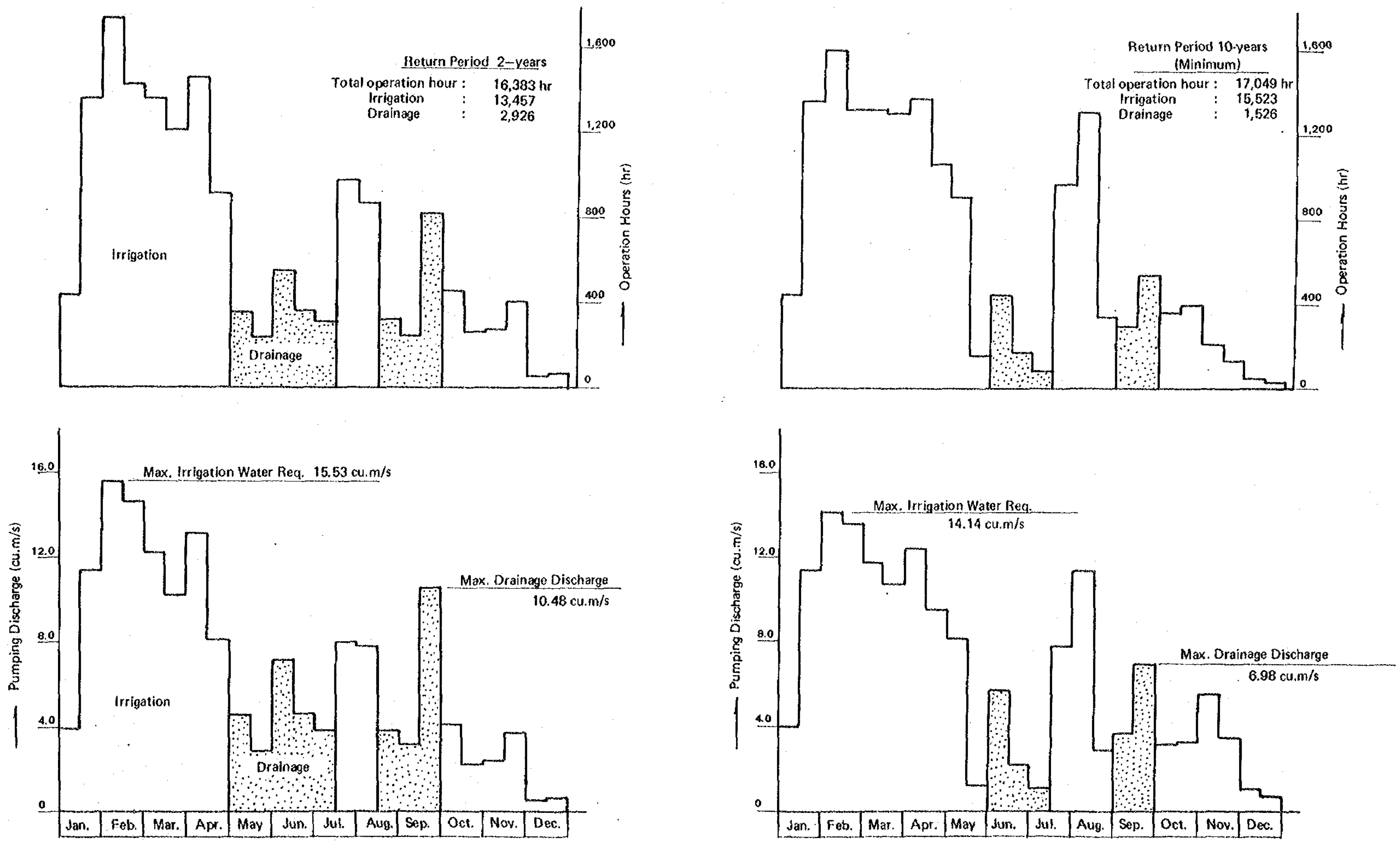
Note: (1): Average field water requirement, in millimeter per day (see Table A. 4-13)
(2): Average field water requirement, in millimeter per half month
(3): Effective rainfall in millimeter per half month (see Appendix A. 4-15)
(4): (2) - (3)
(5): (4)/(1 - 0.2)
(6): (5)/(1 - 0.075)(1 - 0.10)
(7): (6)/8.64 x n
(8): Block A; irrigable area 2,885 ha x (7)
(9): Block B; irrigable area 2,334 ha x (7)
(10): Block C; irrigable area 4,323 ha x (7)
(11): (8) + (9) + (10)

Table A. 4-20 Irrigation Water Requirements for Upland Crops
(Return Period: 10-years)

| Month | | Field Water Requirements (mm/day) (1) | Field Water Requirements (mm/half mon) (2) | Effective Rainfall (mm/half mon) (3) | Net Water Requirements (mm/half mon) (4) | Gross Water Requirements: Farm Gate Water Requirements (mm/half mon) (5) | Gross Water Requirements: Diversion Water Requirements (mm/half mon) (6) | Gross Water Requirements: Diversion Water Requirements (ℓ/sec/ha) (7) | Irrigation Water Requirements: Block A (cu.m/s) (8) | Block B (cu.m/s) (9) | Block C (cu.m/s) (10) | Total (cu.m/s) (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | I | 3.1 | 46.5 | - | 46.5 | 71.5 | 85.9 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |
| | II | 3.1 | 49.6 | - | 49.6 | 76.3 | 91.7 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |
| Feb. | I | 3.7 | 55.6 | 10.0 | 45.6 | 70.2 | 84.2 | 0.650 | 0.09 | 0.16 | 0.40 | 0.65 |
| | II | 3.7 | 48.1 | 12.0 | 36.1 | 55.5 | 66.7 | 0.594 | 0.08 | 0.15 | 0.36 | 0.59 |
| Mar. | I | 4.2 | 63.0 | 5.0 | 58.0 | 89.2 | 107.1 | 0.826 | 0.11 | 0.21 | 0.50 | 0.82 |
| | II | 4.2 | 67.2 | 3.5 | 63.7 | 98.0 | 117.7 | 0.851 | 0.12 | 0.21 | 0.52 | 0.85 |
| Apr. | I | 4.6 | 69.0 | 9.4 | 59.6 | 91.7 | 110.2 | 0.850 | 0.12 | 0.21 | 0.52 | 0.85 |
| | II | 4.6 | 69.0 | 31.0 | 38.0 | 58.5 | 70.3 | 0.542 | 0.08 | 0.13 | 0.33 | 0.54 |
| May | I | 4.0 | 60.0 | 2.5 | 57.5 | 88.5 | 106.3 | 0.820 | 0.12 | 0.20 | 0.50 | 0.82 |
| | II | 4.0 | 64.4 | 28.5 | 35.9 | 55.2 | 66.3 | 0.480 | 0.07 | 0.12 | 0.29 | 0.48 |
| Jun. | I | 3.7 | 55.5 | 50.0 | 5.5 | 8.5 | 10.2 | 0.078 | 0.01 | 0.02 | 0.08 | 0.11 |
| | II | 3.7 | 55.5 | 21.0 | 34.5 | 53.1 | 63.8 | 0.492 | 0.07 | 0.12 | 0.30 | 0.49 |
| Jul. | I | 3.4 | 51.0 | 26.1 | 24.9 | 38.3 | 46.0 | 0.355 | 0.05 | 0.09 | 0.22 | 0.39 |
| | II | 3.4 | 54.4 | 30.9 | 23.5 | 36.2 | 43.5 | 0.315 | 0.04 | 0.08 | 0.19 | 0.31 |
| Aug. | I | 3.2 | 48.0 | 22.1 | 25.9 | 39.8 | 47.8 | 0.369 | 0.05 | 0.09 | 0.22 | 0.36 |
| | II | 3.2 | 51.2 | 69.0 | - | - | - | - | - | - | - | - |
| Sep. | I | 3.0 | 45.0 | 74.4 | - | - | - | - | - | - | - | - |
| | II | 3.0 | 45.0 | 96.1 | - | - | - | - | - | - | - | - |
| Oct. | I | 3.1 | 46.5 | 56.8 | - | - | - | - | - | - | - | - |
| | II | 3.1 | 49.6 | 57.4 | - | - | - | - | - | - | - | - |
| Nov. | I | 3.2 | 48.0 | 9.0 | 39.0 | 60.0 | 72.1 | 0.556 | 0.08 | 0.14 | 0.34 | 0.56 |
| | II | 3.2 | 48.0 | 1.3 | 46.7 | 71.8 | 86.2 | 0.665 | 0.09 | 0.17 | 0.40 | 0.66 |
| Dec. | I | 3.1 | 46.5 | - | 46.5 | 71.5 | 85.9 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |
| | II | 3.1 | 49.6 | - | 49.6 | 76.3 | 91.7 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |

Note:
(1): Average field water requirements, in millimeter per day (see Table A.4-13)
(2): Average field water requirements, in millimeter per half month
(3): Effective rainfall, in millimeter per half month, (see Appendix A. 4-15)
(4): (2) -(3)
(5): (4)/(1 - 0.35)
(6): (5)/(1 - 0.075)(1 - 0.10)
(7): (6)/8.64 x n
(8): Block A; irrigable area 142 ha x (7)
(9): Block B; irrigable area 249 ha x (7)
(10): Block C; irrigable area 609 ha x (7)
(11): (8) + (9) + (10)

FIGURE A.4-5 AVERAGE PUMPING DISCHARGE AND PUMP OPERATION HOURS




Note: Detail estimation is given in Table A.4 - 21

Return Period: 2-years

| Month | | Pumping Discharge (cu.m/s) Block A | Block B | Block C | Total | Operation Hours of Pumps (hr) Block A | Block B | Block C | Total |
|---|---|---|---|---|---|---|---|---|---|
| Jan. | I | 1.09 a/ | 0.98 | 1.90 | 3.97 | 141 c/ | 147 | 151 | 439 |
| | II | 3.35 | 2.81 | 5.28 | 11.44 | 461 | 448 | 450 | 1,359 |
| Feb. | I | 4.57 | 3.80 | 7.16 | 15.53 | 590 | 567 | 572 | 1,729 |
| | II | 4.30 | 3.57 | 6.71 | 14.58 | 481 | 463 | 464 | 1,408 |
| Mar. | I | 3.54 | 2.99 | 5.66 | 12.19 | 458 | 447 | 452 | 1,357 |
| | II | 2.96 | 2.49 | 4.71 | 10.16 | 408 | 397 | 402 | 1,207 |
| Apr. | I | 3.79 | 3.19 | 6.05 | 13.03 | 489 | 477 | 483 | 1,449 |
| | II | 2.39 | 1.99 | 3.76 | 8.14 | 308 | 297 | 300 | 905 |
| May | I | (1.29) b/ | (1.12) | (2.07) | (4.48) | (117) | (117) | (116) | (350) |
| | II | (0.81) | (0.70) | (1.30) | (2.81) | ( 78) | ( 78) | ( 77) | (233) |
| Jun. | I | (2.03) | (1.75) | (3.29) | (7.07) | (183) | (183) | (180) | (546) |
| | II | (1.33) | (1.14) | (2.14) | (4.61) | (120) | (120) | (120) | (360) |
| Jul. | I | (1.12) | (0.97) | (1.81) | (3.90) | (101) | (102) | (101) | (304) |
| | II | 2.43 | 2.02 | 3.80 | 8.25 | 334 | 321 | 324 | 979 |
| Aug. | I | 2,37 | 1.92 | 3.55 | 7.84 | 306 | 287 | 283 | 876 |
| | II | (1.09) | (0.95) | (1.75) | (3.79) | (106) | (106) | (104) | (316) |
| Sep. | I | (0.89) | (0.78) | (1.43) | (3.10) | ( 81) | ( 81) | ( 80) | (242) |
| | II | (3.02) | (2.59) | (4.87) | (10.48) | (273) | (272) | (272) | (817) |
| Oct. | I | 1.22 | 0.99 | 1.83 | 4.04 | 158 | 149 | 146 | 453 |
| | II | 0.67 | 0.54 | 1.00 | 2.21 | 93 | 86 | 85 | 264 |
| Nov. | I | 0.59 | 0.59 | 1.13 | 2.41 | 89 | 89 | 90 | 268 |
| | II | 1.00 | 0.90 | 1.77 | 3.67 | 129 | 135 | 141 | 405 |
| Dec. | I | 0.07 | 0.12 | 0.30 | 0.49 | 9 | 18 | 24 | 51 |
| | II | 0.09 | 0.12 | 0.40 | 0.61 | 13 | 19 | 34 | 66 |
| | | | | | Total | 4,548<br>(978) | 4,428<br>(978) | 4,481<br>(970) | 13,457<br>(2,925) |
| | | | | | | 5,526 | 5,406 | 5,451 | 16,383 |

Note: a/ : derived from Table A. 4-17 and A. 4-18

b/ : derived from Table A. 4-23

c/ : 1.09 cu.m/s x 86,400 x 15/2.79 cu.m/s (pump capacity) x 3,600

pump capacity:
Block A: 2.79 cu.m/s (3.99) x 3 units (φ1,350)
Block B: 2.41 cu.m/s (3.44) x 3 units (φ1,350)
Block C: 4.51 cu.m/s (6.44) x 3 units (φ1,650)

( ) shows the drainage discharge and operation hours of pumps for drainage

Table A. 4-22 Average Operation Hours of the Proposed Pump

Return Period: 10-years (Minimum)

| Month | | Pumping Discharge (cu.m/s) Block A | Block B | Block C | Total | Operation Hours of Pumps (hr) Block A | Block B | Block C | Total |
|---|---|---|---|---|---|---|---|---|---|
| Jan. | I | 1.09 | 0.98 | 1.90 | 3.97 | 141 | 147 | 152 | 440 |
| | II | 3.35 | 2.81 | 5.28 | 11.44 | 461 | 448 | 450 | 1,359 |
| Feb. | I | 4.17 | 3.46 | 6.51 | 14.14 | 540 | 534 | 527 | 1,601 |
| | II | 4.01 | 3.33 | 6.25 | 13.59 | 449 | 432 | 433 | 1,314 |
| Mar. | I | 3.41 | 2.88 | 5.44 | 11.73 | 440 | 431 | 434 | 1,305 |
| | II | 3.39 | 2.85 | 4.42 | 10.66 | 467 | 454 | 376 | 1,297 |
| Apr. | I | 3.60 | 3.02 | 5.73 | 12.35 | 465 | 452 | 458 | 1,375 |
| | II | 2.79 | 2.32 | 4.39 | 9.50 | 360 | 347 | 351 | 1,058 |
| May | I | 2.34 | 1.99 | 3.82 | 8.15 | 302 | 297 | 305 | 904 |
| | II | 0.30 | 0.31 | 0.64 | 1.25 | 42 | 50 | 54 | 146 |
| Jun. | I | (1.63) | (1.40) | (2.64) | (5.67) | (147) | (147) | (147) | (441) |
| | II | (0.62) | (0.54) | (1.00) | (2.16) | ( 56) | ( 57) | ( 56) | (169) |
| Jul. | I | (0.31) | (0.27) | (0.49) | (1.07) | ( 29) | ( 29) | ( 27) | ( 85) |
| | II | 2.31 | 1.91 | 3.59 | 7.81 | 318 | 342 | 306 | 966 |
| Aug. | I | 3.39 | 2.79 | 5.22 | 11.40 | 438 | 459 | 417 | 1,314 |
| | II | 0.86 | 0.70 | 1.29 | 2.85 | 118 | 112 | 110 | 340 |
| Sep. | I | (1.07) | (0.93) | (1.71) | (3.71) | ( 96) | ( 98) | ( 95) | (289) |
| | II | (2.01) | (1.74) | (3.23) | (6.98) | (180) | (182) | (180) | (542) |
| Oct. | I | 0.97 | 0.78 | 1.45 | 3.20 | 125 | 117 | 116 | 358 |
| | II | 1.00 | 0.81 | 1.50 | 3.31 | 138 | 130 | 128 | 396 |
| Nov. | I | 1.59 | 1.36 | 2.61 | 5.56 | 206 | 266 | 209 | 681 |
| | II | 0.94 | 0.86 | 1.68 | 3.48 | 130 | 216 | 134 | 480 |
| Dec. | I | 0.21 | 0.27 | 0.59 | 1.07 | 27 | 41 | 47 | 115 |
| | II | 0.09 | 0.17 | 0.40 | 0.66 | 13 | 27 | 34 | 74 |
| | | | | | Total | 5,180<br>(508)<br>5,688 | 5,302<br>(513)<br>5,815 | 5,041<br>(505)<br>5,546 | 15,523<br>(1,526)<br>17,049 |

Table A. 4-23 Drainage Discharge for Project Area

Return Period: 2-years

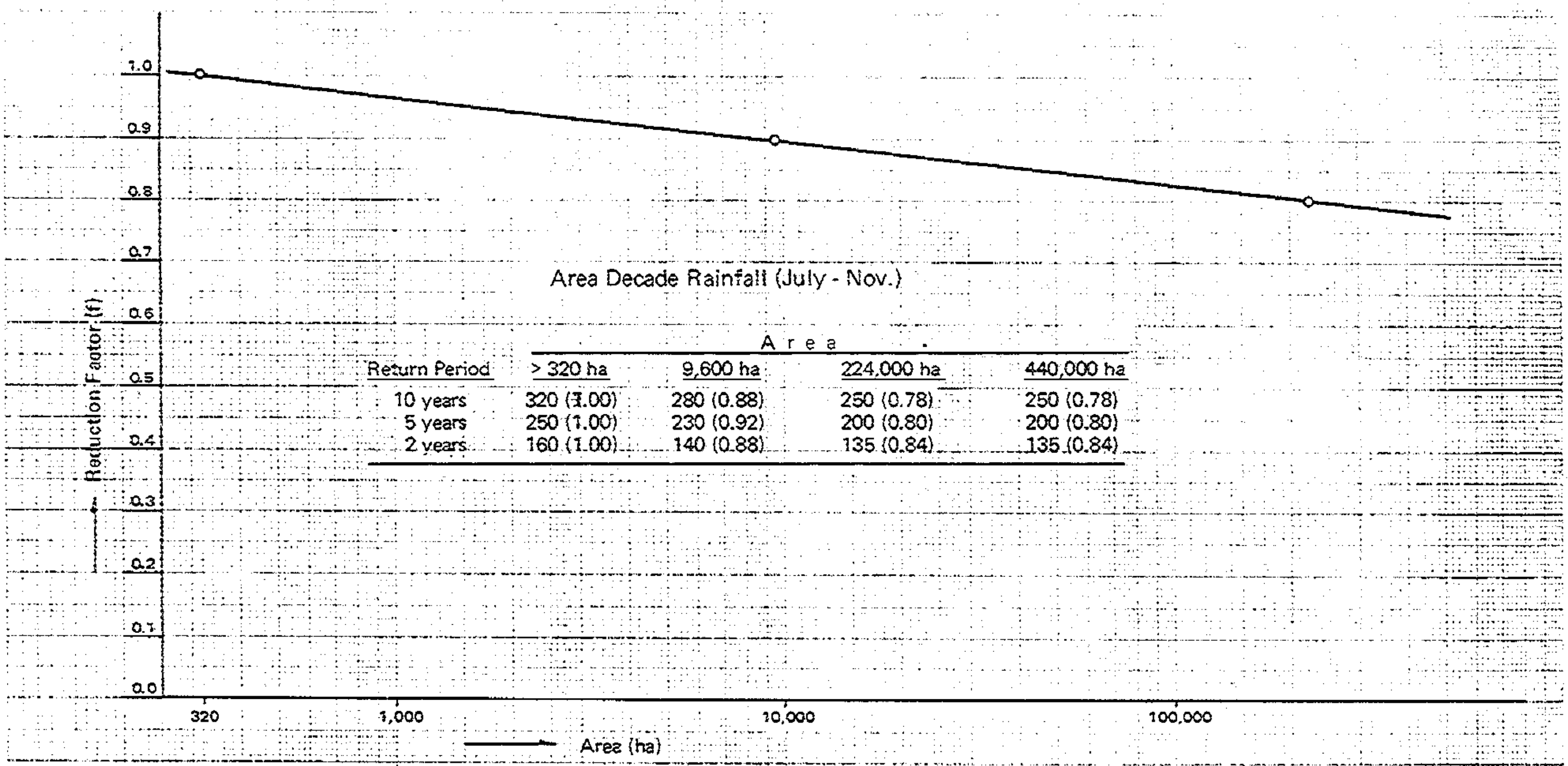
| Month | Rainfall (mm) (1) | Cultivated Area: Field Water Requirements: Paddy Fields (mm) (2) | Upland Fields (mm) (3) | Average (mm) (4) | Drain Water: mm (5) | ℓ/sec/ha (6) | Drainage Discharge: Block A (cu.m/s) (7) | Block B (cu.m/s) (8) | Block C (cu.m/s) (9) | Sub-Total (cu.m/s) (10) | Others: Drain Water: mm (11) | ℓ/sec/ha (12) | Drainage Discharge: Block A (cu.m/s) (13) | Block B (cu.m/s) (14) | Block C (cu.m/s) (15) | Sub-Total (cu.m/s) (16) | Total Drainage Discharge (cu.m/s) (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May I | 113.1 | 69.0 | 60.0 | 68.1 | 45.0 | 0.347 | 1.05 | 0.90 | 1.71 | 3.66 | 73.5 | 0.567 | 0.24 | 0.22 | 0.36 | 0.82 | 4.48 |
| II | 69.9 | 36.8 | 64.4 | 39.4 | 30.5 | 0.221 | 0.67 | 0.57 | 1.09 | 2.33 | 45.4 | 0.328 | 0.14 | 0.13 | 0.21 | 0.48 | 2.81 |
| Jun. I | 87.2 | 3.0 | 55.5 | 8.0 | 79.2 | 0.611 | 1.85 | 1.58 | 3.01 | 6.44 | 56.7 | 0.437 | 0.18 | 9.17 | 0.28 | 0.63 | 7.07 |
| II | 56.8 | - | 55.5 | 5.3 | 51.5 | 0.397 | 1.21 | 1.03 | 1.96 | 4.20 | 36.9 | 0.285 | 0.12 | 0.11 | 0.18 | 0.41 | 4.61 |
| Jul. I | 70.9 | 27.0 | 51.0 | 29.3 | 41.6 | 0.321 | 0.97 | 0.83 | 1.58 | 3.38 | 46.1 | 0.356 | 0.15 | 0.14 | 0.23 | 0.52 | 3.90 |
| II | 35.1 | 102.4 | 54.4 | 97.8 | - | - | - | - | - | - | 22.8 | 0.165 | 0.07 | 0.06 | 0.11 | 0.24 | 0.24 |
| Aug. I | 69.5 | 123.0 | 48.0 | 115.9 | - | - | - | - | - | - | 45.2 | 0.349 | 0.15 | 0.14 | 0.22 | 0.51 | 0.51 |
| II | 137.2 | 104.8 | 51.2 | 99.7 | 37.5 | 0.271 | 0.82 | 0.70 | 1.34 | 2.86 | 89.2 | 0.645 | 0.27 | 0.25 | 0.41 | 0.93 | 3.79 |
| Sep. I | 106.1 | 81.0 | 45.0 | 77.6 | 28.5 | 0.220 | 0.67 | 0.57 | 1.09 | 2.33 | 69.0 | 0.532 | 0.22 | 0.21 | 0.34 | 0.77 | 3.10 |
| II | 192.6 | 84.8 | 45.0 | 81.0 | 111.6 | 0.861 | 2.61 | 2.22 | 4.25 | 9.08 | 125.2 | 0.966 | 0.41 | 0.37 | 0.62 | 1.40 | 10.48 |
| Oct. I | 70.9 | 82.5 | 46.5 | 79.1 | - | - | - | - | - | - | 46.1 | 0.356 | 0.15 | 0.14 | 0.23 | 0.52 | 0.52 |
| II | 85.6 | 86.4 | 49.6 | 82.9 | 2.7 | 0.020 | 0.06 | 0.05 | 0.10 | 0.21 | 55.6 | 0.402 | 0.17 | 0.16 | 0.26 | 0.59 | 0.80 |

Return Period: 10-years (Minimum)

| Month | Rainfall (mm) (1) | Cultivated Area: Field Water Requirements: Paddy Fields (mm) (2) | Upland Fields (mm) (3) | Average (mm) (4) | Drain Water: mm (5) | ℓ/sec/ha (6) | Drainage Discharge: Block A (cu.m/s) (7) | Block B (cu.m/s) (8) | Block C (cu.m/s) (9) | Sub-Total (cu.m/s) (10) | Others: Drain Water: mm (11) | ℓ/sec/ha (12) | Drainage Discharge: Block A (cu.m/s) (13) | Block B (cu.m/s) (14) | Block C (cu.m/s) (15) | Sub-Total (cu.m/s) (16) | Total Drainage Discharge (cu.m/s) (17) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May I | 3.6 | 69.0 | 60.0 | 68.1 | - | - | - | - | - | - | 2.3 | 0.018 | 0.01 | 0.01 | 0.01 | 0.03 | 0.03 |
| II | 39.1 | 36.8 | 64.4 | 39.4 | - | - | - | - | - | - | 25.4 | 0.184 | 0.08 | 0.07 | 0.12 | 0.27 | 0.27 |
| Jun. I | 71.4 | 3.0 | 55.5 | 8.0 | 63.4 | 0.489 | 1.48 | 1.26 | 2.41 | 5.15 | 46.4 | 0.358 | 0.15 | 0.14 | 0.23 | 0.52 | 5.67 |
| II | 29.1 | - | 55.5 | 5.3 | 23.8 | 0.184 | 0.56 | 0.48 | 0.91 | 1.95 | 18.9 | 0.146 | 0.06 | 0.06 | 0.09 | 0.21 | 2.16 |
| Jul. I | 39.0 | 27.0 | 51.0 | 29.3 | 9.7 | 0.075 | 0.23 | 0.19 | 0.37 | 0.79 | 25.4 | 0.196 | 0.08 | 0.08 | 0.12 | 0.28 | 1.07 |
| II | 40.1 | 102.4 | 54.4 | 97.8 | - | - | - | - | - | - | 26.1 | 0.189 | 0.08 | 0.07 | 0.12 | 0.27 | 0.27 |
| Aug. I | 31.1 | 123.0 | 48.0 | 115.9 | - | - | - | - | - | - | 20.2 | 0.156 | 0.07 | 0.06 | 0.10 | 0.23 | 0.23 |
| II | 103.2 | 104.8 | 51.2 | 99.7 | 3.5 | 0.025 | 0.08 | 0.06 | 0.12 | 0.26 | 67.1 | 0.485 | 0.21 | 0.19 | 0.31 | 0.71 | 0.97 |
| Sep. I | 113.1 | 81.0 | 45.0 | 77.6 | 35.5 | 0.274 | 0.83 | 0.71 | 1.35 | 2.89 | 73.5 | 0.567 | 0.24 | 0.22 | 0.36 | 0.82 | 3.71 |
| II | 152.9 | 84.8 | 45.0 | 81.0 | 71.9 | 0.555 | 1.68 | 1.44 | 2.74 | 5.86 | 99.4 | 0.767 | 0.33 | 0.30 | 0.49 | 1.12 | 6.98 |
| Oct. I | 76.9 | 82.5 | 46.5 | 79.1 | - | - | - | - | - | - | 50.0 | 0.386 | 0.16 | 0.15 | 0.25 | 0.56 | 0.56 |
| II | 83.0 | 86.4 | 49.6 | 83.0 | - | | - | - | - | - | 54.0 | 0.391 | 0.16 | 0.15 | 0.25 | 0.56 | 0.56 |

Note:
(1) Average half month rainfall at three stations, Sing Ha Nat, Phraya Banlu and Lakkhon, in each probable year
(2) See Table A. 4-17
(3) See Table A. 4-18
(4) (2)x0.905+(3)x0.095
(5) (1)-(4)
(6) (5)/8.64 x n
(7) 3,027 ha x (6)
(8) 2,583 ha x (6)
(9) 4,932 ha x (6)
(10) (7) + (8) + (9)
(11) (1) x run-off coefficient 0.65 (assumed)
(12) (11)/8.64 x n
(13) 422 ha x (12)
(14) 387 ha x (12)
(15) 637 ha x (12)
(16) (13) + (14) + (15)
(17) (10) + (16)

**FIGURE A.4-6 AREA – REDUCTION FACTOR FOR DRAINAGE MODULUS**




Area Decade Rainfall (July - Nov.)

| Return Period | > 320 ha | 9,600 ha | 224,000 ha | 440,000 ha |
|---|---|---|---|---|
| 10 years | 320 (1.00) | 280 (0.88) | 250 (0.78) | 250 (0.78) |
| 5 years | 250 (1.00) | 230 (0.92) | 200 (0.80) | 200 (0.80) |
| 2 years | 160 (1.00) | 140 (0.88) | 135 (0.84) | 135 (0.84) |

Source: Northern Chao Phya study report prepared by NEDECO, 1970

## Runoff Analysis by Mononobe's Graphic Method

Basic equation is shown as follows;

$$\frac{(I_1 + I_2)}{2} \Delta t - \frac{(Q_1 + Q_2)}{2} \Delta t = V_2 - V_1 \;\; \ldots\ldots\ldots (1)$$

Where; $I_1$: Inflow at time $t_1$
$I_2$: Inflow at time $t_2$
$Q_1$: Outflow at time $t_1$
$Q_2$: Outflow at time $t_2$
$t$ : too showrt time considered to be linear in changing of inflow and outflow
$V_1$: Field surface storage at time $t_1$
$V_2$: Field surface storage at time $t_2$

The above equation shall be transformed into:

$$\phi = V + Q \frac{\Delta t}{2}, \qquad \psi = V - Q \frac{\Delta t}{2}$$

and presented in a form of a general equation as below:

$$\phi_{n+1} = \psi_n + (I_n + I_{n+1}) \frac{\Delta t}{2} \;\; \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The equation (2) is expressed in the following diagram which indicates the procedure of estimation of run-off discharges through notches of the paddy fields.

### ILLUSTRATION OF PROCEDURE FOR RUN--OFF DISCHARGE

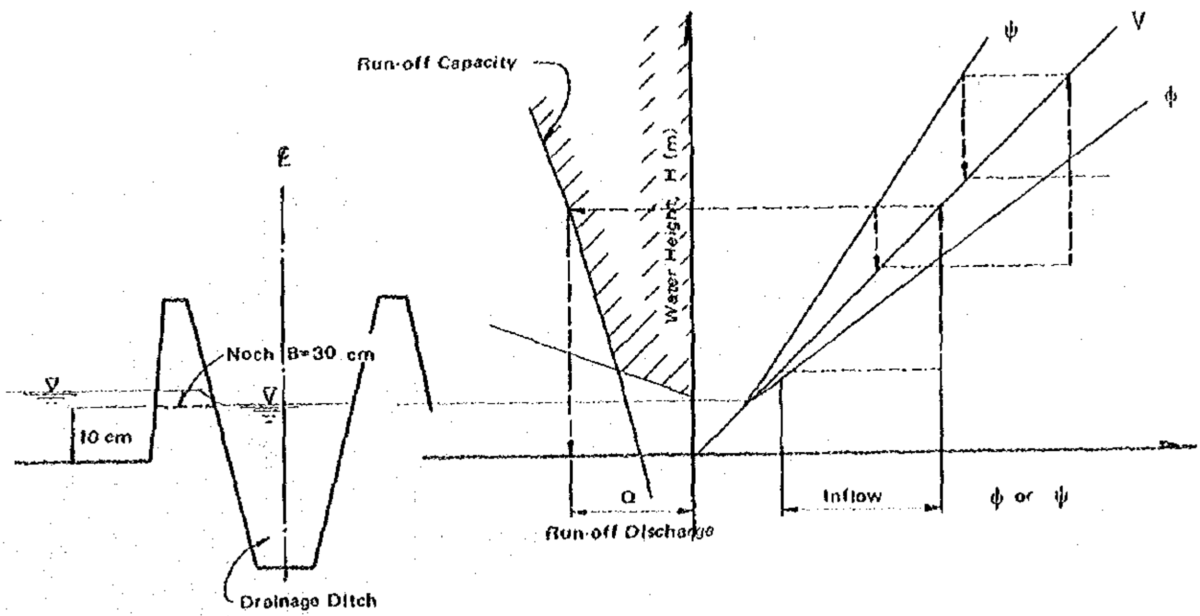


Table A. 4-24 Drainage Conditions at Each Pumping Rate (Block A)

| Pumping Rate | Maximum 1/ Water Level | Maximum 2/ Water Depth | Inundation 3/ Period | Inundation 4/ Area | Max. Water Depth 5/ of Each Field |
|---|---|---|---|---|---|
| mm/hr | m | m | hr | ha | m |
| Case 1 : B = 0.20 m (Width of notch) | | | days | | |
| q = 1.20 | 2.24 | 0.34 | 105 (4.4) | 2,132 | 0.190 |
| 1.25 | 2.24 | 0.34 | 100 (4.2) | 2,052 | 0.190 |
| 1.30 | 2.23 | 0.33 | 95 (4.0) | 1,972 | 0.180 |
| 1.35 | 2.23 | 0.33 | 90 (3.8) | 1,893 | 0.180 |
| 1.40 | 2.22 | 0.32 | 85 (3.5) | 1,815 | 0.170 |
| 1.45 | 2.22 | 0.32 | 81 (3.4) | 1,738 | 0.170 |
| 1.50 | 2.21 | 0.21 | 76 (3.2) | 1,662 | 0.160 |
| Case 2 : B = 0.30 m (Width of notch) | | | days | | |
| q = 1.20 | 2.26 | 0.36 | 114 (4.8) | 2,465 | 0.210 |
| 1.25 | 2.25 | 0.35 | 109 (4.5) | 2,387 | 0.200 |
| 1.30 | 2.25 | 0.35 | 104 (4.3) | 2,310 | 0.200 |
| 1.35 | 2.25 | 0.35 | 100 (4.2) | 2,233 | 0.200 |
| 1.40 | 2.24 | 0.34 | 96 (4.0) | 2,157 | 0.190 |
| 1.45 | 2.24 | 0.34 | 92 (3.8) | 2,081 | 0.190 |
| 1.50 | 2.23 | 0.33 | 89 (3.7) | 2,007 | 0.180 |

Note:
1/ : Lowest elevation of paddy field: EL. 1.70 m
2/ : Water depth above basic elevation of paddy field EL. 1.90 m
3/ : Inundation periods above allowable water level EL. 2.15 m
4/ : Inundation area at maximum water level.
5/ : Maximum water depth of each paddy fields controled by noch and drainage ditch.

Table A. 4-25 Drainage Conditions at Each Pumping Rate (Block B)

| Pumping Rate | Maximum 1/ Water Level | Maximum 2/ Water Depth | Inundation 3/ Period | Inundation 4/ Area | Max. Water Depth 5/ of Each Field |
|---|---|---|---|---|---|
| mm/hr | m | m | hr | ha | m |
| Case 1 : B = 0.20 m (Width of notch) | | | days | | |
| q = 1.20 | 2.00 | 0.30 | 64 (2.6) | 1,594 | 0.215 |
| 1.25 | 1.99 | 0.29 | 59 (2.5) | 1,557 | 0.215 |
| 1.30 | 1.99 | 0.29 | 53 (2.2) | 1,520 | 0.215 |
| 1.35 | 1.98 | 0.28 | 47 (2.0) | 1,484 | 0.215 |
| 1.40 | 1.97 | 0.27 | 41 (1.7) | 1,448 | 0.215 |
| 1.45 | 1.97 | 0.27 | 34 (1.4) | 1,413 | 0.215 |
| 1.50 | 1.96 | 0.26 | 14 (0.6) | 1,378 | 0.215 |
| Case 2 : B = 0.30 m (Width of notch) | | | days | | |
| q = 1.20 | 2.02 | 0.32 | 81 (3.4) | 1,710 | 0.211 |
| 1.25 | 2.01 | 0.31 | 76 (3.2) | 1,683 | 0.211 |
| 1.30 | 2.01 | 0.31 | 68 (2.8) | 1,657 | 0.211 |
| 1.35 | 2.01 | 0.31 | 63 (2.6) | 1,630 | 0.211 |
| 1.40 | 2.00 | 0.30 | 59 (2.5) | 1,604 | 0.211 |
| 1.45 | 1.99 | 0.29 | 55 (2.3) | 1,571 | 0.211 |
| 1.50 | 1.99 | 0.29 | 51 (2.1) | 1,537 | 0.211 |

Note: 1/ : Lowest elevation of paddy field : EL. 1.65 m
2/ : Water depth above basic elevation of paddy field EL. 1.70 m
3/ : Inundation periods above allowable water level EL. 1.95 m
4/ : Inundation area at maximum water level
5/ : Maximum water depth of each paddy fields controled by noch and drainage ditch

Table A. 4-26 Drainage Conditions at Ecah Pumping Rate (Block C)

| Pumping Rate mm/hr | Maximum Water Level 1/ m | Maximum Water Depth 2/ m | Inundation Period 3/ hr (days) | Inundation Area 4/ ha | Max. Water Depth of Each Field 5/ m |
|---|---|---|---|---|---|
| Case 1 : B = 0.20 m (Width of notch) | | | | | |
| q = 1.20 | 1.83 | 0.33 | 91 (3.8) | 2,915 | 0.213 |
| 1.25 | 1.83 | 0.33 | 85 (3.5) | 2,844 | 0.213 |
| 1.30 | 1.82 | 0.32 | 80 (3.3) | 2,774 | 0.213 |
| 1.35 | 1.82 | 0.32 | 73 (3.0) | 2,704 | 0.213 |
| 1.40 | 1.81 | 0.31 | 66 (2.8) | 2,636 | 0.213 |
| 1.45 | 1.81 | 0.31 | 61 (2.5) | 2,568 | 0.213 |
| 1.50 | 1.80 | 0.30 | 57 (2.4) | 2,501 | 0.213 |
| Case 2 : B = 0.30 m (Width of notch) | | | | | |
| q = 1.20 | 1.86 | 0.36 | 104 (4.3) | 3,208 | 0.209 |
| 1.25 | 1.85 | 0.35 | 99 (4.1) | 3,139 | 0.209 |
| 1.30 | 1.85 | 0.35 | 95 (4.0) | 3,071 | 0.209 |
| 1.35 | 1.84 | 0.34 | 91 (3.8) | 3,003 | 0.209 |
| 1.40 | 1.84 | 0.34 | 86 (3.6) | 2,936 | 0.209 |
| 1.45 | 1.83 | 0.33 | 82 (3.4) | 2,870 | 0.209 |
| 1.50 | 1.83 | 0.33 | 79 (3.3) | 2,799 | 0.209 |

Note:
1/ : Lowest elevation of paddy field : EL. 1.40 m
2/ : Water depth above basic elevation of paddy field EL. 1.50 m
3/ : Inundation periods above allowable water level EL. 1.75 m
4/ : Inundation area at maximum water level.
5/ : Maximum water depth of each paddy fields controled by noch and drainage ditch

FIGURE A.4-7 STAGE - AREA AND STORAGE CURVE (BLOCK A)

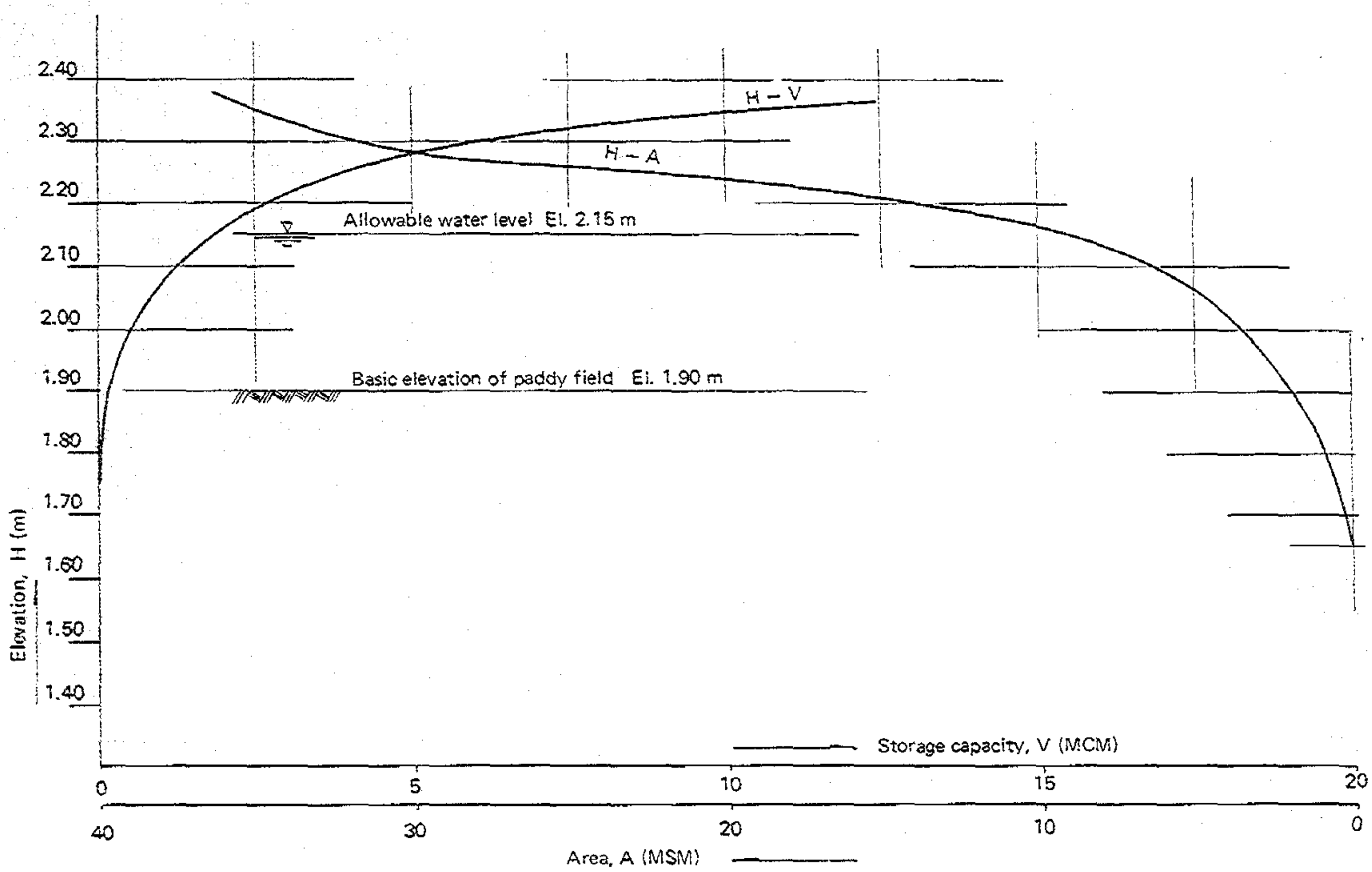


FIGURE A. 4–8 STAGE – AREA AND STORAGE CURVE (BLOCK B)

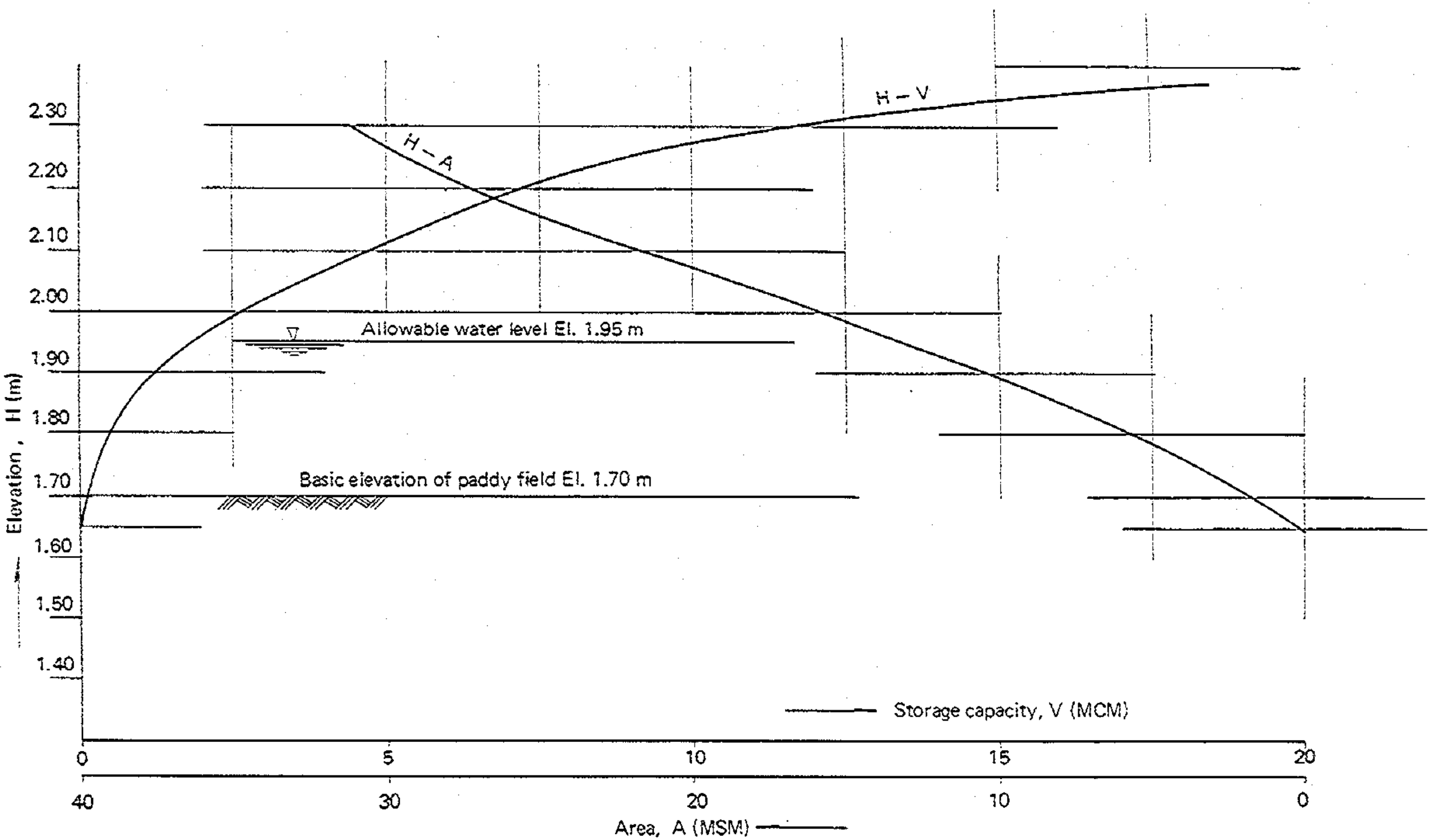


FIGURE A. 4-9 STAGE – AREA AND STORAGE CURVE (BLOCK C)

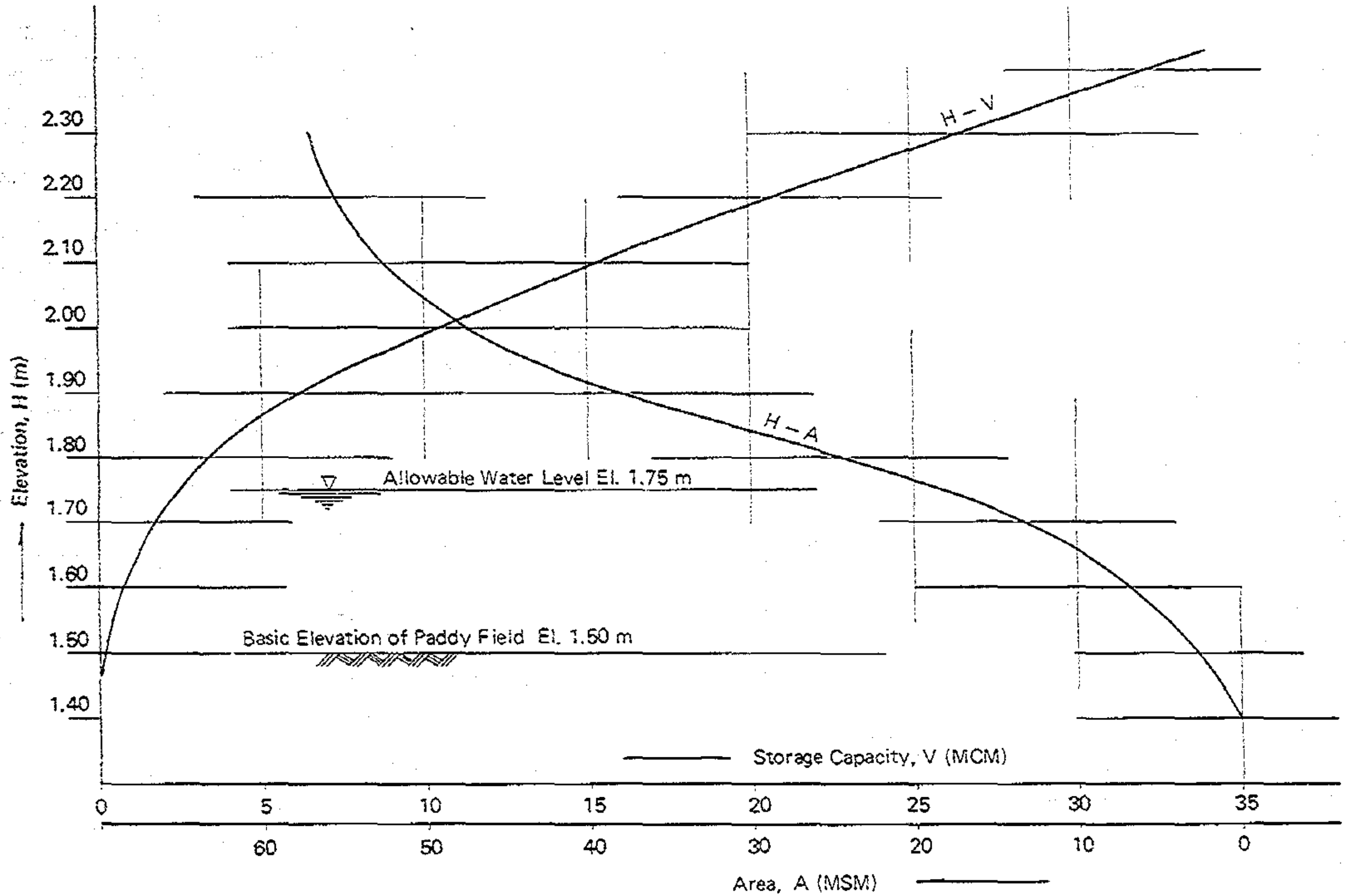


FIGURE A.4-10 DRAINAGE CONDITIONS IN BLOCK "A"

Drainage Area : 3,449 ha
Pump Capacity: 11.98 cu.m/s (1.25 mm/hr)

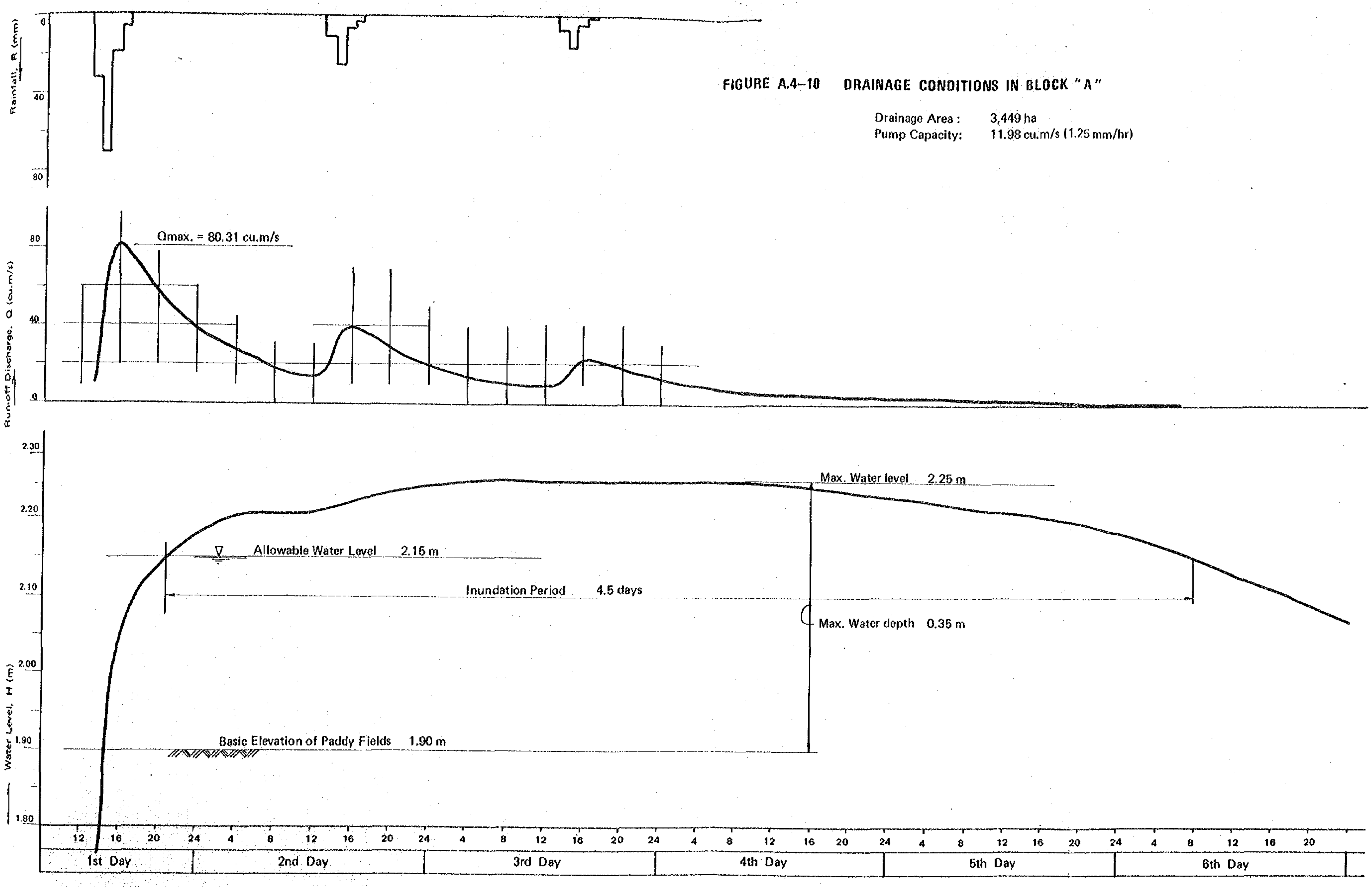


FIGURE A.4-11 DRAINAGE CONDITIONS IN BLOCK "B"

Drainage Area : 2,970 ha
Pump Capacity: 10.31 cu.m/s (1.25 mm/hr)

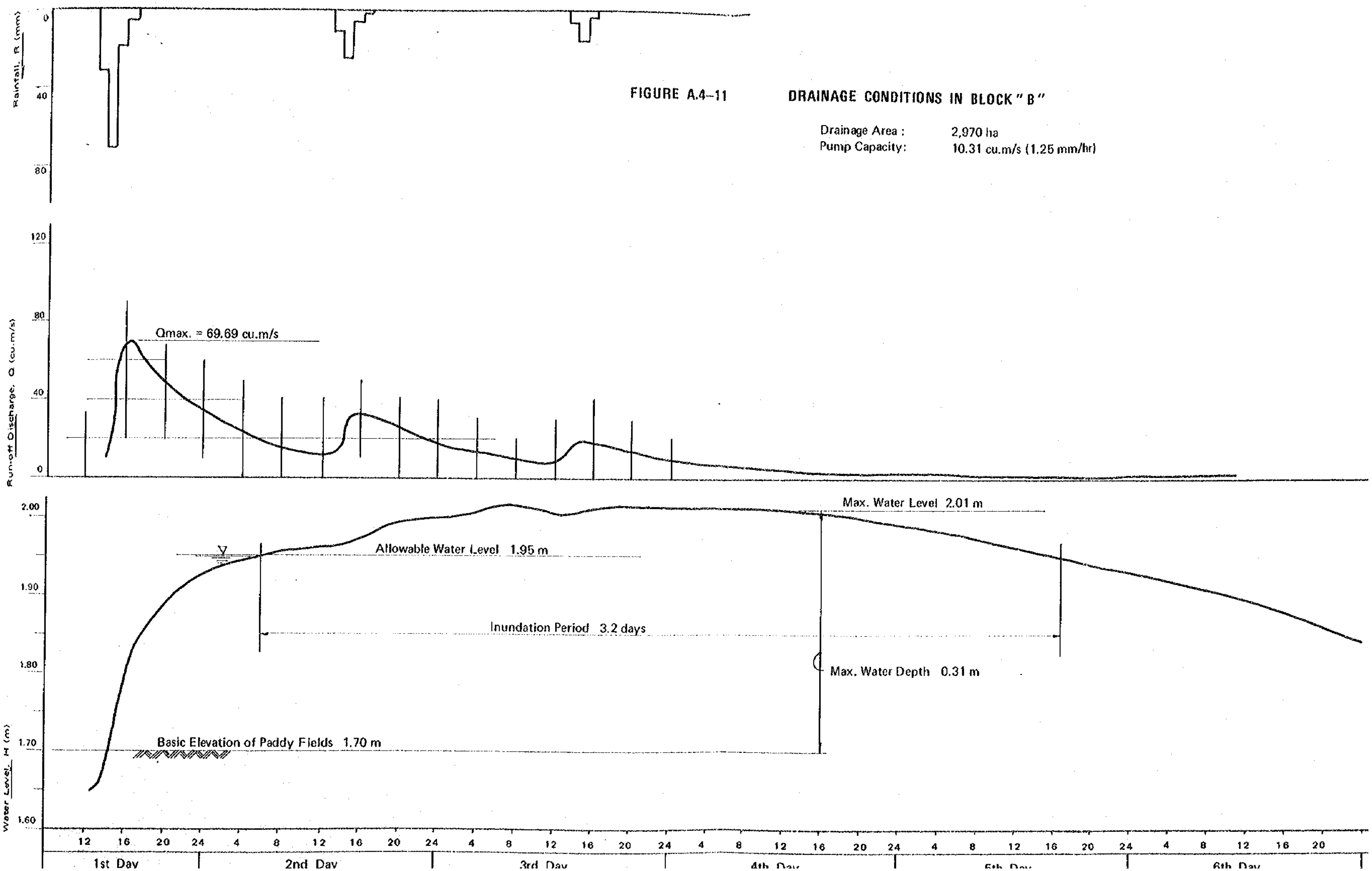


FIGURE A.4-12 DRAINAGE CONDITIONS IN BLOCK "C"

Drainage Area : 5,569 ha
Pump Capacity : 19.33 cu.m/s (1.25 mm/hr)

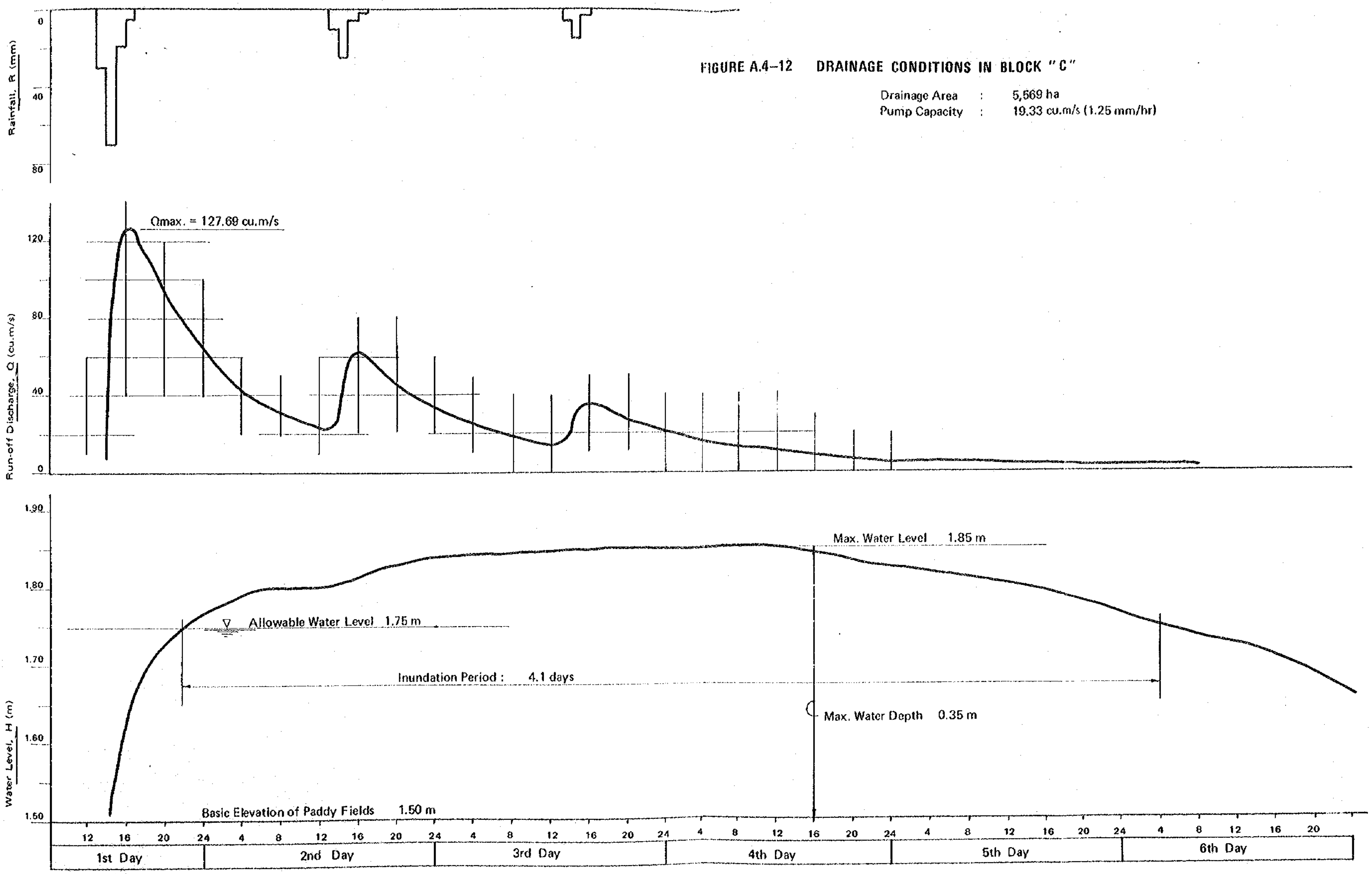
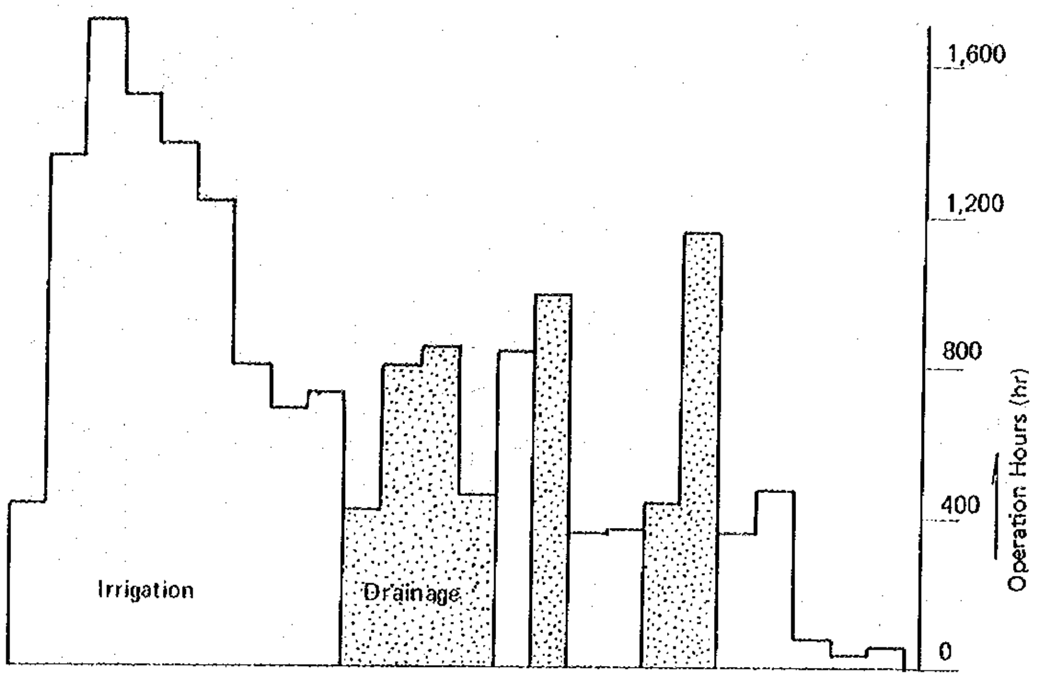


FIGURE A.4-13 AVERAGE PUMPING DISCHARGE AND OPERATION HOURS

Return Period:
10 - years (maximum)

Total operation hour: 17,620 hr
Irrigation : 12,391
Drainage : 5,229



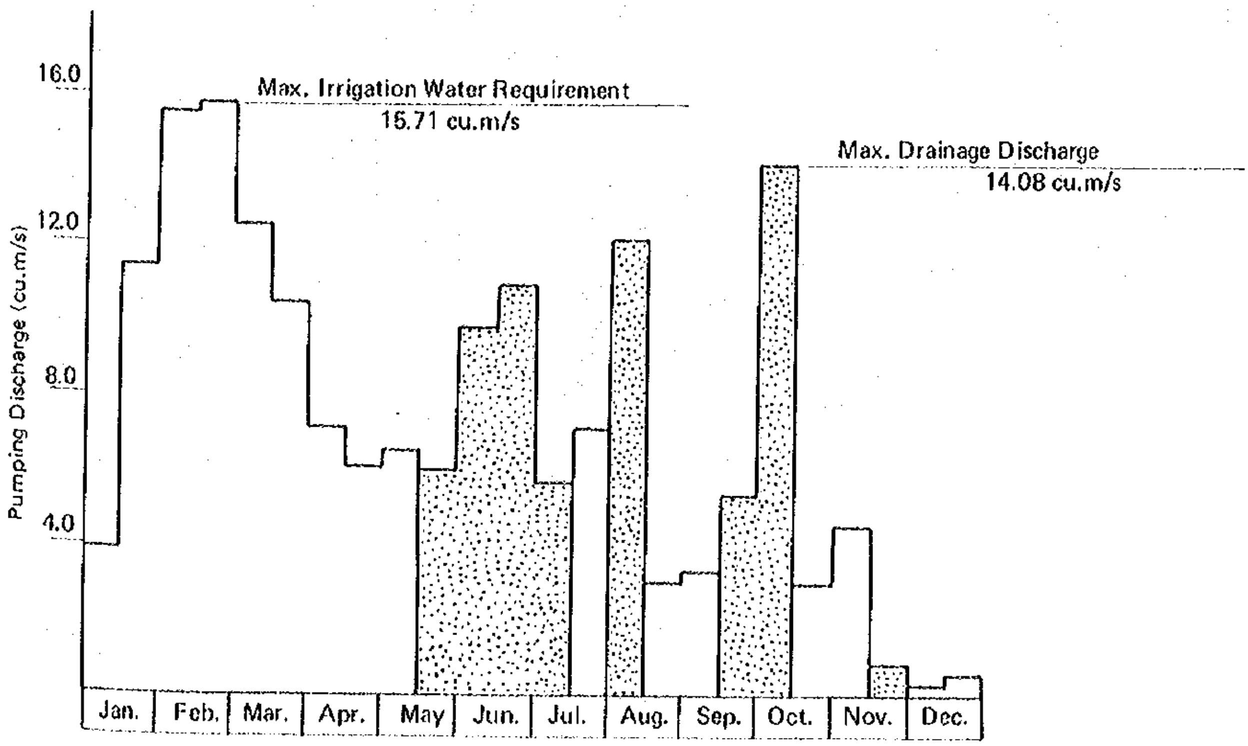



Table A. 4-27 Average Operation Hours of the Proposed Pump

Return Period: 10 years (Maximum)

| Month | Pumping Discharge (cu.m/s) | | | | Operation Hours of Pumps | | | |
|---|---|---|---|---|---|---|---|---|
| | Block A | Block B | Block C | Total | Block A | Block B | Block C | Total |
| Jan. I | 1.09a/ | 0.98 | 1.90 | 3.97 | 141c/ | 147 | 151 | 439 |
| II | 3.35 | 2.81 | 5.28 | 11.44 | 461 | 448 | 450 | 1,359 |
| Feb. I | 4.56 | 3.79 | 7.14 | 15.49 | 588 | 566 | 570 | 1,724 |
| II | 4.62 | 3.85 | 7.24 | 15.71 | 517 | 498 | 501 | 1,516 |
| Mar. I | 3.64 | 3.06 | 5.81 | 12.51 | 470 | 457 | 464 | 1,391 |
| II | 3.05 | 2.56 | 4.85 | 10.46 | 420 | 408 | 413 | 1,241 |
| Apr. I | 2.12 | 1.75 | 3.30 | 7.17 | 274 | 261 | 263 | 798 |
| II | 1.82 | 1.51 | 2.82 | 6.15 | 235 | 226 | 225 | 686 |
| May I | 1.88 | 1.61 | 3.09 | 6.58 | 242 | 240 | 247 | 729 |
| II | (1.44)b/ | (1.24) | (2.32) | (5.00) | (139) | (138) | (138) | (415) |
| Jan. I | (2.82) | (2.42) | (4.56) | (9.80) | (254) | (295) | (255) | (804) |
| II | (3.15) | (2.71) | (5.10) | (10.96) | (284) | (284) | (285) | (853) |
| Jul. I | (1.63) | (1.41) | (2.64) | (5.68) | (147) | (170) | (148) | (465) |
| II | 2.11 | 1.73 | 3.26 | 7.10 | 290 | 275 | 278 | 843 |
| Aug. I | (3.47) | (3.00) | (5.61) | (12.08) | (313) | (363) | (314) | (990) |
| II | 0.92 | 0.74 | 1.37 | 3.03 | 127 | 119 | 116 | 362 |
| Sep. I | 1.02 | 0.82 | 1.53 | 3.37 | 131 | 122 | 122 | 375 |
| II | (1.56) | (1.34) | (2.49) | (5.39) | (141) | (163) | (139) | (443) |
| Oct. I | (4.05) | (3.49) | (6.54) | (14.08) | (390) | (424) | (366) | (1,180) |
| II | 0.91 | 0.73 | 1.36 | 3.00 | 125 | 116 | 116 | 357 |
| Nov. I | 1.23 | 1.04 | 2.01 | 4.28 | 158 | 155 | 160 | 473 |
| II | (0.28) | (0.24) | (0.45) | (0.97) | ( 25) | ( 29) | ( 25) | ( 79) |
| Dec. I | 0.05 | 0.09 | 0.22 | 0.36 | 6 | 13 | 18 | 37 |
| II | 0.09 | 0.17 | 0.40 | 0.66 | 13 | 14 | 34 | 61 |
| | | | | Total | 4,198 | 4,065 | 4,128 | 12,391 |
| | | | | | (1,693) | (1,866) | (1,670) | (5,229) |
| | | | | | 5,891 | 5,931 | 5,798 | 17,620 |

Note: a/ : derived from Table A. 4-28 and A. 4-29

b/ : derived from Table A. 4-31

c/ : 1.09 cu.m/s x 86,400 x 15/2.79 cu.m/s (pump capacity) x 3,600

pump capacity:
Block A : 2.79 cu.m/s (3.99) x 8 units (ø1,350)
Block B : 2.41 cu.m/s (3.44) x 3 units (ø1,350)
Block C : 4.51 cu.m/s (6.44) x 3 units (ø1,650)

( ) shows the drainage discharge and operation hours of pumps for drainage

Table A. 4-28 Irrigation Water Requirements for Paddy Fields
(Return Period: 10-years)

| Month | | Field Water Requirement (mm/day) (1) | Field Water Requirement (mm/half mon) (2) | Effective Rainfall (mm/half mon) (3) | Net Water Requirements (mm/half mon) (4) | Gross Water Requirements: Farm Gate Water Requirements (mm/half mon) (5) | Gross Water Requirements: Diversion Water Requirements (mm/half mon) (6) | Gross Water Requirements: Diversion Water Requirements (ℓ/sec/ha) (7) | Irrigation Water Requirements: Block A (cu.m/s) (8) | Irrigation Water Requirements: Block B (cu.m/s) (9) | Irrigation Water Requirements: Block C (cu.m/s) (10) | Irrigation Water Requirements: Total (cu.m/s) (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | I | 2.0 | 30.0 | - | 30.0 | 37.5 | 45.0 | 0.347 | 1.00 | 0.81 | 1.50 | 3.31 |
| | II | 6.5 | 104.0 | - | 104.0 | 130.0 | 156.2 | 1.130 | 3.26 | 2.64 | 4.88 | 10.78 |
| Feb. | I | 9.0 | 135.0 | 1.8 | 133.2 | 166.5 | 200.0 | 1.543 | 4.45 | 3.60 | 6.67 | 14.72 |
| | II | 9.0 | 117.0 | - | 117.0 | 146.3 | 175.7 | 1.564 | 4.51 | 3.65 | 6.76 | 14.92 |
| Mar. | I | 7.0 | 105.0 | - | 105.0 | 131.3 | 157.7 | 1.217 | 3.51 | 2.84 | 5.26 | 11.61 |
| | II | 6.8 | 108.8 | 15.1 | 93.7 | 117.1 | 140.7 | 1.018 | 2.94 | 2.38 | 4.40 | 9.72 |
| Apr. | I | 7.6 | 114.0 | 51.8 | 62.2 | 77.8 | 93.5 | 0.721 | 2.08 | 1.68 | 3.12 | 6.88 |
| | II | 7.4 | 111.0 | 57.5 | 53.5 | 66.9 | 80.4 | 0.620 | 1.79 | 1.45 | 2.68 | 5.92 |
| May | I | 4.6 | 69.0 | 15.3 | 53.7 | 67.1 | 80.6 | 0.622 | 1.79 | 1.45 | 2.69 | 5.93 |
| | II | 2.3 | 36.8 | 72.2 | - | - | - | - | - | - | - | - |
| Jun. | I | 0.2 | 3.0 | 98.4 | - | - | - | - | - | - | - | - |
| | II | - | - | 96.5 | - | - | - | - | - | - | - | - |
| Jul. | I | 1.8 | 27.0 | 68.3 | - | - | - | - | - | - | - | - |
| | II | 6.4 | 102.4 | 36.5 | 65.9 | 82.4 | 99.0 | 0.716 | 2.07 | 1.67 | 3.10 | 6.84 |
| Aug. | I | 8.2 | 123.0 | 182.1 | - | - | - | - | - | - | - | - |
| | II | 7.8 | 104.8 | 75.5 | 29.3 | 36.6 | 44.0 | 0.318 | 0.92 | 0.74 | 1.37 | 3.03 |
| Sep. | I | 5.4 | 81.0 | 50.5 | 30.5 | 38.1 | 45.8 | 0.353 | 1.02 | 0.82 | 1.53 | 3.37 |
| | II | 5.3 | 84.8 | 87.9 | - | - | - | - | - | - | - | - |
| Oct. | I | 5.5 | 82.5 | 150.5 | - | - | - | - | - | - | - | - |
| | II | 5.4 | 86.4 | 57.5 | 28.9 | 36.1 | 43.4 | 0.314 | 0.91 | 0.73 | 1.36 | 3.00 |
| Nov. | I | 3.7 | 55.5 | 20.7 | 34.8 | 43.5 | 52.3 | 0.404 | 1.17 | 0.94 | 1.75 | 3.86 |
| | II | 1.8 | 27.0 | 30.0 | - | - | - | - | - | - | - | - |
| Dec. | I | 0.2 | 3.0 | 25.9 | - | - | - | - | - | - | - | - |
| | II | - | - | 0.5 | - | - | - | - | - | - | - | - |

Note:
(1): Average field water requirement, in millimeter per day (see Table A. 4-13)
(2): Average field water requirement, in millimeter per half month
(3): Effective rainfall in millimeter per half month (Table A. 4-30)
(4): (2) - (3)
(5): (4)/(1 - 0.2)
(6): (5)/(1 - 0.075)(1 - 0.10)
(7): (6)/8.64 x n
(8): Block A; irrigable area 2,885 ha x (7)
(9): Block B; irrigable area 2,334 ha x (7)
(10): Block C; irrigable area 4,323 ha x (7)
(11): (8) + (9) + (10)

Table A. 4-29 Irrigation Water Requirements for Upland Crops
(Return Period: 10-years)

| Month | | Field Water Requirement (mm/day) (1) | Field Water Requirement (mm/half mon) (2) | Effective Rainfall (mm/half mon) (3) | Net Water Requirements (mm/half mon) (4) | Gross Water Requirements: Farm Gate Water Requirements (mm/half mon) (5) | Gross Water Requirements: Diversion Water Requirements (mm/half mon) (6) | Gross Water Requirements: Diversion Water Requirements (ℓ/sec/ha) (7) | Irrigation Water Requirements: Block A (cu.m/s) (8) | Block B (cu.m/s) (9) | Block C (cu.m/s) (10) | Total (cu.m/s) (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | I | 3.1 | 46.5 | - | 46.5 | 71.5 | 85.9 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |
| | II | 3.1 | 49.6 | - | 49.6 | 76.3 | 91.7 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |
| Feb. | I | 3.7 | 55.6 | 1.5 | 54.1 | 83.2 | 99.9 | 0.771 | 0.11 | 0.19 | 0.47 | 0.77 |
| | II | 3.7 | 48.1 | - | 48.1 | 74.0 | 88.9 | 0.791 | 0.11 | 0.20 | 0.48 | 0.79 |
| Mar. | I | 4.2 | 63.0 | - | 63.0 | 96.9 | 116.4 | 0.898 | 0.13 | 0.22 | 0.55 | 0.90 |
| | II | 4.2 | 67.2 | 11.7 | 55.5 | 85.4 | 102.6 | 0.742 | 0.11 | 0.18 | 0.45 | 0.74 |
| Apr. | I | 4.6 | 69.0 | 48.5 | 20.5 | 31.5 | 37.8 | 0.292 | 0.04 | 0.07 | 0.18 | 0.29 |
| | II | 4.6 | 69.0 | 53.0 | 16.0 | 24.6 | 29.5 | 0.227 | 0.03 | 0.06 | 0.14 | 0.23 |
| May | I | 4.0 | 60.0 | 14.5 | 45.5 | 70.0 | 84.1 | 0.649 | 0.09 | 0.16 | 0.40 | 0.65 |
| | II | 4.0 | 64.4 | 65.0 | - | - | - | - | - | - | - | - |
| Jun. | I | 3.7 | 55.5 | 77.5 | - | - | - | - | - | - | - | - |
| | II | 3.7 | 55.5 | 83.0 | - | - | - | - | - | - | - | - |
| Jul. | I | 3.4 | 51.0 | 61.0 | - | - | - | - | - | - | - | - |
| | II | 3.4 | 54.4 | 35.0 | 19.4 | 29.8 | 35.8 | 0.259 | 0.04 | 0.06 | 0.16 | 0.26 |
| Aug. | I | 3.2 | 48.0 | 129.0 | - | - | - | - | - | - | - | - |
| | II | 3.2 | 51.2 | 67.5 | - | - | - | - | - | - | - | - |
| Sep. | I | 3.0 | 45.0 | 47.5 | - | - | - | - | - | - | - | - |
| | II | 3.0 | 45.0 | 86.3 | - | - | - | - | - | - | - | - |
| Oct. | I | 3.1 | 46.5 | 125.5 | - | - | - | - | - | - | - | - |
| | II | 3.1 | 49.6 | 60.5 | - | - | - | - | - | - | - | - |
| Nov. | I | 3.2 | 48.0 | 18.5 | 29.5 | 45.4 | 54.5 | 0.421 | 0.06 | 0.10 | 0.26 | 0.42 |
| | II | 3.2 | 48.0 | 27.0 | 21.0 | 32.3 | 38.8 | 0.299 | 0.04 | 0.07 | 0.18 | 0.29 |
| Dec. | I | 3.1 | 46.5 | 21.0 | 25.5 | 39.2 | 47.1 | 0.363 | 0.05 | 0.09 | 0.22 | 0.36 |
| | II | 3.1 | 49.6 | - | 49.6 | 76.3 | 91.7 | 0.663 | 0.09 | 0.17 | 0.40 | 0.66 |

Note: (1): Average field water requirements, in millimeter per day (see Table A. 4-13)
(2): Average field water requirements, in millimeter per half month
(3): Effective rainfall, in millimeter per half month, (Table A. 4-30)
(4): (2) - (3)
(5): (4)/(1 - 0.35)
(6): (5)/(1 - 0.075)(1 - 0.10)
(7): (6)/8.64 x n
(8): Block A; irrigable area 142 ha x (7)
(9): Block B; irrigable area 249 ha x (7)
(10): Block C; irrigable area 609 ha x (7)
(11): (8) + (9) + (10)

Table A.4-30

Effective Rainfall (Return Period: 10-years)

(Unit: mm)

| Month | | Rainfall | | | | Effective Rainfall | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Paddy Field | | |
| | | Sing Ha Nat. Reg. | Phraya Banlu Reg. | Lakkhon Reg. | Average (1) | Ratio of Effective Rainfall (2) | Effective Rainfall (3)=(1)x(2) | Upland Field (4) |
| Nov. | I | 0 | 77.7 | 0 | 25.9 | 0.80 | 20.7 | 18.5 |
| | II | 20.0 | 74.5 | 18.4 | 37.6 | 0.80 | 30.0 | 27.0 |
| Dec. | I | 67.5 | 0 | 18.9 | 28.8 | 0.90 | 25.9 | 21.0 |
| | II | 1.5 | 0 | 0 | 0.5 | 0.90 | 0.5 | 0 |
| Jan. | I | 0 | 0 | 0 | 0 | 0.90 | 0 | 0 |
| | II | 0 | 0 | 0 | 0 | 0.90 | 0 | 0 |
| Feb. | I | 6.1 | 0 | 0 | 2.0 | 0.90 | 1.8 | 1.5 |
| | II | 0 | 0 | 0 | 0 | 0.90 | 0 | 0 |
| Mar. | I | 0 | 0 | 0 | 0 | 0.90 | 0 | 0 |
| | II | 29.6 | 2.3 | 18.4 | 16.8 | 0.90 | 15.1 | 11.7 |
| Apr. | I | 89.5 | 69.9 | 47.6 | 69.0 | 0.75 | 51.8 | 48.5 |
| | II | 92.6 | 121.5 | 15.8 | 76.6 | 0.75 | 57.5 | 53.0 |
| May | I | 24.7 | 6.5 | 29.7 | 20.4 | 0.75 | 15.3 | 14.5 |
| | II | 130.2 | 79.9 | 78.5 | 96.3 | 0.75 | 72.2 | 65.0 |
| Jun. | I | 149.5 | 23.1 | 181.0 | 117.9 | 0.75 | 98.4 | 77.5 |
| | II | 94.9 | 86.5 | 204.8 | 128.6 | 0.75 | 96.5 | 83.0 |
| Jul. | I | 105.5 | 46.0 | 121.7 | 91.1 | 0.75 | 68.3 | 61.0 |
| | II | 22.4 | 112.1 | 11.6 | 48.6 | 0.75 | 36.5 | 35.0 |
| Aug. | I | 330.3 | 101.5 | 296.8 | 242.8 | 0.75 | 182.1 | 129.0 |
| | II | 74.3 | 155.4 | 72.4 | 100.7 | 0.75 | 75.5 | 67.5 |
| Sep. | I | 64.6 | 57.0 | 80.7 | 67.3 | 0.75 | 50.5 | 47.5 |
| | II | 196.6 | 61.7 | 147.8 | 135.2 | 0.65 | 87.9 | 86.3 |
| Oct. | I | 117.6 | 415.3 | 161.8 | 231.6 | 0.65 | 150.5 | 125.5 |
| | II | 46.2 | 148.3 | 71.8 | 88.7 | 0.65 | 57.5 | 60.5 |

Note: (4); estimated based on Figure A.4-4

Table A. 4-31 Drainage Discharge for Project Area

Return Period: 10-years (Maximum)

| | | Cultivated Area | | | | | | | | | | Others | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Field Water Requirements | | | Drain Water | | Drainage Discharge | | | | Drain Water | | | | | | Total Drainage Discharge |
| Month | | Rainfall mm (1) | Paddy Fields mm (2) | Upland Fields mm (3) | Average mm (4) | mm (5) | ℓ/sec/ha (6) | Block A cu.m/s (7) | Block B cu.m/s (8) | Block C cu.m/s (9) | Sub-Total cu.m/s (10) | mm (11) | ℓ/sec/ha (12) | Block A cu.m/s (13) | Block B cu.m/s (14) | Block C cu.m/s (15) | Sub-Total cu.m/s (16) | cu.m/s (17) |
| Apr. | I | 69.0 | 114.0 | 69.0 | 109.7 | - | - | - | - | - | - | 44.9 | 0.346 | 0.15 | 0.13 | 0.22 | 0.50 | 0.50 |
| | II | 76.6 | 111.0 | 69.0 | 107.0 | - | - | - | - | - | - | 49.8 | 0.384 | 0.16 | 0.15 | 0.24 | 0.55 | 0.55 |
| May | I | 20.4 | 69.0 | 60.0 | 68.1 | - | - | - | - | - | - | 13.3 | 0.103 | 0.04 | 0.04 | 0.07 | 0.15 | 0.15 |
| | II | 96.3 | 36.8 | 64.4 | 39.4 | 56.9 | 0.412 | 1.25 | 1.06 | 2.03 | 4.34 | 62.6 | 0.453 | 0.19 | 0.18 | 0.29 | 0.66 | 5.00 |
| Jun. | I | 117.9 | 3.0 | 55.5 | 8.0 | 109.9 | 0.848 | 2.57 | 2.19 | 4.18 | 8.94 | 76.6 | 0.591 | 0.25 | 0.23 | 0.38 | 0.86 | 9.80 |
| | II | 128.6 | - | 55.5 | 5.3 | 123.3 | 0.951 | 2.88 | 2.45 | 4.69 | 10.03 | 83.6 | 0.645 | 0.27 | 0.25 | 0.41 | 0.93 | 10.96 |
| Jul. | I | 91.1 | 27.0 | 51.0 | 29.3 | 61.8 | 0.477 | 1.44 | 1.23 | 2.36 | 5.03 | 59.2 | 0.457 | 0.19 | 0.18 | 0.29 | 0.66 | 5.69 |
| | II | 48.6 | 102.4 | 54.4 | 97.8 | - | - | - | - | - | - | 31.6 | 0.229 | 0.10 | 0.09 | 0.15 | 0.34 | 0.34 |
| Aug. | I | 242.8 | 123.0 | 48.0 | 115.9 | 126.9 | 0.979 | 2.96 | 2.53 | 4.83 | 10.32 | 157.8 | 1.218 | 0.51 | 0.47 | 0.78 | 1.76 | 12.08 |
| | II | 100.7 | 104.8 | 51.2 | 99.7 | 1.0 | 0.07 | 0.21 | 0.18 | 0.35 | 0.74 | 65.5 | 0.474 | 0.20 | 0.18 | 0.30 | 0.68 | 1.42 |
| Sep. | I | 67.3 | 81.0 | 45.0 | 77.6 | - | - | - | - | - | - | 43.7 | 0.338 | 0.14 | 0.13 | 0.22 | 0.49 | 0.49 |
| | II | 135.2 | 84.8 | 45.0 | 81.0 | 54.2 | 0.418 | 1.27 | 1.08 | 2.06 | 4.41 | 87.9 | 0.678 | 0.29 | 0.26 | 0.43 | 0.98 | 5.39 |
| Oct. | I | 231.6 | 82.5 | 46.5 | 79.1 | 152.5 | 1.177 | 3.57 | 3.04 | 5.80 | 12.41 | 150.5 | 1.161 | 0.49 | 0.45 | 0.74 | 1.68 | 14.09 |
| | II | 88.7 | 88.4 | 49.6 | 84.7 | 4.0 | 0.029 | 0.09 | 0.08 | 0.14 | 0.31 | 57.7 | 0.417 | 0.18 | 0.16 | 0.27 | 0.61 | 0.92 |
| Nov. | I | 25.9 | 55.5 | 48.0 | 54.8 | - | - | - | - | - | - | 16.8 | 0.130 | 0.05 | 0.05 | 0.08 | 0.18 | 0.18 |
| | II | 37.6 | 27.0 | 48.0 | 29.0 | 8.6 | 0.066 | 0.20 | 0.17 | 0.32 | 0.69 | 24.4 | 0.188 | 0.08 | 0.07 | 0.12 | 0.27 | 0.96 |

Note: (1) Average half month rainfall at three stations, sing Na Nat, Phraya Banlu and Lakkhon, in probable 10-years

(2) See Table A.4-17
(3) See Table A.4-18
(4) (2) x 0.905 + (3) x 0.095
(5) (1) - (4)
(6) (5)/8.64 x n
(7) 3,027 ha x (6)
(8) 2,583 ha x (6)
(9) 4,932 ha x (6)
(10) (7) + (8) + (9)
(11) (1) x runoff coefficient 0.65 (assumed)
(12) (11)/8.64 x n
(13) 422 ha x (12)
(14) 387 ha x (12)
(15) 637 ha x (12)
(16) (13) + (14) + (15)
(17) (10) + (16)

# Necessity and Possibility for Separation of Irrigation and Drainage System

## Necessity

The modernized paddy cultivation requires systematic irrigation and drainage systems controlled intentionally in each rotation block. The puddling period has been planned at 48 days so that not only transplanting but also harvesting of paddy should be completed within 48 days in one rotation block. For this purpose, each plot has to control irrigation water freely under the separated irrigation and drainage systems. In case of planning a dual purpose canal system, it is virtually difficult to control irrigation water freely, because the irrigation water supply in plot by plot are different due to the difference of growing stage of paddy.

## Possibility

It is necessary to examine thoroughly the possibility for the separation of irrigation and drainage systems in the project, because the project area lies on generally low-lying and flat area, and the outer water level is high during the wet season even after the Project. During the wet seasons when the outer water level is higher than the inner one, it is planned that drainage will be made forcedly by pumps. On the other hand, in the dry season, the irrigation water is lifted by pumps and is conveyed to the field with effective hydraulic potential in canals provided along the roads. These plans will make it possible to separate irrigation and drainage systems in the field.

Table A. 4-32  Comparison of Land Consolidation Cost for Each Length of Run

| Alternatives | Area | | On-farm Facilities | | | | | Construction Cost | |
|---|---|---|---|---|---|---|---|---|---|
| | Gross ha | Net ha | Land Levelling | On-farm Road | Drainage Ditch | Leading Ditch | Community Road | Total Cost | Cost/ha |
| Case (1) (100x50m) | 102.3 | 96.0a/ | $44,160 | 4,800m $4,320 | 3,600m $5,400 | 833.4m $5,667 | 833.4m $2,083 | $61,630 | $642 (106) |
| Case (2) (130x50m) | 131.9 | 124.8 | $57,454 | 4,800m $4,320 | 3,600m $5,400 | 1,033.4m $7,027 | 1,033.4m $2,583 | $76,784 | $615 (102) |
| Case (3) (150x50m) | 151.5 | 144.0 | $66,240 | 4,800m $4,320 | 3,600m $5,400 | 1,233.4m $8,387 | 1,233.4 $3,083 | $87,430 | $607 (101) |
| Case (4) (160x50m) | 161.3 | 153.6 | $70,656 | 4,800m $4,320 | 3,600m $5,400 | 1,313.4m $8,931 | 1,313.4m $3,283 | $92,590 | $603 (100) |

Note: a/ Gross area minus area of on-farm facilities

1) Unit cost of on-farm facilities:

| | |
|---|---|
| Land levelling | 460 $/ha |
| On-farm road | 0.9 $/m |
| Drainage ditch | 1.5 $/m |
| Leading ditch | 6.8 $/m |
| Community road | 2.5 $/m |

2) Costs of survey, preparation, land clearing, structures, and overhead are not included in the above costs.

Table A. 4-33 Comparison of Deduction Ratio of Land for Each Length of Run

| Alternatives | Gross Area(ha) | Area of On-farm Facilities (ha): On-farm Road | Drainage Ditch | Leading Ditch | Community Road | Sub-total | Deduction Ratio of Land (%): Main Road | Total |
|---|---|---|---|---|---|---|---|---|
| Case (1) | 102.3a/ | 2.54b/ | 1.48c/ | 1.17d/ | 1.17e/ | 6.36f/ (6.2%) | 1.8 | 8.0 |
| Case (2) | 131.9 | 2.54 | 1.48 | 1.50 | 1.50 | 7.02 (5.5%) | 1.8 | 7.3 |
| Case (3) | 151.5 | 2.54 | 1.48 | 1.73 | 1.73 | 7.49 (4.9%) | 1.8 | 6.7 |
| Case (4) | 161.3 | 2.54 | 1.48 | 1.84 | 1.84 | 7.70 (4.8) | 1.8 | 6.6 |

Note: a/: A x B

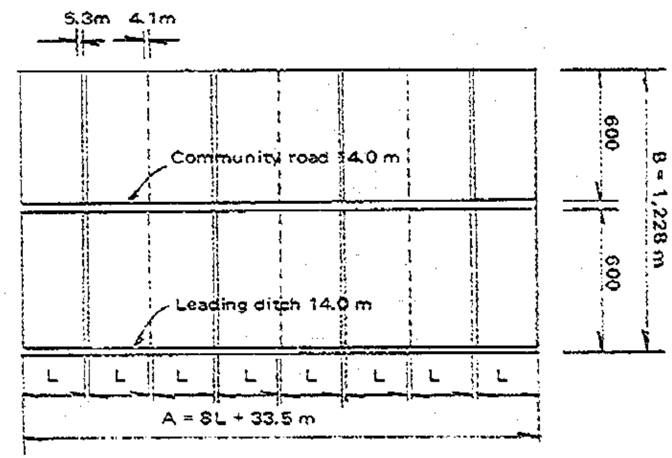
b/: 600m x 8 x 5.3m (width of on-farm road) including farm ditch

c/: 600m x 6 x 4.1m (width of drainage ditch)

d/: A x 14 (width of leading ditch including road)

e/: A x 14 (width of community road including lateral irrigation canal)

f/: b/ + c/ + d/ + e/
( ) shows the percentage of area of on-farm facilities



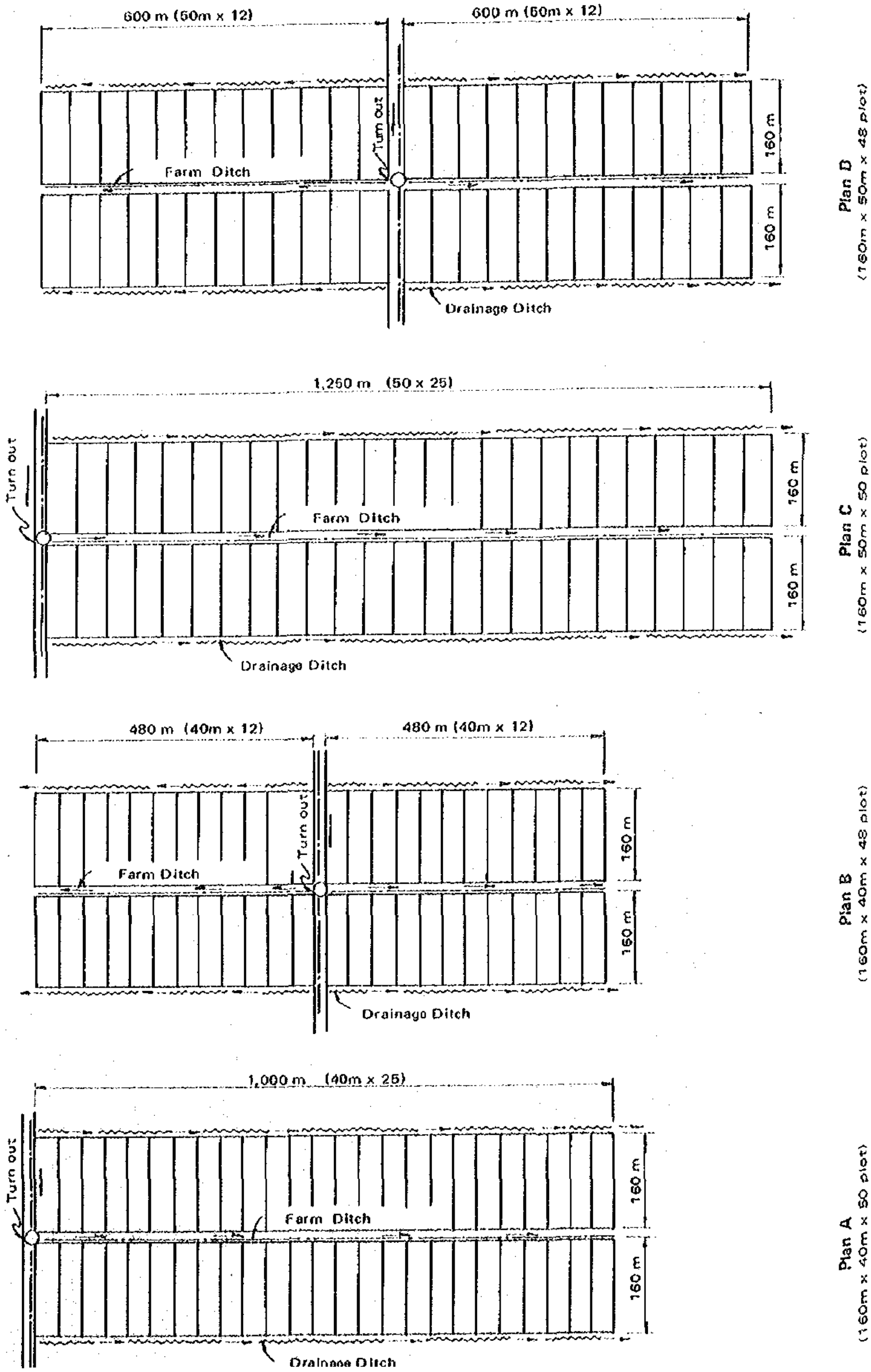



FIGURE A. 4-14 ALTERNATIVES ON SIZE OF PLOT AND REPARCELING OF LAND

Table A. 4-34 Comparison of Land Consolidation Cost for Each Width of Plot

| Case | Area | | On-farm Facilities | | | | | Construction Cost | |
|---|---|---|---|---|---|---|---|---|---|
| | Gross (ha) | Net (ha) | Land Levelling | On-farm Road | Drainage Ditch | Leading Ditch | Community Road | Total Cost | Cost/ha |
| Case B | 129.8 | 122.9 | $56,534 | 3,840m<br>$3,456 | 2,880m<br>$4,320 | 1,313.4m<br>$8,931 | 1,313.4m<br>$3,283 | $76,524 | $623 (103) |
| Case D | 161.3 | 153.6 | 70,656 | 4,800m<br>$4,320 | 3,600m<br>$5,400 | 1,313.4m<br>$8,931 | 1,313.4m<br>$3,283 | $92,590 | $603 (100) |

Note: 1) Unit cost of on-farm facilities;

| | |
|---|---|
| Land levelling | 460 $/ha |
| On-farm road | 0.9 $/m |
| Drainage ditch | 1.5 $/m |
| Leading ditch | 6.8 $/m |
| Community road | 2.5 $/m |

2) Costs of survey, preparation, land clearing, structures and overhead are not included in the above costs.

Table A. 4-35 Comparison of Deduction Ratio of Land for Each Width of Plot

| Case | Gross Area(ha) | Area of On-farm Facilities (ha) | | | | | Deduction Ratio of Land (%) | |
|---|---|---|---|---|---|---|---|---|
| | | On-farm Road | Drainage Ditch | Leading Ditch | Community Road | Sub-total | Main Road | Total |
| Case B | 129.8 | 2.04a/ | 1.18b/ | 1.84c/ | 1.84 | 6.90 (5.3%) | 1.8 | 7.1 |
| Case D | 161.3 | 2.54 | 1.48 | 1.84 | 1.84 | 7.70 (4.8%) | 1.8 | 6.6 |

Note: a/: b m x 8 x 5.3 (Width of on-farm road including farm ditch)
b/: b m x 6 x 4.1 (Width of drainage ditch)
c/: A x 14m (Width of community road including lateral irrigation canal)

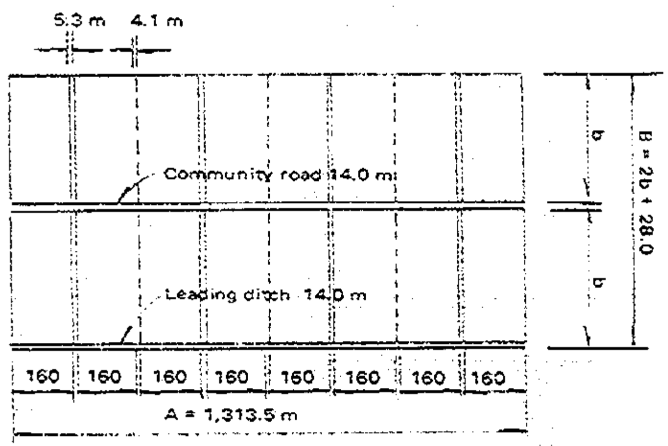
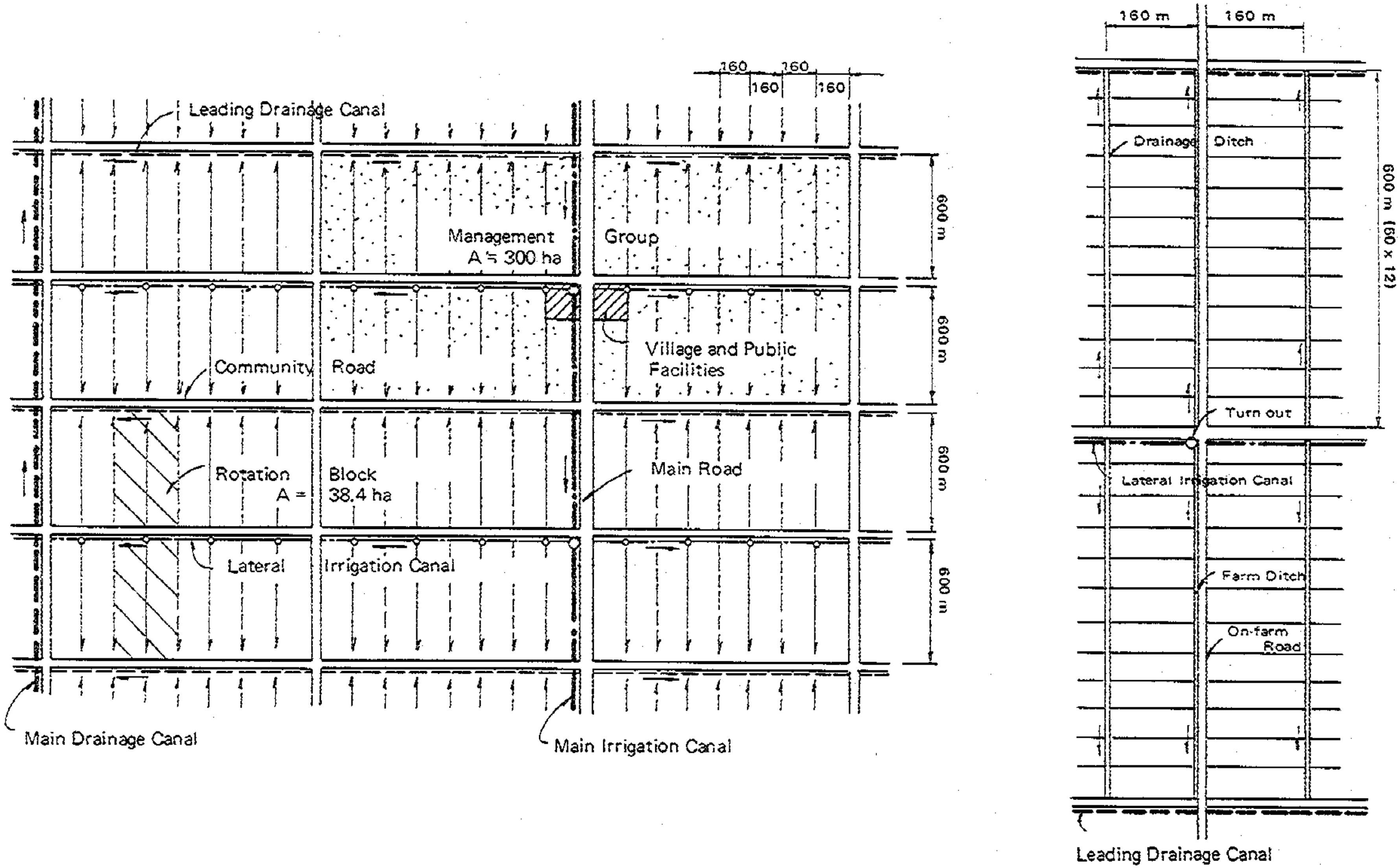


FIGURE A. 4-15 TYPICAL LAYOUT OF FARM LAND DEVELOPMENT



## Procedure for Computation of Land Leveling

The computation of land leveling is made by applying the mech method. According to this method, it is assumed that the topography is levelled within the same mech after partitioning off the present field surface into several meshes with regular intervals, as shown in the following figures, and each moving volume and hauling distance can be computed by the following formula;

Area: $A_{iJ}$ (mesh area surrounded by coordinates)

Centroid coordinate: $X_{iJ}$, $Y_{iJ}$

Ground elevation, $Z_{iJ}$: $1/4 \times (Z_{iJ} + Z_{i+1,J} + Z_{i,J+1} + Z_{i+1,\ J+1})$

Designed elevation F: $\dfrac{\Sigma\Sigma(A_{iJ} + Z_{iJ})}{\Sigma\Sigma A_{iJ}}$

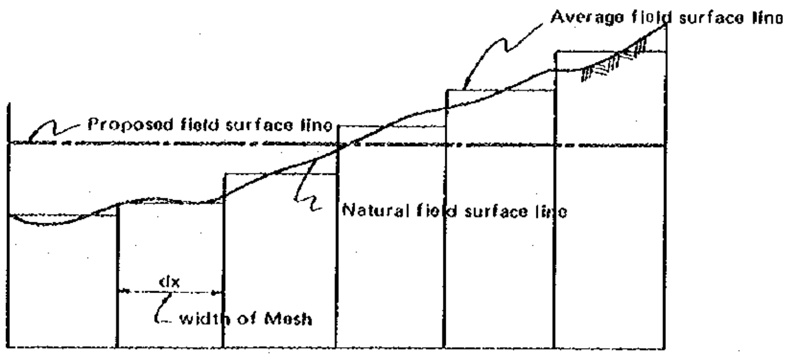
Height of cut and bank, $Hc$, $H_B$:
Designed elevation minus $Z_{iJ}$

Earth moving volume, $Vc$, $V_B$:
Height of cut and bank x $A_{ij}$

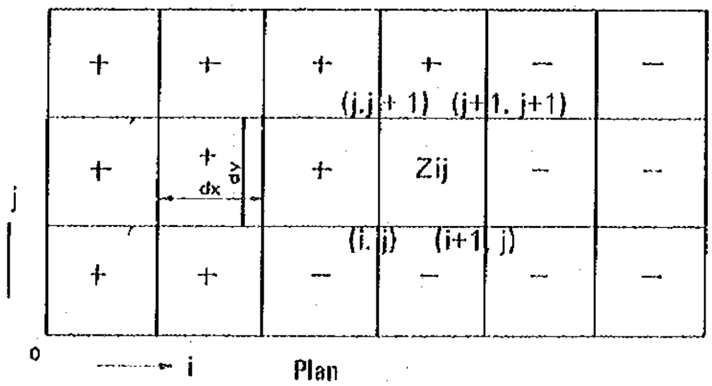
Hauling distance D: $\{(Xc - X_B)^2 + (Yc - Y_B)^2\}^{1/2}$

$$Xc = \frac{\Sigma\Sigma Vc \times X_{iJ}}{\Sigma Vc} \qquad Yc = \frac{\Sigma\Sigma Vc \times Y_{iJ}}{\Sigma Vc}$$

$$X_B = \frac{\Sigma\Sigma V_B \times X_{iJ}}{\Sigma V_B} \qquad X_B = \frac{\Sigma\Sigma V_B \times Y_{iJ}}{\Sigma V_B}$$




Section




Plan

Flow chart for the above computation is shown in Figure A. 4-16.

FIGURE A. 4-16 FLOW CHART OF ESTIMATION FOR EARTH MOVING VOLUME

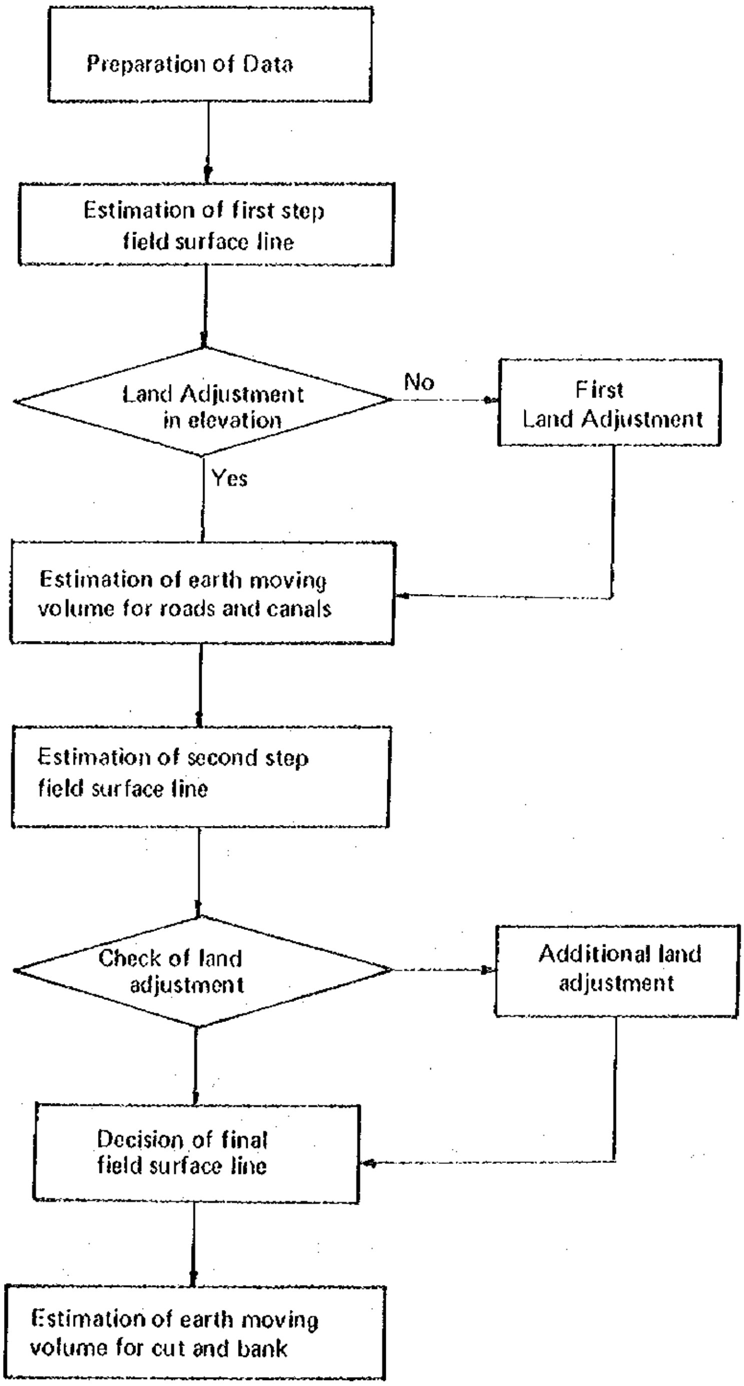


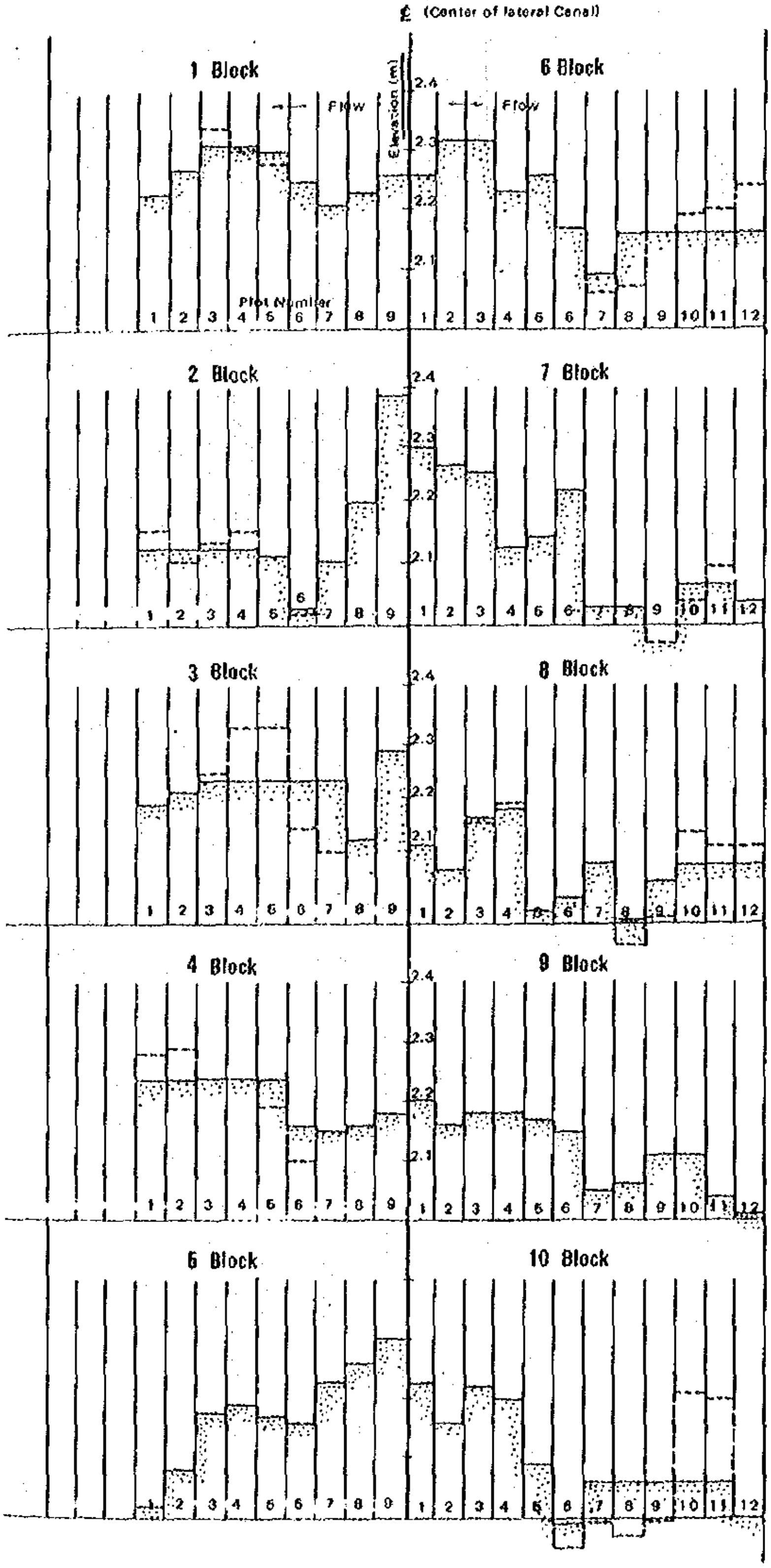
Table A. 4-36 Summary of Estimation for Earth Moving Volume and Hauling Distance

| Description | Case (E) | Case (F) | Case (G) | Case (H) |
|---|---|---|---|---|
| 1. Area (ha) | | | | |
| Site I | 84.0 | 84.0 | 84.0 | 83.2 |
| Site II | 96.0 | 96.0 | 96.0 | 96.0 |
| Total | 180.0 | 180.0 | 180.0 | 179.2 |
| 2. Size of plot (length of run x width of spot) | 160mx50m | 160mx50m | 160mx50m | 160mx40m |
| 3. Allowable difference in field elevation (cm) | no land adjustment | 10 | 5 | 10 |
| 4. Land leveling works (cu.m) | | | | |
| Cut volume, Site I | 26,833 | 29,731 | 31,519 | 29,443 |
| Site II | 50,645 | 63,930 | 65,649 | 61,234 |
| Total | 77,478(430m$^3$/ha) | 93,661(520) | 97,168(540) | 90,677(506) |
| Bank volume, Site I | 28,571 | 31,470 | 33,259 | 30,491 |
| Site II | 52,487 | 65,773 | 67,493 | 63,077 |
| Total | 81,058(450) | 97,243(540) | 100,752(560) | 93,568(522) |
| Land adjustment in elevation Site I | - | 9,315 | 16,490 | 10,133 |
| Site II | - | 34,303 | 49,940 | 41,013 |
| Total | - | 43,618(242) | 66,430(369) | 51,146(285) |
| 5. Average hauling distance (m) | | | | |
| Cuting works Site I | 61 | 63 | 64 | 63 |
| Site II | 70 | 66 | 68 | 70 |
| Average | 67 | 65 | 66 | 67 |
| Land adjustment in elevation Site I | - | 140 | 173 | 149 |
| Site II | - | 213 | 219 | 200 |
| Average | - | 197 | 208 | 190 |

Table A. 4-37 Earth Moving Volume and Hauling Distance

| Location | Block Number | Case (E) | | | Case (F) | | | Case (G) | | | Case (H) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cut ($m^3$) | Bank ($m^3$) | Dist. (m) | Cut ($m^3$) | Bank ($m^3$) | Dist. (m) | Cut ($m^3$) | Bank ($m^3$) | Dist. (m) | Cut ($m^3$) | Bank ($m^3$) | Dist. (m) |
| Site I | | | | | | | | | | | | | |
| Land Leveling | | | | | | | | | | | | | |
| | 1 | 1,222 | 1,068 | 58 | 1,284 | 1,131 | 60 | 1,572 | 1,418 | 68 | 1,487 | 1,195 | 73 |
| | 2 | 2,491 | 2,540 | 84 | 2,594 | 2,643 | 87 | 2,757 | 2,806 | 89 | 2,587 | 2,097 | 82 |
| | 3 | 2,218 | 2,542 | 52 | 2,894 | 3,218 | 75 | 2,294 | 3,218 | 79 | 2,765 | 3,085 | 70 |
| | 4 | 2,666 | 2,989 | 40 | 2,873 | 3,197 | 42 | 3,403 | 3,726 | 42 | 2,814 | 3,134 | 44 |
| | 5 | 1,955 | 2,230 | 65 | 1,955 | 2,230 | 65 | 1,955 | 2,230 | 65 | 1,699 | 1,968 | 65 |
| | 6 | 2,685 | 2,456 | 67 | 3,280 | 3,051 | 70 | 3,186 | 2,958 | 69 | 3,291 | 3,063 | 64 |
| | 7 | 2,751 | 2,792 | 57 | 2,829 | 2,870 | 58 | 3,042 | 3,084 | 56 | 2,938 | 2,979 | 54 |
| | 8 | 3,703 | 4,087 | 62 | 3,816 | 4,200 | 65 | 4,058 | 4,442 | 67 | 3,908 | 4,291 | 75 |
| | 9 | 3,614 | 3,997 | 72 | 3,614 | 3,997 | 72 | 3,640 | 4,023 | 72 | 3,571 | 3,955 | 72 |
| | 10 | 3,528 | 3,870 | 54 | 4,592 | 4,933 | 45 | 5,012 | 5,354 | 46 | 4,383 | 4,724 | 42 |
| | Total | 26,833 | 28,571 | 61 | 29,731 | 31,470 | 63 | 31,519 | 33,259 | 54 | 29,443 | 30,491 | 63 |
| Land adjustment in elevation | | | | | | | | | | | | | |
| | | - | | - | 9,315 | | 140 | 16,490 | | 173 | 10,133 | | 149 |
| Site II | | | | | | | | | | | | | |
| Land levelling | | | | | | | | | | | | | |
| | 1 | 6,948 | 6,719 | 58 | 6,943 | 6,715 | 58 | 6,984 | 6,755 | 58 | 7,033 | 6,805 | 64 |
| | 2 | 5,037 | 5,078 | 45 | 5,754 | 5,795 | 50 | 6,118 | 6,160 | 52 | 5,733 | 5,774 | 42 |
| | 3 | 4,111 | 4,495 | 68 | 4,662 | 5,045 | 67 | 4,932 | 5,316 | 73 | 4,335 | 4,718 | 78 |
| | 4 | 4,318 | 4,701 | 75 | 6,307 | 6,691 | 78 | 6,723 | 7,106 | 78 | 5,971 | 6,354 | 80 |
| | 5 | 3,865 | 4,206 | 66 | 6,904 | 7,245 | 47 | 7,116 | 7,458 | 46 | 6,335 | 6,677 | 63 |
| | 6 | 3,804 | 3,576 | 40 | 7,025 | 6,796 | 49 | 6,274 | 6,045 | 47 | 5,552 | 5,324 | 56 |
| | 7 | 3,734 | 3,776 | 60 | 4,519 | 4,560 | 66 | 4,770 | 4,812 | 73 | 4,446 | 4,488 | 72 |
| | 8 | 8,270 | 8,653 | 95 | 8,505 | 8,889 | 95 | 8,596 | 8,980 | 95 | 8,405 | 8,788 | 95 |
| | 9 | 2,728 | 3,112 | 71 | 4,278 | 4,662 | 43 | 4,636 | 5,020 | 51 | 4,541 | 4,924 | 55 |
| | 10 | 7,830 | 8,171 | 88 | 9,033 | 9,378 | 88 | 9,500 | 9,841 | 89 | 8,883 | 9,225 | 80 |
| | Total | 50,645 | 52,487 | 70 | 63,930 | 65,773 | 66 | 65,649 | 67,493 | 68 | 61,234 | 63,077 | 70 |
| Land Adjustment in elevation | | | | | | | | | | | | | |
| | | - | | - | 34,303 | | 213 | 49,940 | | 219 | 41,013 | | 200 |

**FIGURE A.4-17**
**PROPOSED ELEVATION OF PLOT IN CASE OF WITH AND WITHOUT LAND ADJUSTMENT IN ELEVATION (SITE I)**




Case (E) (Without land adjustment)

| | Cut m3 | Bank m3 | Dist. m |
|---|---|---|---|
| 1 Block | 1,222 | 1,068 | 58 |
| 2 Block | 2,491 | 2,540 | 84 |
| 3 Block | 2,218 | 2,542 | 52 |
| 4 Block | 2,666 | 2,989 | 40 |
| 5 Block | 1,955 | 2,230 | 65 |
| 6 Block | 2,684 | 2,456 | 67 |
| 7 Block | 2,751 | 2,792 | 57 |
| 8 Block | 3,703 | 4,087 | 62 |
| 9 Block | 3,614 | 3,997 | 72 |
| 10 Block | 3,529 | 3,870 | 54 |
| Total | 26,833 | 28,571 | 61 |

Case (F) (with land adjustment, 10 cm)

| | Cut m3 | Bank m3 | Dist. m |
|---|---|---|---|
| 1 Block | 1,284 | 1,131 | 60 |
| 2 Block | 2,594 | 2,643 | 87 |
| 3 Block | 2,894 | 3,218 | 75 |
| 4 Block | 2,873 | 3,197 | 42 |
| 5 Block | 1,955 | 2,230 | 65 |
| 6 Block | 3,280 | 3,051 | 70 |
| 7 Block | 2,829 | 2,870 | 58 |
| 8 Block | 3,816 | 4,200 | 65 |
| 9 Block | 3,614 | 3,997 | 72 |
| 10 Block | 4,592 | 4,933 | 46 |
| Total | 29,731 | 31,470 | 63 |

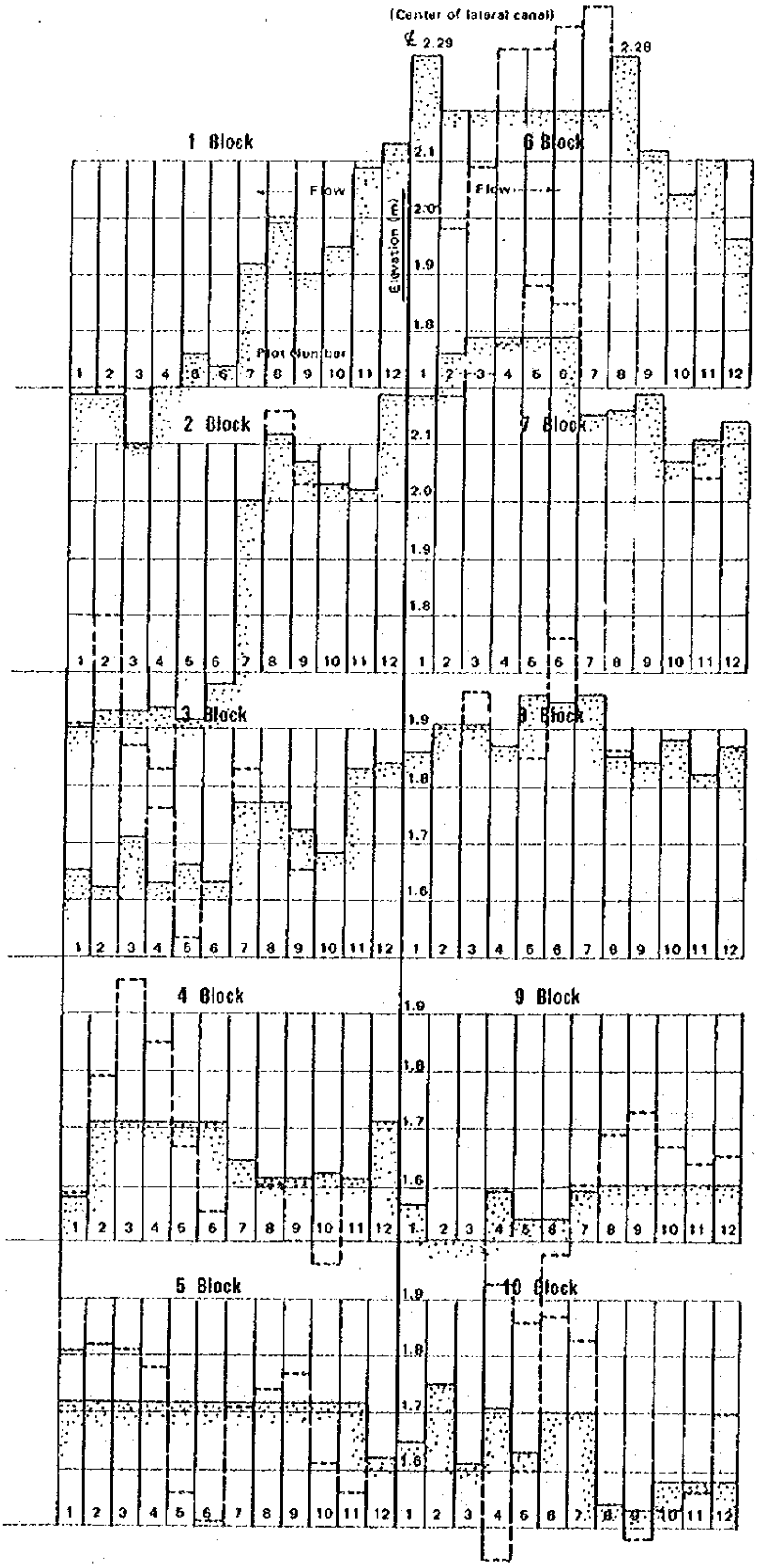
LEGEND

- - - - - Case E
....... Case F

Numbers of block and plot are given in the drawing No. 1 in main report.

FIGURE A.4 – 18

PROPOSED ELEVATION OF PLOT IN CASE OF WITH AND WITHOUT LAND ADJUSTMENT IN ELEVATION (SITE II)




Case (E) (without land adjustment)

| | Cut m³ | Bank m³ | Dist. m |
|---|---|---|---|
| 1 Block | 6,948 | 6,719 | 58 |
| 2 Block | 5,037 | 5,078 | 45 |
| 3 Block | 4,111 | 4,495 | 68 |
| 4 Block | 4,318 | 4,701 | 76 |
| 5 Block | 3,865 | 4,206 | 66 |
| 6 Block | 3,804 | 3,576 | 40 |
| 7 Block | 3,734 | 3,776 | 60 |
| 8 Block | 8,270 | 8,653 | 95 |
| 9 Block | 2,728 | 3,112 | 71 |
| 10 Block | 7,830 | 8,171 | 88 |
| Total | 50,646 | 52,487 | 70 |

Case (F) (with land adjustment, 10cm)

| | | | |
|---|---|---|---|
| 1 Block | 6,943 | 6,716 | 68 |
| 2 Block | 5,754 | 5,795 | 50 |
| 3 Block | 4,662 | 5,045 | 67 |
| 4 Block | 6,307 | 6,601 | 78 |
| 5 Block | 6,904 | 7,246 | 47 |
| 6 Block | 7,026 | 6,796 | 49 |
| 7 Block | 4,519 | 4,560 | 66 |
| 8 Block | 8,505 | 8,889 | 95 |
| 9 Block | 4,278 | 4,662 | 43 |
| 10 Block | 9,033 | 9,375 | 88 |
| Total | 63,930 | 65,773 | 66 |

LEGEND

-------- , Case E

Case F

Numbers of block and plot are given in the drawing No. 2 in the main report

FIGURE A. 4-19 LONGITUDINAL SECTION OF LATERAL CANAL (SITE I)

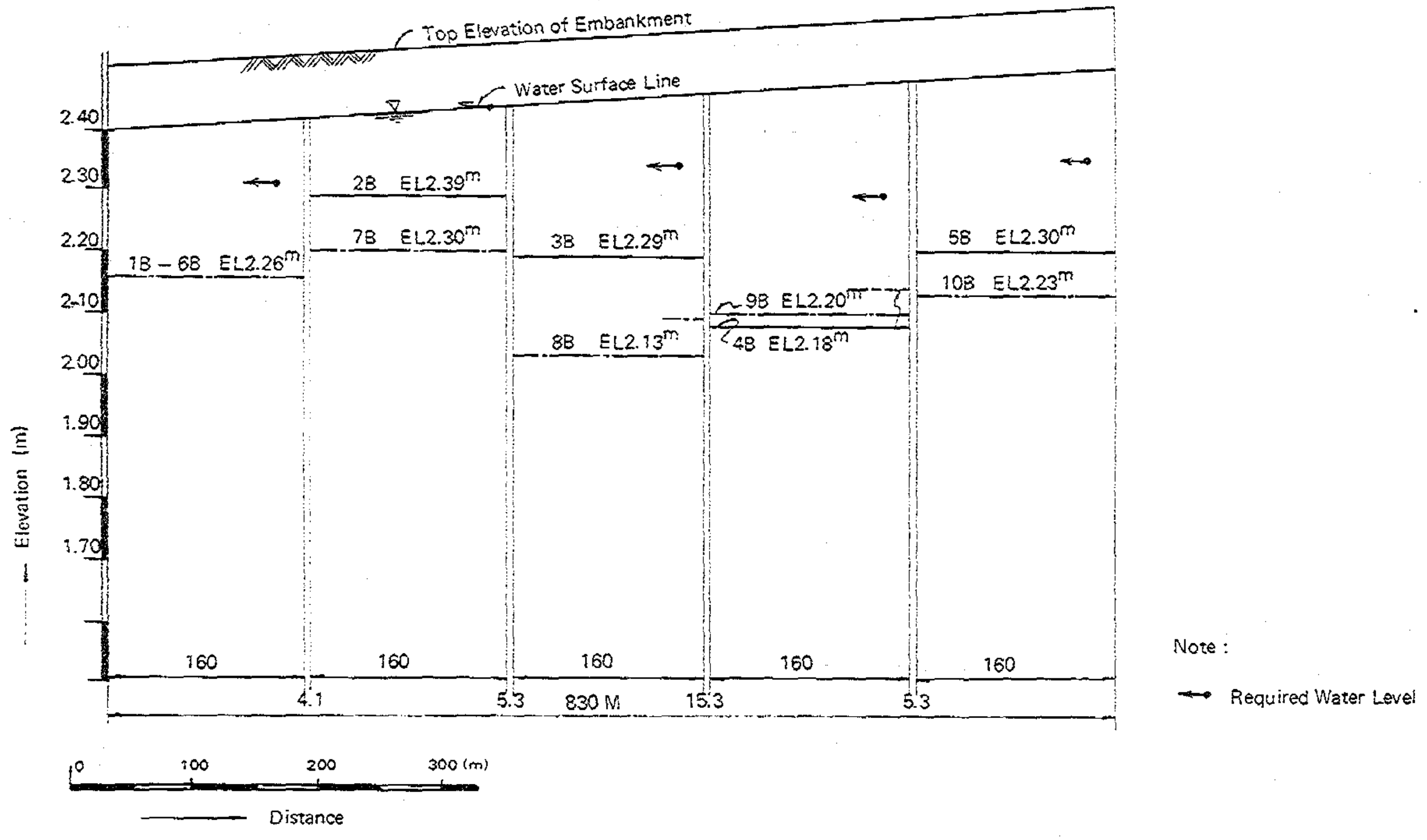


FIGURE A. 4–20 LONGITUDINAL SECTION OF LATERAL CANAL (SITE II)

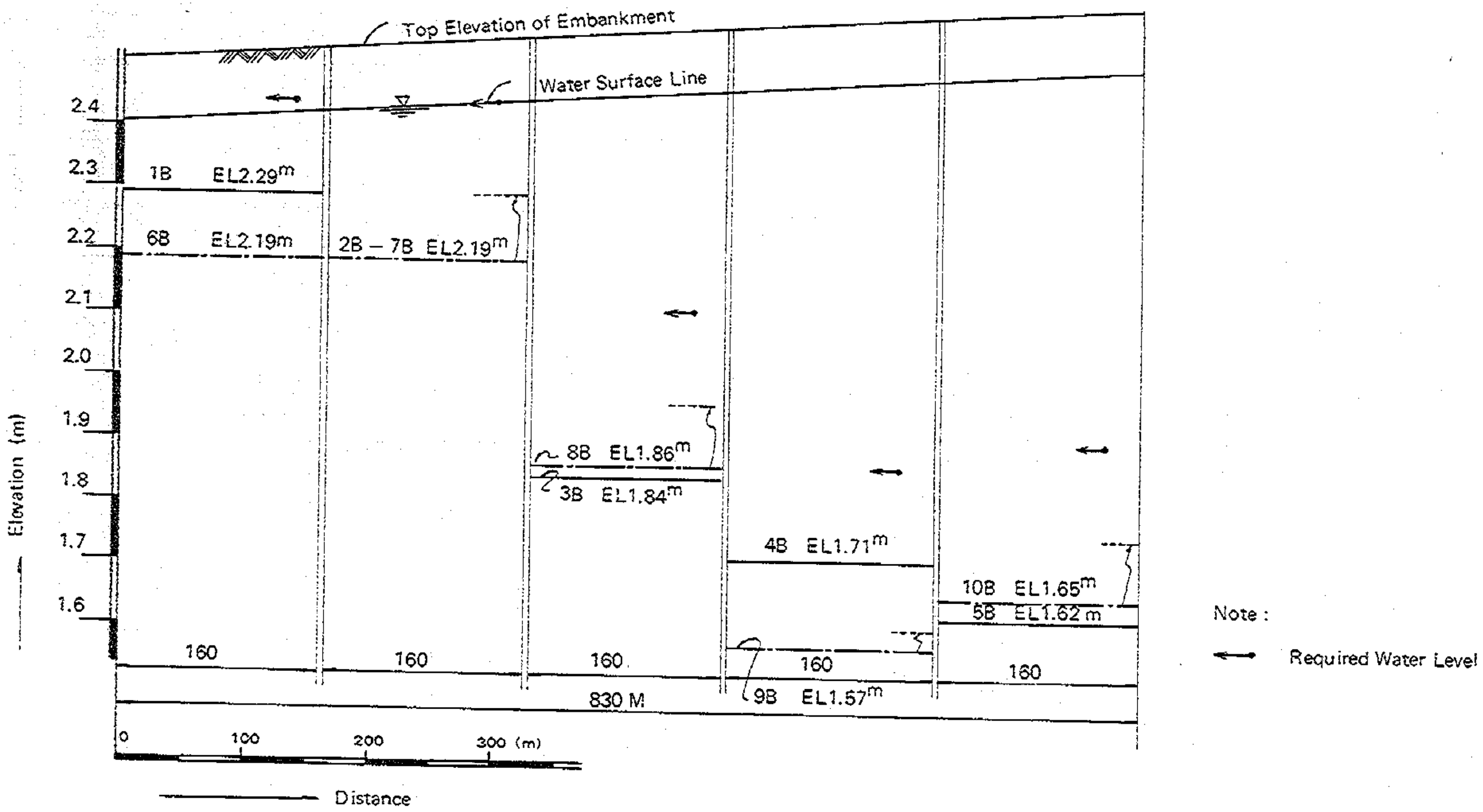


FIGURE A. 4-21

LAYOUT OF VILLAGE WATER SUPPLY PLANT

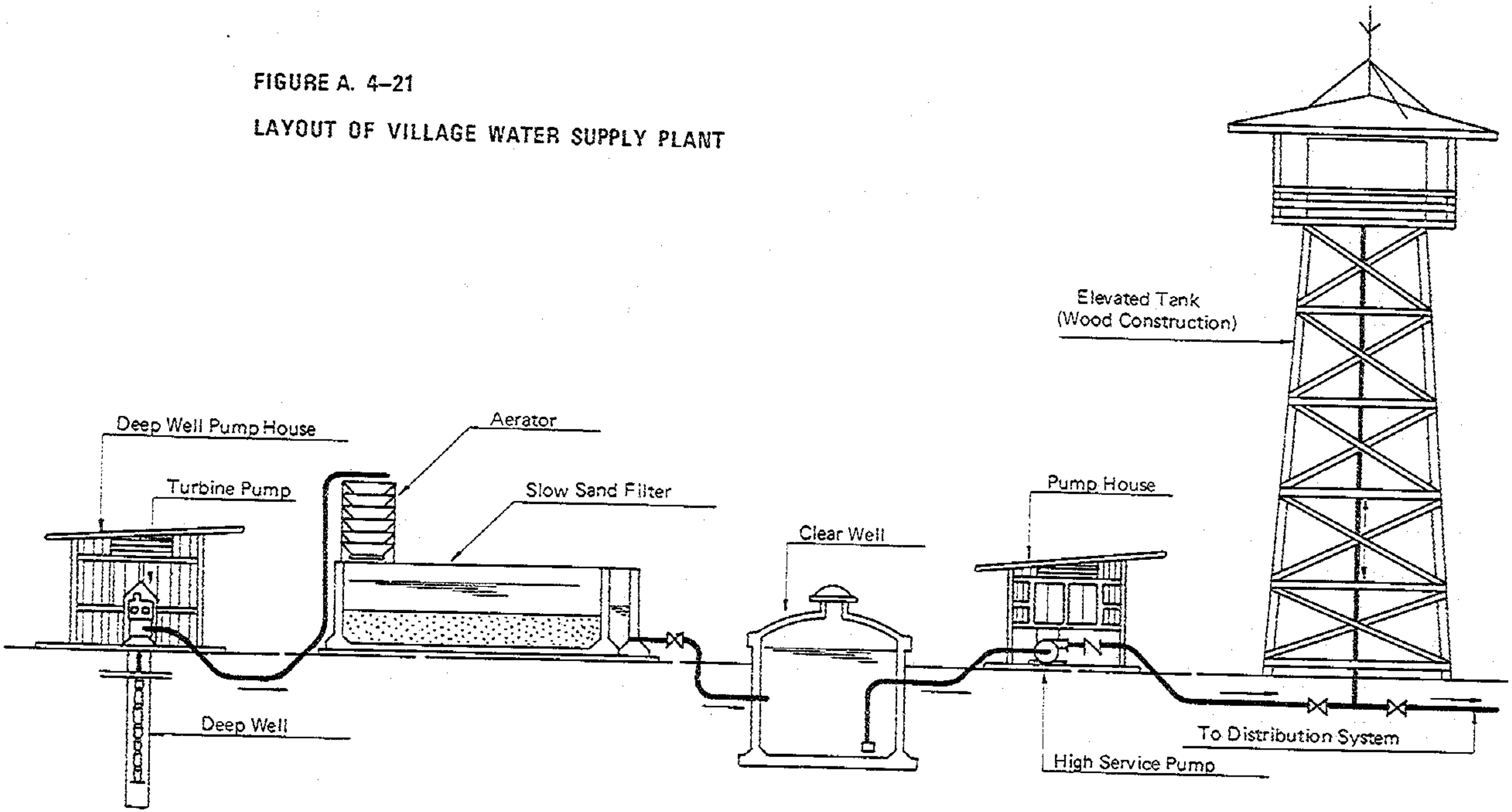


Table A. 4-38 Recommended Farm Practices for Paddy Rice

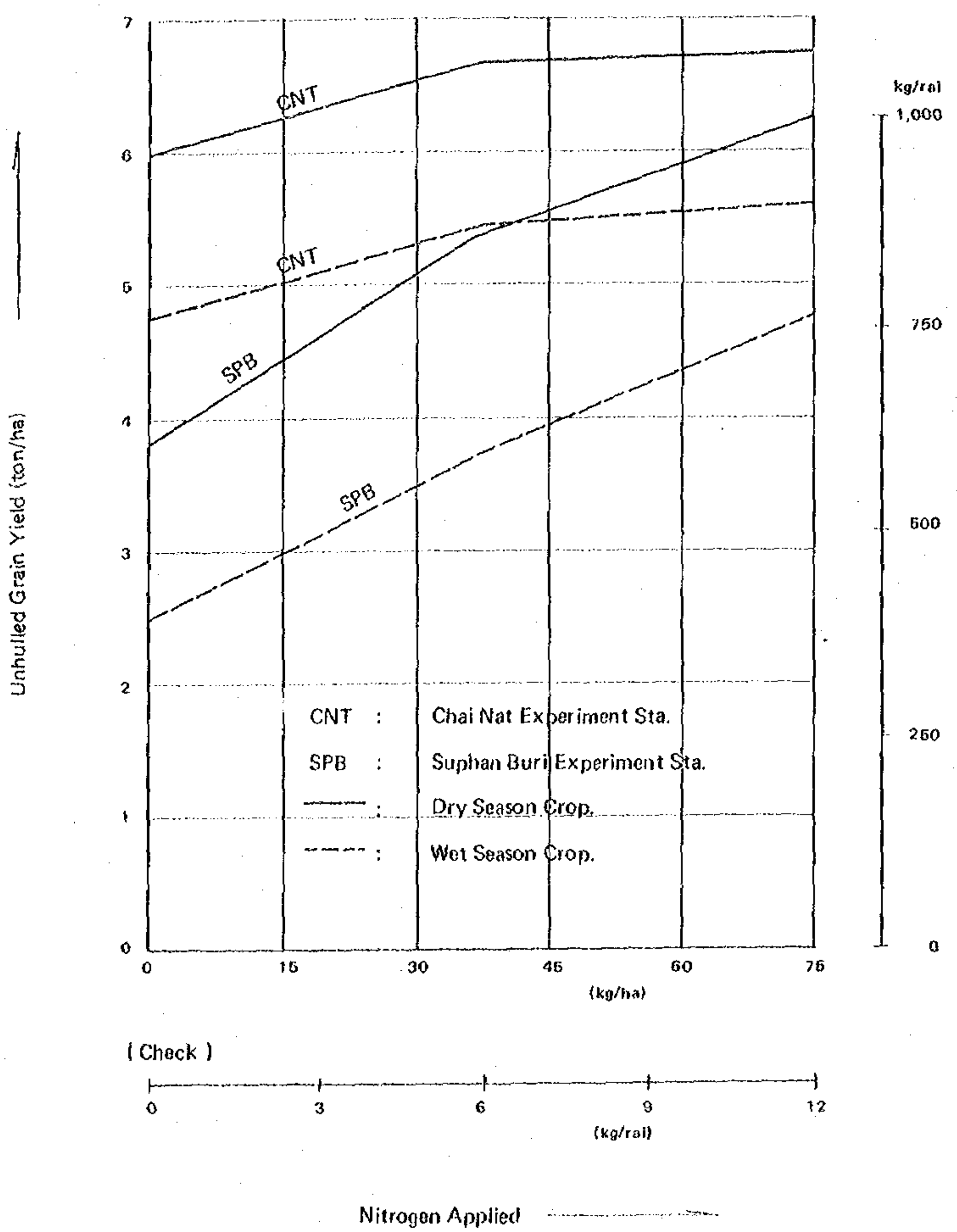
| Field Operation | | Recommended Practice | Inputs per Ha |
|---|---|---|---|
| 1. Sowing (1st day after sowing) | (a) | Form and size of nursery: wet-seedbeds with the width of 120-150 cm (area for nursery is 500 $m^2$ per 1 ha of transplanting area) | Fertilizer for nursery: 9 kg of Ammophos (16-20-0) |
| | (b) | Seed rate and the method of seed preparation<br>- Seed rate : 60 g per one $m^2$ of seed-bed<br>- Selection : select seed with water<br>- Soaking : in clean or fungicided water for 24 hr.<br>- Incubation: keep seeds moist and warm in half filled, losely tied sacks for 36 to 48 hr. | Seed: 40 kg<br><br>Fungicide for seed: Ditane M-45 1.5 kg or any other kinds of chemicals |
| 2. Care of Seedlings (8-20 days) | (a) | Apply recommended insecticides at 8 to 10 days after sowing | Insecticieds for seedlings: 0.1 kg of Carbaryl (Sevin) 85%, WSP or any other kinds of chemicals. |
| | (b) | After sowing, the beds should be covered by filmy shallow water | |
| | (c) | 3 to 4 days after sowing, drain the water in the nursery and make the surface of beds dry for 1 to 2 days to make the sprouting seeds fix to soil. | |
| | (d) | Then, water should be deepened gradually in a range between 2 to 3 cm, so that seedling are not submerged. | |

| Field Operation | Recommended Practice | Inputs per Ha |
|---|---|---|
| 3. Land Preparation (1st-25 days) | Prepare land by soaking (if land is too dry to plow), plowing and harrowing. The harrowing is to be performed as:<br>1st step: after flooding with enough water, harrow the field longitudinal and cross-wise<br>2nd step: more than 6 days after 1st harrowing, harrow with applying basal fertilizer finally. | Basal fertilizer:<br>Wet - 156 kg of Ammophos (16-20-0) (N: 25kg, $P_2O_5$: 31kg)<br>Dry - 188 kg of Ammophos (16-20-0) (N: 30kg, $P_2O_5$: 38kg) |
| 4. Transplanting (26-30 days) | After final harrowing, transplant imediately in the way as:<br>(a) Planting distance: 25cm x 25cm (wet season), 20cm x 20cm (dry season) in the way of regular planting with using 3 to 5 seedlings per hill.<br>(b) Seedlings should be planted as shallow as possible | |
| 5. Spraying herbicides (3-5 days & 20-25days) | (a) 3 to 5 days after transplanting (before the weeds can be seen), apply herbicide and maintain water 3 to 5 cm deep for 10 days at least.<br>(b) 20 to 25 days after transplanting (when weeds are showing), apply herbicide to the completely drained field and keep the field dry for 2 days. | Herbicides of pre-emergency application: 25kg of Benthiocarb 8%, G or any other kind of herbicides.<br>Herbicides of post-emergency application; 0.8-1.0 kg of 2.4D sodium salt 95%, WSP or any other kinds of chemi chemicals. |
| 6. Weeding (45-60 days) | Weed between hills by hand or rotary weeder | |

| Field Operation | Recommended Practices | Inputs per Ha |
|---|---|---|
| 7. Additional Fertiliging (65-70 days) | 20 to 10 days before heading, apply additional fertilizer. | Additional Fertilizer; Wet - 55kg of Urea (46-0-0) (N: 25kg) Dry - 65kg of Urea (46-0-0) (N: 30kg) |
| 8. Spraying Insecticides (30 & 65 days) | (a) 1st: 30 days after transplanting<br>(b) 2nd: 65 days after transplanting (for the field where much harmful insects would be found).<br>These insecticide should be applied after checking the number of each harmful insects in the field. | Insecticides<br>1st: 2 kg of Carbaryl (Sevin) 85%, WSP or any other kind of insecticides<br>2nd: 30 kg of carbofuran (Furadan) 3%, G or any other kind of insecticides |
| 9. Drainage | After milk-ripe stage (14 days before harvesting), stop irrigation and drain the water from the field. | |
| 10. Harvesting (125-130 days) | When 80 % of panicle turns yellowish and become firm to touch, harvest the rice | |
| 11. Drying | Dry up harvested paddy hills in the field for 2 to 4 days by sunshine. Bring them to dry place and pile up. | |
| 12. Threshing | After drying paddy hills, thresh them. Threshed paddy must be reduced in their moisture contents to 14 % by sunshine or dryer. | |

Note: (1) Besides above mentioned chemicals, 0.25kg of Warfaring or any other kind of rodenticides per one times of applying will be needed to control rats
(2) WSP: Water soluble powder, G: Granule

## FIGURE A.4–22 PADDY YIELD RESPONSE TO NITROGEN




Remarks: (1) Source: "Annual Research Report of 1969" Rice Dep.
(2) Yield : Mean yield of RD1 and C4-63
(3) Another fertilizer application: $P_2O_5$ 75 kg/ha, $K_2O$ 6 kg/ha

# FIGURE A.4 – 23 FARM MECHANIZATION SYSTEM WITH PROJECT

## 1. Paddy

### (a) Type I

| Plowing | Puddling | Transplanting | Spraying | Harvesting | Threshing | Drying | Transportation |
|---|---|---|---|---|---|---|---|
| Heavy tractor with disk plow | Hand tractor with puddling harrow | Man-power | Hand sprayer | Man-power | Thresher with hand tractor power | Sunshine & dryer | Hand tractor with trailer |

### (b) Type II

| Plowing | Puddling | Transplanting | Spraying | Harvesting | Threshing | Drying | Transportation |
|---|---|---|---|---|---|---|---|
| Heavy tractor with disk plow | Hand tractor with puddling harrow | Transplanter | Powered sprayer | Harvestor or Combine | Thresher with hand tractor's power | Sunshine & dryer | Hand tractor with trailer |

## 2. Upland Crops (Vegetable) & Fruit

| Plowing | Harrowing | Sowing & Transplanting | Irrigation | Spraying | Cultivation | Harvesting | Transportation |
|---|---|---|---|---|---|---|---|
| Heavy tractor with disk plow | Hand tractor with rotary | Man-power | Man-power (Furrow irrigation) | Hand sprayer | Hand tractor with cultivator | Man-power | Hand tractor with trailer |

Remarks: (1) Heavy tractor; 4 wheel tractor (more than 50 PH)
(2) Hand tractor; 2 wheel tractor (7 – 8 PH)

Table A.4-39 Capacity of Farm Machinery for Paddy Rice Cultivation (Mechanization System Type I)

| Items | Unit | Plowing | Puddling | Threshing | Drying |
|---|---|---|---|---|---|
| 1. Machinery | | | | | |
| (a) Power | | ~50 PH 4 wheel tractor | 7-8 PH 2 wheel hand tractor | 7-8 PH 2 wheel hand tractor | 5PH Gasoline engine, kerosine burner |
| (b) Impliment | | Disc plow | Puddling harrow | Throw-in type thresher (IRRI type) | Flat type rice dryer (UP type) |
| | | 26"x6 disc | 1.2m width | 1.8m drum | 2 ton bin |
| 2. Capacity of Machinery | | | | | |
| (a) Operational width | m | 1.58 (=26"x2/5x6) | 0.97 | - | - |
| (b) Ope. speed | km/hr | 5.0 | 2.9 | - | - |
| (c) Theoretical ope. capacity 4/ | ha/hr | 0.79 | 0.28 | - | - |
| (d) Field ope. efficiency | % | 85 | 80 | - | - |
| (e) Field ope. capacity | ha/hr | 0.67 | 0.22 | 0.16 (=0.8ton) | 0.20 (=1.0 ton) |
| (f) Field ope. hours 2/ | hr/ha | 1.49 | 4.54 | 6.25 | 5.00 |
| (g) Real ope. efficiency | % | 80 | 80 | 75 | 80 |
| (h) Real ope. hours | hr/ha | 1.86 | 5.68 | 8.33 | 6.25 |
| (i) Ope. times | time | 2 | 3 | 1 | 1 |
| (j) Real ope. hours | hr/ha | 3.72 | 17.0 | 8.33 | 6.25 |
| (k) Real ope. capacity | ha/hr | 0.269 | 0.059 | 0.120 | 0.160 |
| (l) Real ope. days per ha 3/ | day/ha | 0.5 | 2.2 | 1.1 | 0.4 |
| (m) Real ope. capacity per day | ha/day | 2.2 | 0.5 | 1.0 | 2.5 |
| (m) Possible ope. days | day | 70 | 48 | 40 | 40 |
| 3. Coverage per one unit of machinery | | one unit per two farming groups | one unit per one farm household | Two units per one farming group | Three units one management group |

Note: 1/ Field operational efficiency is based on the data for 50m x 160m field plot

2/ Real operational efficiency means the efficiency inclusive of loss time outside the field

3/ One day = 8 hours, but in the case of drying, one day is 16 hours

Table A.4-40 Farm Machinery Cost per Hectare for Paddy Rice Cultivation

1. Fixed Cost

(Unit: Ƀ/ha/crop)

| Machinery | (1) Purchasing Price (Ƀ) | (2) Durable Period (year) | (3) Depreciation Cost 2/ (Ƀ) | (4) Repair Cost (Ƀ) | (5) Other Fixed Cost 3/ (Ƀ) | (6) Total (Ƀ/unit/year) | (7) Coverage per Unit (ha) | (8) Total Cost per ha (Ƀ) |
|---|---|---|---|---|---|---|---|---|
| Heavy tractor | 208,000 | 10 | 18,720 | (1)x0.08 =16,640 | 2,080 | 37,440 | 308 (154ha x 2) | 92 4/ |
| Disc plow | 25,000 | 5 | 4,500 | (1)x0.04 = 1,000 | 250 | 5,750 | | 19 |
| Sub-total | 233,000 | | 23,220 | 15,560 | 2,330 | 41,110 | | 111 |
| 7-8PH Hand tractor | 12,000 1/ | 5 | 2,160 | (1)x0.08=960 | 120 | 3,765 | 8 (4ha x 2) | 471 |
| Puddling harrow | 1,500 | 5 | 270 | (1)x0.02= 30 | 15 | | | |
| Trailer | 1,000 | 5 | 180 | (1)x0.02= 20 | 10 | | | |
| Sub-total | 14,500 | | 2,610 | 1,010 | 145 | 3,765 | | 471 |
| Thresher | 12,000 | 8 | 1,350 | (1)x0.03=360 | 120 | 1,830 | 76 (38ha x 2) | 24 |
| Dryer | 15,000 | 8 | 1,688 | (1)x0.02=300 | 150 | 2,138 | 204 (102ha x 2) | 10 |
| Total | | | | | | | | 616 |

Note:
1/ Price of Thai made hand tractor = Ƀ4,000(Body) + Ƀ8,000(7-8PH diesel engine)
2/ (1) x 0.9 ÷ (2)
3/ (1) x 1% = 0.025%(Insuarance fee) + 0.5%(Garage cost) + 0.1%(Lubricating oil cost)
4/ Ƀ92 = Ƀ122 x $\frac{1,026hr}{1,360hr}$. 1,360hr; Annual average hours of tractor operation in Thailand
1,026hr; 1,360hr - 334hr of estimated operational hours besides paddy rice cultivation.

2. Variable Cost

| Operation | Machinery | (1) Operation Hour per ha (hr/ha) | (2) Fuel Consumption 1/ (ℓ/hr) | (3) Fuel Price (฿/ℓ) | (4)=(1)x(2)x(3) Fuel Cost (฿/ha) | (5)=(4)x13 Fuel Cost Inclusive of Lubricating Oil Cost (฿/ha) |
|---|---|---|---|---|---|---|
| 1. Land preparation for seed-bed | Hand tractor with puddling harrow | 2.6 | L 2.0 | 2.6 | 13.5 | 17.6 |
| 2. Plowing | Heavy tractor with disc plow | 3.7 | L 5.5 | 2.6 | 52.9 | 68.8 |
| 3. Puddling | Hand tractor with puddling harrow | 17.0 | L 2.0 | 2.6 | 88.4 | 114.9 |
| 4. Threshing | Thresher with engine of hand tractor | 8.3 | L 2.0 | 2.6 | 43.2 | 56.2 |
| 5. Drying | Dryer | 2.5 2/ | G+O 0.75 | 4.0 | 7.5 | 9.8 |
| | | | K 1.5 | 1.2 | 4.5 | 5.9 |
| 6. Transportation | Hand tractor with trailer | 7.3 | L 2.0 | 2.6 | 38.0 | 49.4 |
| Total | | | | | | 322.6 |

Remarks: 1/ L: Light oil, G+O: Gasoline mixed with lubricating oil, K: Kerosene
2/ Average hours of 1st and 2nd crops

3. Farm Machinery Cost per Hectare

฿616 + ฿323 = ฿939

Table A.4-41 Labour Requirement of Paddy Rice per Hectare
(With Project)

| Operation | Man-day | Machinery-day | Remarks |
|---|---|---|---|
| 1. Nursery | | | |
| a) Preparation & sowing | 3.0 | 0.3 | Hand tractor with puddling harrow (three times) |
| b) Care of seedling | 2.0 | | |
| Sub-total | 5.0 | 0.3 | |
| 2. Land Operation | | | |
| a) Plowing | 0.5 | 0.5 | Heavy tractor with discplow (cross-wise) |
| b) First puddling | 1.5 | 1.5 | Hand tractor with puddling harrow (cross-wise) |
| c) Second puddling | 0.8 | 0.6 | -do- (one time) |
| d) Repair of dikes | 1.8 | | |
| Sub-total | 4.6 | 2.6 | |
| 3. Transplanting | | | |
| a) Pulling seedlings | 8.0 | | |
| b) Transplanting | 22.0 | | Regular planting |
| Sub-total | 30.0 | | |
| 4. Fertilization | | | |
| a) Basal fertilization | 1.0 | | |
| b) Additional fert. | 1.0 | | |
| Sub-total | 2.0 | | |
| 5. Spraying | | | |
| a) Insecticides | 2.0 | | |
| b) Herbicides | 1.0 | | |
| Sub-total | 3.0 | | |
| 6. Weeding | 11.0 | | |
| 7. Irrigation/Drainage | 6.0 | | |
| 8. Harvesting | | | |
| a) Cutting/Bundling | 20.8 | | |
| b) Hauling/Piling | 3.7 | 0.9 | Hand tractor with trailer |
| c) Threshing | 5.5 | 1.0 | Thesher with hand tractor's engine |
| Sub-total | 30.0 | 1.9 | |
| 9. Post Harvesting | | | |
| a) Drying | 4.0 | 2.5 | Dryer |
| b) Sacking | 2.0 | | |
| c) Piling/Delivery | 1.5 | 0.3 | Hand tractor with trailer |
| Sub-total | 7.5 | 2.8 | |
| Total | 99.1 | 7.6 | |

Table A.4-42 Farm Labour Balance with Project

(Unit: man-day)

| | Area | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Double cropping of paddy rice | 1 ha | 9.0 | 23.5 | 20.4 | 7.0 | 16.3 | 19.6 | 16.8 | 25.0 | 15.1 | 7.5 | 19.8 | 18.2 | 198.2 |
| Vegetables & Fruits | 1 ha | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 360.0 |
| Animal husbandry | 1 unit | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 180.0 |
| Inland fishery | 1 unit | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 180.0 |
| Double cropping of paddy rice | 9,452 ha | 85,878 | 224,237 | 194,657 | 66,794 | 155,535 | 187,023 | 160,000 | 238,550 | 144,084 | 71,565 | 188,932 | 173,664 | 1,891,225 |
| Vegetables | 500 ha | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 180,000 |
| Fruits | 500 ha | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 15,000 | 180,000 |
| Animal husbandry | 250 unit | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 45,000 |
| Inland fishery | 250 unit | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 3,750 | 45,000 |
| Total labour requirement | (1) | 123,378 | 261,737 | 232,157 | 104,294 | 193,035 | 224,523 | 197,806 | 276,050 | 181,580 | 109,065 | 226,432 | 211,164 | 2,341,221 |
| Available farm labour force | (2) | 191,250 | 191,250 | 191,250 | 191,250 | 191,250 | 191,250 | 191,250 | 191,250 | 191,250 | 191,250 | 191,250 | 191,250 | 2,295,000 |
| Balance | (2)-(1) | 67,872 | -70,487 | -40,907 | 86,956 | -1,785 | -33,273 | -6,556 | -84,800 | 9,670 | 82,185 | -35,182 | -19,914 | -46,221 |

Remarks: (1) Available farm labour force = 2,550 household x 3.0 workablemen per household x 25 days per month = 191,250 man-days per month

FIGURE A.4-24 FARM LABOUR BALANCE WITH PROJECT

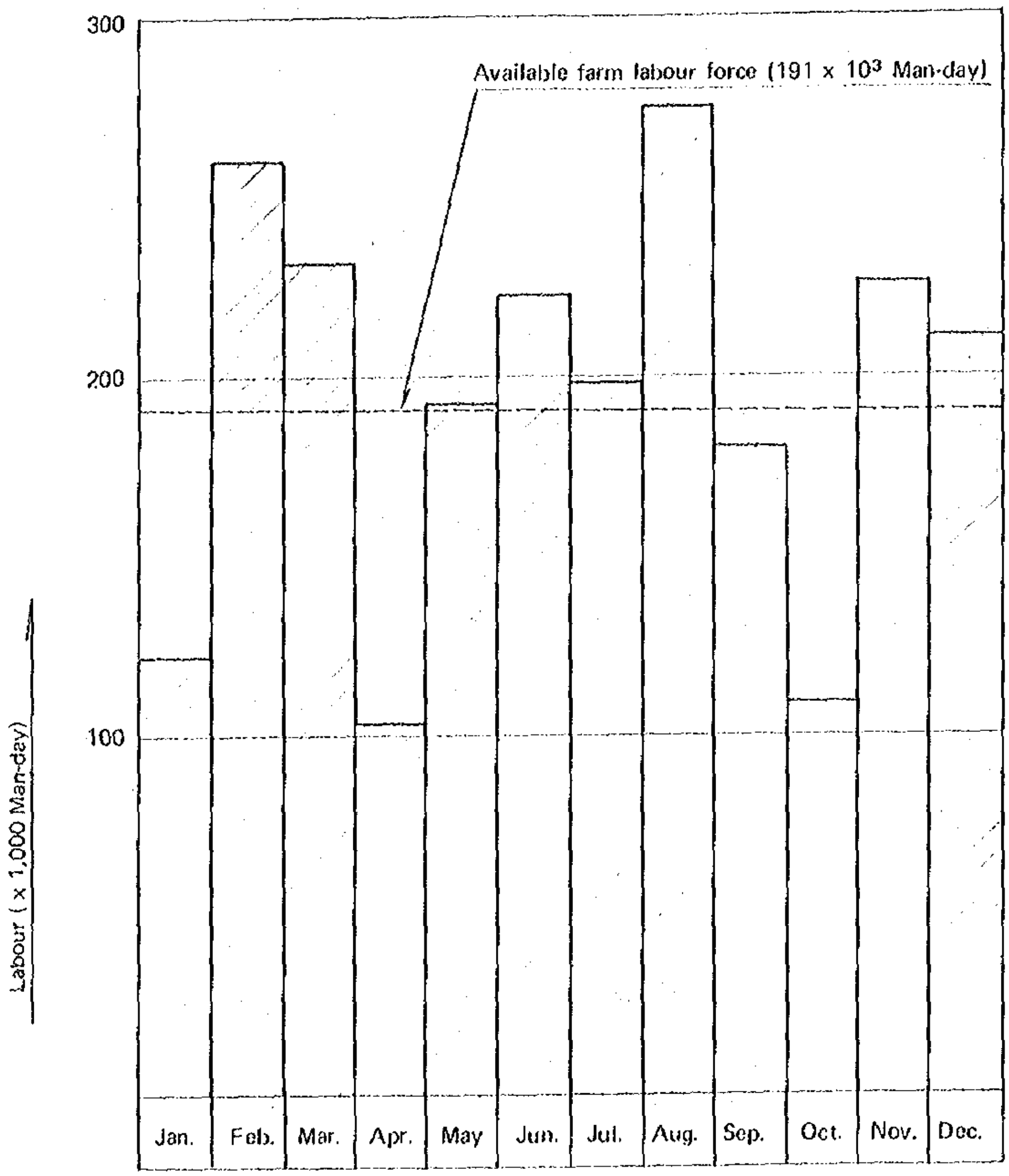


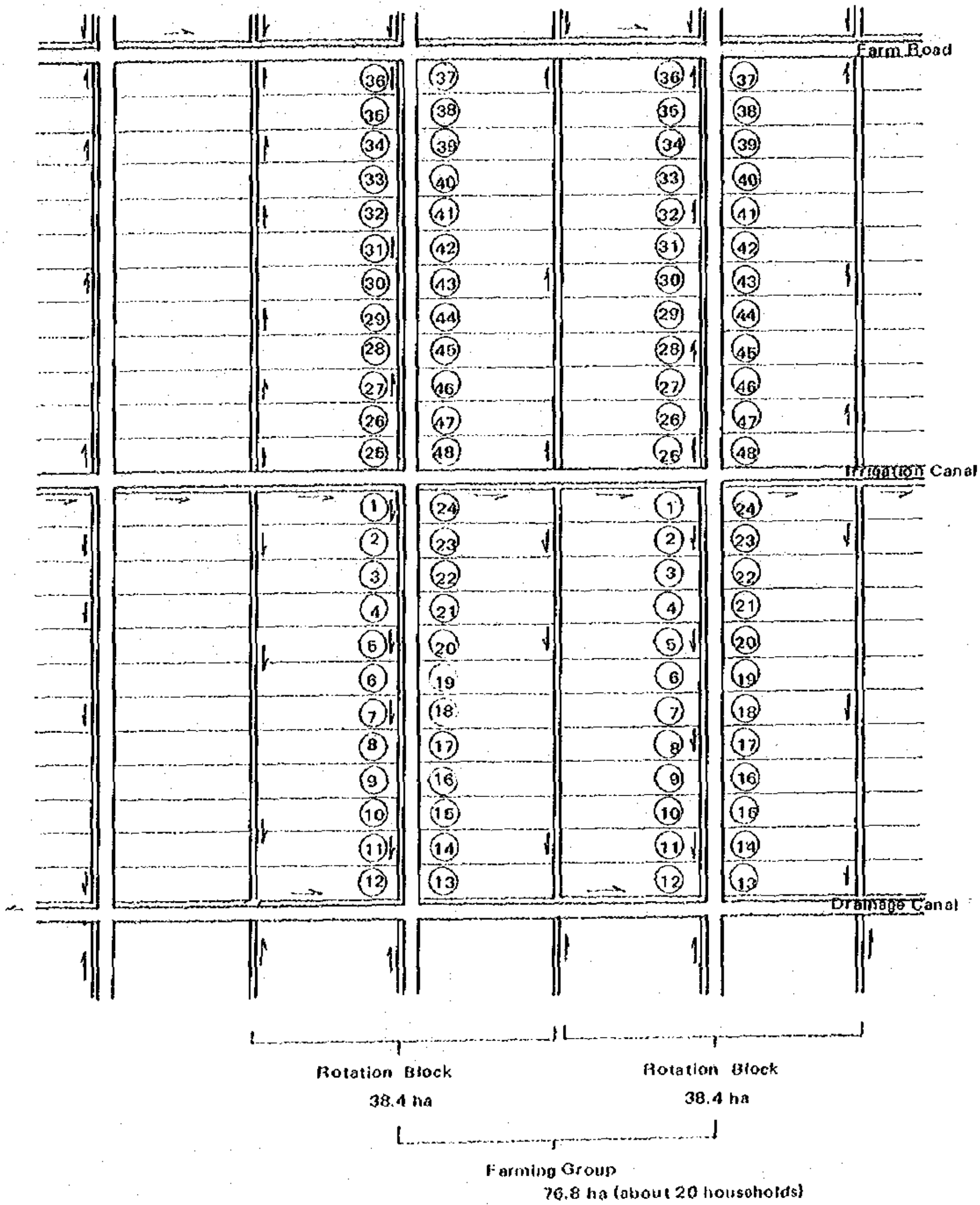
Table A.4-43 Introduction Plan of Animal Hosbandry with Project

| Kind | Managing Method | Production Unit: Raising Scale | Production Unit: Facility | Production Unit: Annual Production | No. of unit in Project Area |
|---|---|---|---|---|---|
| Swine | Integrated hog raising from breeding to fattening | Gilts(♀): 5 head<br>Sire (♂): 1 head<br>Breeded pigs: 80 head/year (7 head, usually)<br>Fattening hogs: 78 head/year (10 head, usually) | Pen of gilts, sire & pigs: 48 $m^2$<br>Grazing ground of gilts & sire: 180 $m^2$<br>Pen of fattening hogs etc.: 35 $m^2$<br>Site area: 580 $m^2$ | Fattening hogs: 78 head (weight, 100 kg/head)<br>Scraped gilt & sire: 2 head (weight, 140 kg/head) | 83 |
| Chicken | Raising "egg and meat type" chicken with introduction of 140 days old chicks | Chicks: 530 bird/year (177 bird, usually)<br>Matured hens: 500 bird, usually | Pen of matured hens: 110 $m^2$<br>Pen of chicks: 25 $m^2$<br>Other facility: 40 $m^2$<br>Site area: 350 $m^2$ | Eggs: 108,000 eggs (216 egg/year x 500 head)<br>Meat: 1,000 kg (2 kg/head x 500 head) | 83 |
| Duck | Raising "egg and meat type" ducks | Matured ducks: 500 bird, usually | Pen of matured ducks: 70 $m^2$<br>Site area 140 $m^2$ | Eggs: 67,500 egg (150 egg x 500 head x 0.9)<br>Meat: 675 kg (1.5 kg/head x 500 head x 0.9) | 84 |
| | | | Total | | 250 |

Table A.4-44 Introduction Plan of Fresh-Water Fish Culture with Project

| Kind | Managing Method | Production Unit: Raising Scale | Production Unit: Facility | Production Unit: Annual Production | No. of unit in Project Area |
|---|---|---|---|---|---|
| Carp | Raising 2 crops per year | No. of fry fishes per crop: 8,000 fish | Fish pond: 1,600 $m^2$ (one rai) | Fresh fishes: 1,500 kg x 2 (weight: 0.7 kg/fish) | 83 |
| Ciclid (Tilapia) | Raising 2 crops per year | No. of fry fishes per crop: 8,000 fish | -do- | Fresh fishes: 1,500 kg x 2 (weight: 0.5 kg/fish) | 83 |
| Cat-fish | Raising one crop per year | No. of fry fishes per crop: 6,000 fish | -do- | Fresh fishes: 7,500 kg (weight: 2.0 kg/fish) | 84 |
| | | | Total | | 250 |

FIGURE A.4 – 25 PLAN OF FARMING GROUP




| | | |
|---|---|---|
| (16) | : | Plot number |
| 1 plot | : | 160 x 50 m = 0.8 ha |
| Rotation Block | : | 0.8ha x 48 plots = 38.4 ha (Period of land preparation 48 days) |
| Farming Group | : | 2 Rotation Blocks = 38.4 ha x 2 = 76.8 ha (about 20 farm households) |
| Management Group: | | 4 Farming Groups = 76.8 x 4 = 307.2 ha (about 80 farm households) |

Table A.4-45. Required Capacity and Cost for Rice Processing Facilities

1. Increment of Paddy Yield

(unit: tons)

| | Planned Yield | | Present Yield | | Increment |
|---|---|---|---|---|---|
| Dry Season | 44,847 (9,542ha x 4.7ton/ha) | - | 7,170 | = | 37,677 |
| Wet Season | 40,076 (9,542ha x 4.2ton/ha) | - | 7,404 | = | 32,674 |
| Total | 84,923 | | 14,574 | | 70,349 |

2. Capacity and Equipment Cost of Warehouse (Unit: ฿'000)

37,677 tons (Dry Season) x 0.77 % = 29,000 tons is the required capacity of warehouse

20,000 tons of paddy will be stored by agricultural cooperatives

Capacity per warehouse : 500 tons (300 $m^2$ x 3 m)
Number of warehouse : 40 (= 20,000 tons/500 tons)
Cost of warehouse : ฿20,000 (= 40 warehouses x 2฿500)

Remaining paddy of 9,000 tons will be stored by each farm household

Capacity per warehouse : 15 tons (10 $m^2$ x 3 m)
Number of warehouse : 600 (= 9,000 tons/15 tons)
Cost of warehouse : ฿3,630 (= 600 warehouses x 2฿3,630)

3. Capacity and Equipment Cost of Rice Mill

A half of stored paddy rice (29,000 tons) in the dry season is sold without milling and the remaining half is milled. The yield of paddy in the wet season is less than that in the dry season. So, the required capacity of mill is as follows:

29,000 tons x 1/2 = 15,000 tons

Paddy of 3,000 tons is polished in the dry season by a mill with the annual capacity of 6,000 tons (per 200 days) and 2,000 tons polished by a mill with the annual capacity of 4,000 tons. Thus, three sets of each milling machine are required to polish paddy of 15,000 tons in the dry season. The equipment costs are as follows:

6,000 tons per year : 3 sets x @฿1,900 = ฿5,700 (Unit: ฿'000)
4,000 tons per year : 3 sets x @฿1,600 = ฿4,800

Total ฿10,500

Table A.4-46. Seeds Demand in Planning Stage

| | Cultivation Acreage (ha) | Seeds Demand per Ha. (ton) | Seeds Demand (ton) | Unit Price (₦'000) | Amount (₦'000) |
|---|---|---|---|---|---|
| Paddy | | | | | |
| Wet Season | 9,542 | 0.04 | 382 | 2.6 | 992 |
| Dry Season | 9,542 | 0.04 | 382 | 2.6 | 992 |
| Sub-total | 19,084 | - | 764 | - | 1,984 |
| Vegetables | | | | | |
| Chinese Cabbage | 500 | 0.004 | 2.0 | 158 | 316 |
| Cabbage | 500 | 0.0005 | 0.3 | 400 | 120 |
| Cauliflower | 500 | 0.0004 | 0.2 | 388 | 78 |
| Sub-total | 1,500 | - | 2.5 | - | 517 |
| | | (trees) | (trees) | | |
| Fruits | 260 | 560 | 14,560 | 0.010 | 1,456 |
| Fish | | | | | |
| Carp | 14 | 50 x 2* | 1,400 | 0.2 * | 280 |
| Tilapia | 13 | 50 x 2* | 1,400 | 0.14* | 196 |
| Catfish | 13 | 38 * | 494* | 2.0 * | 988 |
| Sub-total | 40 | - | 3,294* | - | 1,464 |
| Livestock | | | | | |
| Swine | 11 | 455 | 5 | 100 | 500 |
| Chicken | 6 | 10 | 62.5 | 1 | 63 |
| Duch | 3 | 10 | 62.5 | 1 | 63 |
| Sub-total | 20 | - | 130.0 | - | 626 |
| Total | | | | | 7,330 |

Note: * expressed in thousand fingerlings or ₦'000 per thousand fingerlings

FIGURE A.4 - 26 PLAN OF SEED CENTER

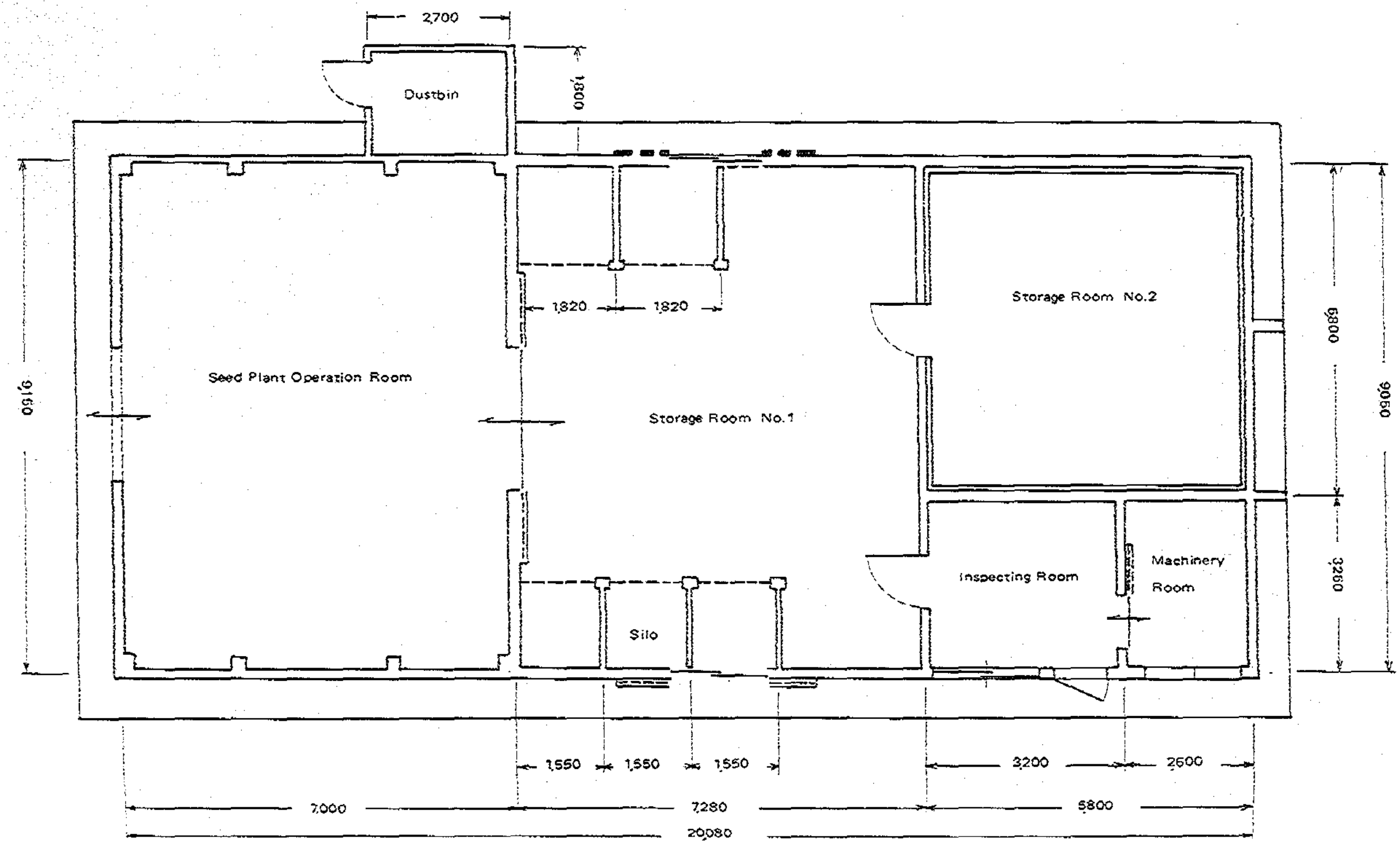


Table A.4-47. Demand of Fertilizers and Agricultural Chemicals

| Crops | Input Qty. per ha. (kg) | Cultivation Acreage (ha) | Input Qty. (ton) | Cost per ha. (฿'000) | Amount (฿'000) |
|---|---|---|---|---|---|
| **Fertilizers** | | | | | |
| Dry season paddy | 262 | 9,542 | 2,500 | 1.049 | 10,010 |
| Wet season paddy | 220 | 9,542 | 2,099 | 0.881 | 8,407 |
| Fruits | 1,960 | 500 | 980 | 8.120 | 4,060 |
| Vegetables | 1,908 | 500 | 954 | 9.540 | 4,770 |
| Total | | | 6,533 | | 27,247 |
| **Other Materials** | | | | | |
| Lime for paddy | 3,000 | 9,542 | 28,626 | 0.270 | 2,576 |
| Lime for fruits & vegetables | 6,000 | 1,000 | 6,000 | 0.936 | 936 |
| Total | | | 34,626 | | 30,759 |
| **Agricultural Chemicals** | | | | | |
| Dry season paddy | 21.2 | 9,542 | 202 | 0.763 | 7,280 |
| Wet season paddy | 21.2 | 9,542 | 202 | 0.763 | 7,280 |
| Fruits | 1,285 | 500 | 642 | 14.805 | 7,403 |
| Vegetables | 1,117 (372 x 3) | 500 | 559 | 19.962 | 9,981 |
| Total | | | 1,605 | | 31,944 |

Table A.4-48. Number of Farm Machinery to be introduced in the Project Area

1. Number of Machinery for One Farming Group (76.8 ha)

| Kinds of Machinery | Case I (set) | Case II (set) | Operational Capacity | |
|---|---|---|---|---|
| Heavy Tractor | 1/2 | - | Plowing: (2 times) | 2.0 ha/day |
| Medium-size Tractor | - | 1 | Plowing: (1 time) | 1.2 ha/day |
| Hand Tractor (7-8 Hp) | 20 | 20 | Puddling: | 1.0 ha/day |
| 7-8 Hp Class Thresher | 2 | 2 | Threshing: | 1.0 ha/day |
| 2 tons Bin Dryer | 1 | 1 | Drying: | 2.5 ha/day |

2. Number of Farm Machinery in the Project (For Farming Groups of Paddy - 9,542 ha, 125 groups)

| Kinds of Machinery | Case I (set) | Case II (set) | Remarks |
|---|---|---|---|
| Heavy Tractor | 63 | - | with disc plow & trailer |
| Medium-size Tractor | - | 124 | with rotary plow & trailer |
| Hand tractor (7-8 Hp) | 2,500 | 2,500 | with puddling harrow and trailer |
| 7-8 Hp Class Thresher | 248 | 248 | without engine |
| 2 tons Bin Dryer | 125 | 125 | |

3. Number of Farm Machinery in the Project (For Farming Groups of Orchard and Vegetables - 500 ha and 6 groups respectively)

| Kinds of Machinery | Case I (set) | Case II (set) | Remarks |
|---|---|---|---|
| Medium-size Tractor | 6 | 6 | one set per group |
| 7-8 Hp Class Power Tiller | 12 | 12 | two sets per group |
| Powered Sprayer | 12 | 12 | two sets per group |

Note: Heavy tractor - over 50 Hp, four wheel type
Medium-size tractor - 20 Hp class, two wheel type

Table A.4-49. Cost of Farm Machinery

| Farm Machinery | Unit | Unit Price (฿'000) | Amount (฿'000) | Unit | Unit Price (฿'000) | Amount (฿'000) |
|---|---|---|---|---|---|---|
| Heavy Tractor | 63 | 253 | 15,939 | - | - | - |
| Medium Size Tractor | 6 | 98 | 588 | 130 | 98 | 12,740 |
| 7-8 HP Hand Tractor | 2,500 | 15 | 37,500 | 2,500 | 15 | 37,500 |
| 7-8 HP Power Tiller | 12 | 25 | 300 | 12 | 25 | 300 |
| 7-8 HP Class Thresher | 248 | 12 | 2,976 | 248 | 12 | 2,976 |
| Powered Sprayer | 12 | 20 | 240 | 12 | 20 | 240 |
| 2 Ton Bin Dryer | 125 | 15 | 1,875 | 125 | 15 | 1,875 |
| Total | | | 59,418 | | | 55,631 |

Note: 1) The prices of tractors are including the prices of their attachments.

2) The price of heavy tractor exclusive of trailer is ฿233,000.

3) Heavy tractor - over 50 Hp, four wheel type
Medium-size tractor - 20 Hp class, four wheel type.

FIGURE A.4 – 27 STANDARD PLAN OF REPAIR SHOP FOR FARM MACHINERY

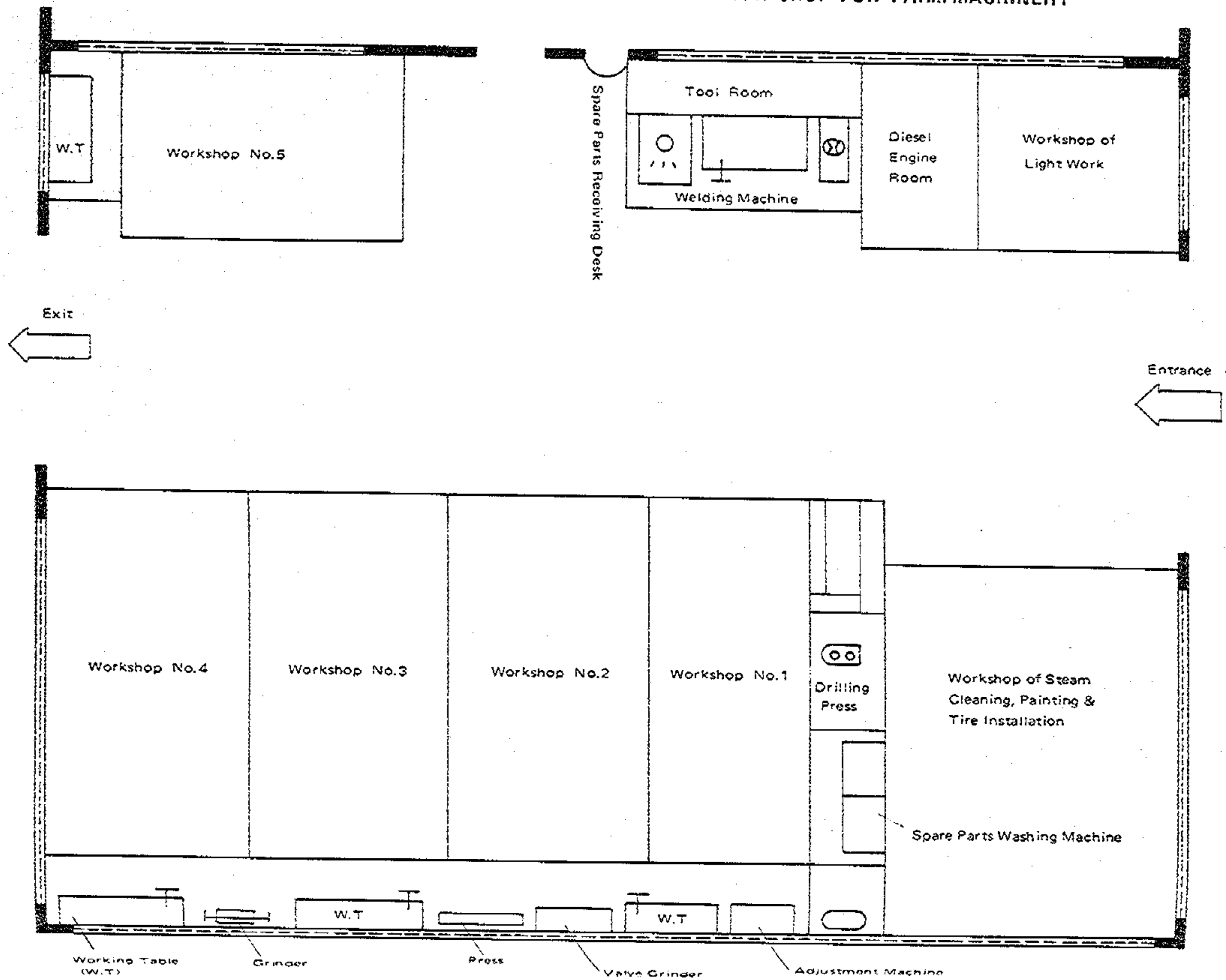


FIGURE A.4 – 28. ANNUAL TRAINING SCHEDULE

Dry season puddling & transplanting period: Jan. 15 – Mar. 15 (60 days)
Wet season puddling & transplanting period: Jul. 15 – Sept. 10 (58 days)

| Training Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water Management (To Common Irrigators) | | | | | | | | | | | | | (B'000) twice 80 |
| Preparation & Guidance for Establishment of ALRC (To ALRC staff) | | | | | | | | | | | | | once 40 |
| Management of Farming Group (To Farming Group Leaders) | | | | | | | | | | | | | four 160 |
| Guidance on Seed Breeding & Paddy Planting (To Persons-in-Charge of Seed Breeding and Farmers) | | | | | | | | | | | | | once 40 |
| Guidance on Agricultural Mechanization (To Persons-in-Charge of Agricultural Mechanization) | | | | | | | | | | | | | twice 80 |
| General Guidance (To Farmers) | Occasional inspections and meetings are applied to farmers' training | | | | | | | | | | | | 100 |
| Total | | | | | | | | | | | | | 500 |

# Table A.4-50. Organization and Operation Expenses of ALRC

## 1. Organization of ALRC

| Personnel | No. of Personnel | Man | Woman | Truck & Boat | Motor Bike | Wireless Telephone | Office Space |
|---|---|---|---|---|---|---|---|
| **1. Director** | | | | | | | |
| Director | 10[1] | - | - | - | - | - | 160[2] |
| Deputy Director | 2 | - | - | - | - | - | |
| **2. Staff** | | | | | | | |
| General Manager | 1 | 1 | - | - | - | - | 10 |
| Div. of General Affairs | 5 | 3 | 2 | - | 1 | - | 30 |
| Div. of Extension | 8 | 6 | 2 | - | 4 | - | 50 |
| Div. of Credits | 9 | 5 | 4 | - | 1 | - | 50 |
| Div. of Sales & Purchasing | 12 | 7 | 5 | 2[3] | 2 | - | 50 |
| Div. of Utilization | 15 | 12 | 3 | 1[4] | 4 | - | 50 |
| Div. of Farm Machinery | 10 | 7 | 3 | 1[5] | 3 | 34 | 50 |
| Div. of Irrigation Water Control | 7 | 5 | 2 | 1[6] | 5 | | 50 |
| Branch (Production Unit) | 8 | 4 | 4 | - | 4 | - | - |
| Total | 75 (87) | 50 | 25 | 5 | 24 | 34 | 500 |

Note:
[1] including each general and vice-general director of ALRC

[2] 160 $m^2$ = 30 $m^2$ (room for general director of ALRC + 50 $m^2$ (meeting room) + 50 $m^2$(directors' room) + 30 $m^2$(preparatory room)

[3] 6-ton truck

[4] boat

[5] 2-ton truck

[6] 2-ton truck

2. Personnel Expenses of ALRC

| Personnel | Yearly Unit Expenses (฿'000) | Number | Amount (฿'000) |
|---|---|---|---|
| 1) Director | | | |
| General Director | 12 | 1 | 12 |
| Vice General Director | 6 | 1 | 6 |
| Director | 3 | 8 | 24 |
| Deputy Director | 3 | 2 | 6 |
| Sub-total | | 12 | 48 |
| 2) Man Staff | | | |
| General Manager | 72 | 1 | * 72 |
| Division Chief | 50 | 7 | *350 |
| Clerk - 1st Class | 30 | 10 | 300 |
| - 2nd Class | 25 | 12 | 300 |
| - 3rd Class | 15 | 9 | 135 |
| Expert | 45 | 11 | *495 |
| Sub-total | | 50 | 1,652 |
| 3) Woman Staff | | | |
| Woman Clerk - 1st Class | 10 | 10 | 100 |
| - 2nd Class | 96 | 15 | 144 |
| Sub-total | | 25 | 244 |
| 4) Others | | | |
| Common Irrigator | 3 | 29 | 97 |
| Leader of Management Group | 3 | 29 | 97 |
| Leader of Farming Group | 1 | 136 | 136 |
| Hired Labor | (1,917 man x ฿30 x 12 mos.) | | 690 |
| Sub-total | | 194 | 1,020 |
| 5) Total | | 281 | 2,964 |

* Paid by the Government (฿917,000). The deduction of ฿917,000 from the total amount of ฿2,964,000 produces ฿2,047,000.

3. Expenses for Preparation and Establishment of ALRC

| Year | Amount (฿'000) |
|---|---|
| 1977 | 500 |
| 1978 | 500 |
| 1979 | 500 |
| Total | 1,500 |

Remarks: Each amount is including the expenses for preparation for land register books and execution of disposition for substitute plots

4. Expenses for the Training by ALRC

| Year | Amount (฿'000) |
|---|---|
| 1977 | 500 |
| 1978 | 500 |
| 1979 | 500 |
| 1980 | 500 |
| 1981 | 500 |
| 1982 | 500 |
| 1983 | 500 |
| Total | 3,500 |

5. Annual Operational Expenses for ALRC

| Expense | Amount (฿'000) |
|---|---|
| Travel | 990 |
| Office Maintenance | 593 |
| Meeting | 100 |
| Fuel & Others | 200 |
| Contingency | 300 |
| Total | 2,183 |

6. Personnel and Operation Expenses Paid by the Government for Execution of Supporting Service

| Government Office | Manager Class @฿72,000 | Expert @฿45,000 | 1st Class Clerk @฿50,000 | 2nd Class Clerk @฿30,000 | 3rd Class Clerk @฿15,000 | Amount |
|---|---|---|---|---|---|---|
| Changwat | - | 1 | - | - | - | 2* |
| | - | 45 | - | 30 | - | 75** |
| Amphoe | - | 1 | - | 1 | - | 2* |
| | - | 45 | - | 30 | - | 75** |
| Tambon | - | - | - | - | 3 | 3* |
| | - | - | - | - | 45 | 45** |
| RID | - | - | 1 | 3 | - | 4* |
| | | | (1) | | | (1) |
| | - | - | 50 | 90 | - | 140 |
| | | | (50) | | | (50) |
| Agric. Cooperative | | | | | | |
| | - | 6 | 3 | 1 | 1 | 11* |
| | | (5) | (2) | | | (7) |
| | - | 270 | 150 | 30 | 15 | 465** |
| | | (225) | (100) | | | (325) |
| Extension | - | 4 | 1 | 3 | - | 8* |
| | | (1) | | | | (1) |
| | - | 180 | 50 | 90 | - | 320** |
| | | (45) | | | | (45) |
| ALRO | 1 | 6 | 5 | 4 | 4 | 20* |
| | (1) | (5) | (4) | | | (10) |
| | 72 | 270 | 250 | 120 | 60 | 772** |
| | (72) | (225) | (200) | | | (497) |
| Operational | | | | | | |
| Expenses for above expenses | | | | | | 608** |
| Total | 1 | 18 | 10 | 13 | 8 | 50* |
| | (1) | (11) | (7) | | | (19) |
| | 72 | 810 | 500 | 390 | 120 | 2,500** |
| | (72) | (495) | (35) | | | (917) |

Note: The expenses in parentheses are for ALRC.
* No. of person
** Amount in ฿1,000

Table A.4-51. Proposed Cropping Area in Accordance with Land Consolidation

| Crops | Block | Unit | 1979 Dry | 1979 Wet | 1980 Dry | 1980 Wet | 1981 Dry | 1981 Wet | 1982 Dry | 1982 Wet | 1983 Dry | 1983 Wet | 1984 Dry | 1984 Wet | 1985 Dry | 1985 Wet | 1986 Dry | 1986 Wet | 1987 Dry | 1987 Wet | 1988 Dry | 1988 Wet | 1989 Dry | 1989 Wet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Paddy | | | | | | | | | | | | | | | | | | | | | | | | |
| Broadcasting | | ton/ha | - | 1.6 | - | 1.6 | - | 1.6 | - | 1.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Area(ha) | - | 2,190 | - | 1,800 | - | 850 | - | 400 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Transplanting | A | ton/ha | 3.0 | 2.2 | 3.0 | 2.6* | 3.4* | 3.0 | 3.7 | 3.4 | 4.0 | 3.8 | 4.3 | 4.2** | 4.7** | 4.2 | 4.7 | 4.2 | 4.7 | 4.2 | 4.7 | 4.2 | 4.7 | 4.2 |
| | | Area(ha) | 540 | 580 | - | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 | 2,500 |
| Transplanting | A+B | ton/ha | 3.0 | 2.2 | 3.0 | 2.2 | 3.0 | 2.6* | 3.4* | 3.0 | 3.7 | 3.4 | 4.0 | 3.8 | 4.3 | 4.2** | 4.7** | 4.2 | 4.7 | 4.2 | 4.7 | 4.2 | 4.7 | 4.2 |
| | | Area(ha) | 290 | 660 | 290 | 660 | - | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 | 2,860 |
| Transplanting | C | ton/ha | 3.0 | 2.2 | 3.0 | 2.2 | 3.0 | 2.2 | 3.0 | 2.6* | 3.4* | 3.0 | 3.7 | 3.4 | 4.0 | 3.8 | 4.3 | 4.2** | 4.7** | 4.2 | 4.7 | 4.2 | 4.7 | 4.2 |
| | | Area(ha) | 780 | 268 | 780 | 268 | 780 | 268 | - | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 |
| Transplanting | C | ton/ha | 3.0 | 2.2 | 3.0 | 2.2 | 3.0 | 2.2 | 3.0 | 2.2 | 3.0 | 2.6* | 3.4* | 3.0 | 3.7 | 3.4 | 4.0 | 3.8 | 4.3 | 4.2** | 4.7** | 4.2 | 4.7 | 4.2 |
| | | Area(ha) | 780 | 265 | 780 | 265 | 780 | 265 | - | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 | 2,182 |
| Fruits | B | ton/ha | 15 | | (-) 18 | | (-) 21 | | (15) 24 | | (21) 27 | | (24) 30 | | (27) 30 | | (30) 30 | | (30) 30 | | (30) 30 | | (30) 30 | |
| | | Area(ha) | 60 | | 100 | | 100 | | 100 | | 100 | | 100 | | 100 | | 100 | | 100 | | 100 | | 100 | |
| | C | ton/ha | 15 | | 15 | | 15 | | (-) 18 | | (-) 21 | | (15) 24 | | (21) 27 | | (24) 30 | | (27) 30 | | (30) 30 | | (30) 30 | |
| | | Area(ha) | 180 | | 180 | | 180 | | 300 | | 400 | | 400 | | 400 | | 400 | | 400 | | 400 | | 400 | |
| Vegetables | A | ton/ha | 8 | | 8 | | 14 | | 20 | | 26 | | 32 | | 38 | | 38 | | 38 | | 38 | | 38 | |
| | | Area(ha) | 39 | | 39 | | 150 | | 150 | | 150 | | 150 | | 150 | | 150 | | 150 | | 150 | | 150 | |
| | B | ton/ha | 8 | | 8 | | 8 | | 14 | | 20 | | 26 | | 32 | | 38 | | 38 | | 38 | | 38 | |
| | | Area(ha) | 20 | | 20 | | 20 | | 150 | | 150 | | 150 | | 150 | | 150 | | 150 | | 150 | | 150 | |
| | C | ton/ha | 8 | | 8 | | 8 | | 8 | | 14 | | 20 | | 26 | | 32 | | 38 | | 38 | | 38 | |
| | | Area(ha) | 47 | | 47 | | 47 | | 47 | | 200 | | 200 | | 200 | | 200 | | 200 | | 200 | | 200 | |
| Total | | | 6,699 | | 7,729 | | 8,800 | | 9,552 | | 10,542 | | 10,542 | | 10,542 | | 10,542 | | 10,542 | | 10,542 | | 10,542 | |

Note: * Initial year after the completion of land consolidation works
** Target year to display full benefits after the completion of land consolidation works
( ) New planting

Table A.4-52. Expected Yield in Accordance with Land Consolidation

(Unit: ton)

| Crop | Block | 1979 | | 1980 | | 1981 | | 1982 | | 1983 | | 1984 | | 1985 | | 1986 | | 1987 | | 1988 | | 1989 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet |
| Paddy | | | | | | | | | | | | | | | | | | | | | | | |
| Broadcasting | ABC | - | 3,504 | - | 2,880 | - | 1,360 | - | 640 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Transplanting | A | 1,620 | 1,276 | - | 6,500 | 8,500 | 7,500 | 9,250 | 8,500 | 10,000 | 9,500 | 10,750 | 10,500 | 11,750 | 10,750 | 11,750 | 10,500 | 11,750 | 10,500 | 11,750 | 10,500 | 11,750 | 10,500 |
| Transplanting | A+B | 870 | 1,452 | 870 | 1,452 | - | 7,436 | 9,724 | 8,580 | 10,582 | 9,724 | 11,440 | 10,868 | 12,298 | 12,012 | 13,442 | 12,012 | 13,442 | 12,012 | 13,442 | 12,012 | 13,442 | 12,012 |
| Transplanting | C | 2,340 | 590 | 2,340 | 590 | 2,340 | 590 | - | 5,200 | 6,800 | 6,000 | 7,400 | 6,800 | 8,000 | 7,600 | 8,600 | 8,400 | 9,400 | 8,400 | 9,400 | 8,400 | 9,400 | 8,400 |
| Transplanting | C | 2,340 | 583 | 2,340 | 583 | 2,340 | 583 | 2,340 | 583 | - | 5,673 | 7,419 | 6,546 | 8,073 | 7,419 | 8,728 | 8,292 | 9,383 | 9,164 | 10,255 | 9,164 | 10,255 | 9,164 |
| Total | | 7,170 | 7,405 | 5,550 | 12,005 | 13,180 | 17,469 | 21,314 | 23,503 | 27,382 | 30,897 | 37,009 | 34,714 | 40,121 | 37,531 | 42,520 | 39,312 | 43,975 | 40,076 | 44,847 | 40,076 | 44,847 | 40,076 |
| Fruits | | | | | | | | | | | | | | | | | | | | | | | |
| | B | 900 | | 1,080 | | 1,260 | | 2,040 | | 2,460 | | 2,760 | | 2,880 | | 3,000 | | 3,000 | | 3,000 | | 3,000 | |
| | C | 2,700 | | 2,700 | | 2,700 | | 3,240 | | 3,780 | | 8,160 | | 9,480 | | 10,680 | | 11,340 | | 12,000 | | 12,000 | |
| Total | | 3,600 | | 3,870 | | 3,960 | | 5,280 | | 6,240 | | 10,920 | | 12,360 | | 13,680 | | 14,340 | | 15,000 | | 15,000 | |
| Vegetable | A | 312 | | 312 | | 2,100 | | 3,000 | | 3,900 | | 4,800 | | 5,700 | | 5,700 | | 5,700 | | 5,700 | | 5,700 | |
| | B | 160 | | 160 | | 160 | | 2,100 | | 3,000 | | 3,900 | | 4,800 | | 5,700 | | 5,700 | | 5,700 | | 5,700 | |
| | C | 376 | | 376 | | 376 | | 376 | | 2,800 | | 4,000 | | 5,200 | | 6,400 | | 7,600 | | 7,600 | | 7,600 | |
| Total | | 848 | | 848 | | 2,636 | | 5,476 | | 9,700 | | 12,700 | | 15,700 | | 17,800 | | 19,000 | | 19,000 | | 19,000 | |

Table A.4-53. Annual Input Materials with Project - Seeds

| Crop | 1979 | | 1980 | | 1981 | | 1982 | | 1983 | | 1984 | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | |
| Paddy | | | | | | | | | | | | | |
| Qty (ton) | (108) | (365) | ( 83) | (290) | ( 70) | (135) | ( 35) | ( 64) | - | - | - | - | |
| Qty (ton) | - | - | - | 100 | 100 | 215 | 215 | 295 | 295 | 382 | 382 | 382 | |
| Amount (Ƀ'000) | 260 | 949 | 216 | 1,014 | 442 | 910 | 650 | 933 | 767 | 992 | 992 | 992 | Unit Price: Ƀ2,600 |
| Fruits | | | | | | | | | | | | | |
| Qty (tree) | - | | 22,400 | | 67,200 | | 56,000 | | - | | - | | Total of tree: 145,600 |
| Amount (Ƀ'000) | - | | 224 | | 672 | | 560 | | - | | - | | |
| Vegetables | | | | | | | | | | | | | |
| Qty (ton) | 0.212 | | 0.212 | | 1.034 | | 1.894 | | 2.5 | | 2.5 | | Unit Price: Ƀ205.6 |
| Amount (Ƀ'000) | 44 | | 44 | | 213 | | 389 | | 514 | | 514 | | |
| Fish | | | | | | | | | | | | | |
| Amount (Ƀ'000) | - | | - | | 320 | | 430 | | 714 | | 1,464 | | |
| Livestock | | | | | | | | | | | | | |
| Amount (Ƀ'000) | - | | - | | 230 | | 250 | | 567 | | 626 | | |
| Total | | | | | | | | | | | | | |
| Amount (Ƀ'000) | 1,253 | | 1,498 | | 2,868 | | 3,212 | | 3,554 | | 4,588 | | |

Note: Figure in parenthisis refers to the quantity of input materials before land consolidation

Table A.4-54. Annual Input Materials with Project — Agricultural Chemicals

| Crops | 1979 | | 1980 | | 1981 | | 1982 | | 1983 | | 1984 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet |
| Paddy | | | | | | | | | | | | |
| Qty (ton) | (152) | (172) | (118) | (232) | ( 99) | ( 61) | ( 50) | ( 31) | | | | |
| Qty (ton) | | | | 53 | 53 | 114 | 114 | 156 | 156 | 202 | 202 | 202 |
| Amount (฿'000) | 1,389 | 1,823 | 1,076 | 3,325 | 3,393 | 5,019 | 5,019 | 6,081 | 5,616 | 7,280 | 7,280 | 7,280 |
| Fruits | | | | | | | | | | | | |
| Qty (ton) | | (216) | | (162) | | (162) | | | | | | |
| Qty (ton) | | | | 128 | | 128 | | 385 | | 514 | | 642 |
| Amount (฿'000) | | 2,487 | | 3,335 | | 3,335 | | 4,428 | | 5,911 | | 7,403 |
| Vegetables | | | | | | | | | | | | |
| Qty (ton) | | - | | - | | 168 | | 335 | | 559 | | 559 |
| Amount (฿'000) | | - | | - | | 2,994 | | 5,989 | | 9,981 | | 9,981 |
| Total | | | | | | | | | | | | |
| Qty (ton) | | 540 | | 693 | | 785 | | 1,071 | | 1,431 | | 1,605 |
| Amount (฿'000) | | 5,699 | | 7,646 | | 14,741 | | 21,517 | | 28,788 | | 31,944 |

Note: Figures in parenthisis refers to the quantity of input materials before land consolidation

Table A.4-55. Annual Input Material with Project — Fertilizers

| Crops | 1979 Dry | 1979 Wet | 1980 Dry | 1980 Wet | 1981 Dry | 1981 Wet | 1982 Dry | 1982 Wet | 1983 Dry | 1983 Wet | 1984 Dry | 1984 Wet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Paddy | | | | | | | | | | | | |
| Qty (ton) | (449) | (334) | (348) | (223) | (293) | (100) | (147) | ( 50) | | | | |
| Qty (ton) | | | | 550 | 655 | 1,179 | 1,404 | 1,619 | 1,928 | 2,090 | 2,500 | 2,099 |
| Amount (B'000) | 1,843 | 1,367 | 1,392 | 3,092 | 3,792 | 5,116 | 6,204 | 6,676 | 8,396 | 7,712 | 10,010 | 8,407 |
| Fruits | | | | | | | | | | | | |
| Qty (ton) | (329) | | (247) | | (247) | | | | | | | |
| Qty (ton) | | | 196 | | 196 | | 980 | | 980 | | 980 | |
| Amount (B'000) | 1,363 | | 1,816 | | 1,816 | | 4,060 | | 4,060 | | 4,060 | |
| Vegetables | | | | | | | | | | | | |
| Qty (ton) | - | | - | | 286 | | 572 | | 954 | | 954 | |
| Amount (B'000) | - | | - | | 1,430 | | 2,860 | | 4,770 | | 4,770 | |
| Others (Lime, Oil) | | | | | | | | | | | | |
| Qty (ton) | - | | - | | - | | - | | - | | 28,626 | |
| Amount (B'000) | - | | 878 | | 1,756 | | 2,634 | | 3,512 | | 3,512 | |
| Total | | | | | | | | | | | | |
| Qty (ton) | 1,112 | | 1,564 | | 2,956 | | 4,772 | | 5,961 | | 6,533 | |
| Amount (B'000) | 4,573 | | 7,178 | | 14,010 | | 22,434 | | 28,450 | | 30,759 | |

Note: Figure in parenthisis refers to the quantity of input materials before land consolidation

Table A.4-56. Expenditures for Supporting Services in Accordance with Land Consolidation

| Facility | 1978 | | 1979 | | 1980 | | 1981 | | 1982 | | 1983 | | 1984 | | 1985 | | 1986 | | 1987 | | 1988 | | 1989 | | 1990 | | 1991 | | Total |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | |
| Seed Center | | | 2,000 | | | | | | | | | | | | | | | | | | | | | | | | | | 2,000 |
| Training Center | 2,000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2,000 |
| ALRC Office | | | | | 2,000 | | | | | | | | | | | | | | | | | | | | | | | | 2,000 |
| Production Unit Office | | | | | 300 | | 300 | | 300 | | 300 | | | | | | | | | | | | | | | | | | 1,200 |
| Motor Pool | | | 1,225 | | | | | | | | | | | | | | | | | | | | | | | | | | 1,225 |
| Spare Machine | | | | 270 | | 490 | | 161 | | 540 | | | | | | | | | | | | | | | | | | | 1,461 |
| Assemble house, etc. | | | | | | | | | | | | | 2,000 | | | | | | | | | | | | | | | | 2,000 |
| Truck, etc. | 200 | | | 144 | | 500 | | 520 | | 144 | | 68 | | | | | | | | | | | | | | | | | 1,576 |
| Water Supply | | | | | | | | | | | 1,400 | | | | | | | | | | | | | | | | | | 1,400 |
| Sub-total | | 2,200 | | 3,639 | | 3,290 | | 981 | | 984 | | 1,768 | | 2,000 | | - | | - | | - | | - | | - | | - | | - | 14,862 |
| Warehouse | | - | | - | | 3,500 | | 3,500 | | 3,500 | | 4,800 | | 3,500 | | 2,400 | | 1,200 | | 1,230 | | - | | - | | - | | - | 23,630 |
| Ricemill | | - | | - | | 1,600 | | 1,900 | | 1,600 | | 1,900 | | 1,600 | | 1,900 | | - | | - | | - | | - | | - | | - | 10,500 |
| Farm Machinery | | - | | - | | 15,037 | | 15,037 | | 15,037 | | 10,520 | | | | | | | | | | | | | | | | | 55,631 |
| Hanger | | - | | - | | 525 | | 525 | | 525 | | 525 | | | | | | | | | | | | | | | | | 2,100 |
| Sub-total | | - | | - | | 20,662 | | 20,962 | | 20,662 | | 17,745 | | 5,100 | | 4,300 | | 1,200 | | 1,230 | | - | | - | | - | | - | 91,861 |
| Operation Cost of ALRC | | 705 | | 1,410 | | 2,115 | | 2,820 | | 3,525 | | 4,230 | | 4,230 | | 4,230 | | 4,230 | | 4,230 | | 4,230 | | 4,230 | | 4,230 | | 4,230 | 48,645 |
| Cost paid by the Government | | 500 | | 1,000 | | 1,500 | | 2,000 | | 2,500 | | 2,500 | | 2,500 | | 2,500 | | 2,500 | | 2,500 | | 2,500 | | 2,500 | | 2,500 | | 2,500 | 30,000 |
| Establishment cost cost of ALRC | | 500 | | 500 | | 500 | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | 1,500 |
| Farmers' training cost | | 500 | | 500 | | 500 | | 500 | | 500 | | 500 | | 500 | | - | | - | | - | | - | | - | | - | | - | 3,500 |
| Sub-total | | 2,205 | | 3,410 | | 4,615 | | 5,320 | | 6,525 | | 7,230 | | 7,230 | | 6,730 | | 6,730 | | 6,730 | | 6,730 | | 6,730 | | 6,730 | | 6,730 | 83,645 |
| Seeds | | 1,253 | | 1,253 | | 1,498 | | 2,868 | | 3,212 | | 3,554 | | 4,588 | | 4,588 | | 4,588 | | 4,588 | | 4,588 | | 4,588 | | 4,588 | | 4,588 | 50,342 |
| Fertilizer | | 4,573 | | 4,573 | | 7,178 | | 14,010 | | 22,434 | | 28,450 | | 30,759 | | 30,759 | | 30,759 | | 30,759 | | 30,759 | | 30,759 | | 30,759 | | 30,759 | 327,290 |
| Agro-chemical | | 5,699 | | 5,699 | | 7,646 | | 14,741 | | 21,517 | | 28,788 | | 31,944 | | 31,944 | | 31,944 | | 31,944 | | 31,944 | | 31,944 | | 31,944 | | 31,944 | 339,642 |
| Sub-total | | 11,525 | | 11,525 | | 16,322 | | 31,619 | | 47,163 | | 60,792 | | 67,291 | | 67,291 | | 67,291 | | 67,291 | | 67,291 | | 67,291 | | 67,291 | | 67,291 | 717,274 |
| Ground Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 907,642 |

Table A.4-57. Cost of Supporting Services Facilities

Annual Interest: 5%
Unit: ฿'000

| Name of Facilities | Cost | Life (year) | Payment per Year | Annual Repair Cost (1%) | Total | ฿/Ha |
|---|---|---|---|---|---|---|
| ALRC Office | 2,000 | 30 | 130 | 20 | 150 | 14 |
| Production Unit Office | 1,200 | 30 | 78 | 12 | 90 | 9 |
| Training Center | 2,000 | 30 | 130 | 20 | 150 | 14 |
| Seed Center | 2,000 | 26 | 139 | 20 | 159 | 15 |
| Motor Pool | 1,225 | 26 | 85 | 12 | 97 | 9 |
| Spare Machine | 1,461 | 8 | 226 | 15 | 241 | 23 |
| Assemble House & Warehouse 1/ | 2,000 | 26 | 140 | 20 | 160 | 15 |
| Truck and Motor Bicycle 2/ | 1,576 | 8 | 244 | 16 | 260 | 25 |
| Water Supply | 1,400 | 26 | 97 | 14 | 111 | 11 |
| Total | 14,862 | | 1,269 | 141 | 1,418 | 135 |

Proposed Area 10,542 ha

| | | |
|---|---|---|
| Farm Machinery | 55,631 | 91,861 is not included in Supporting Services' Cost |
| Hanger | 2,100 | |
| Warehouse | 23,630 | |
| Rice Mill | 10,500 | |

Note: 1/ Inclusive of truck terminal, navigation center and shopping center

2/ Truck - 6 ton : ฿260,000 x 2 = ฿520,000
Pick-Up, 2 ton: ฿100,000 x 2 = ฿200,000
Boat : ฿500,000 x 1 = ฿500,000
Motor Bicycle : ฿ 12,000 x 24 = ฿288,000
Wireless Telephone: ฿ 2,000 x 34 = ฿ 68,000

Total ฿1,576,000

FIGURE A.4 – 28.
TYPICAL PLAN OF VILLAGE RE-ARRANGEMENT

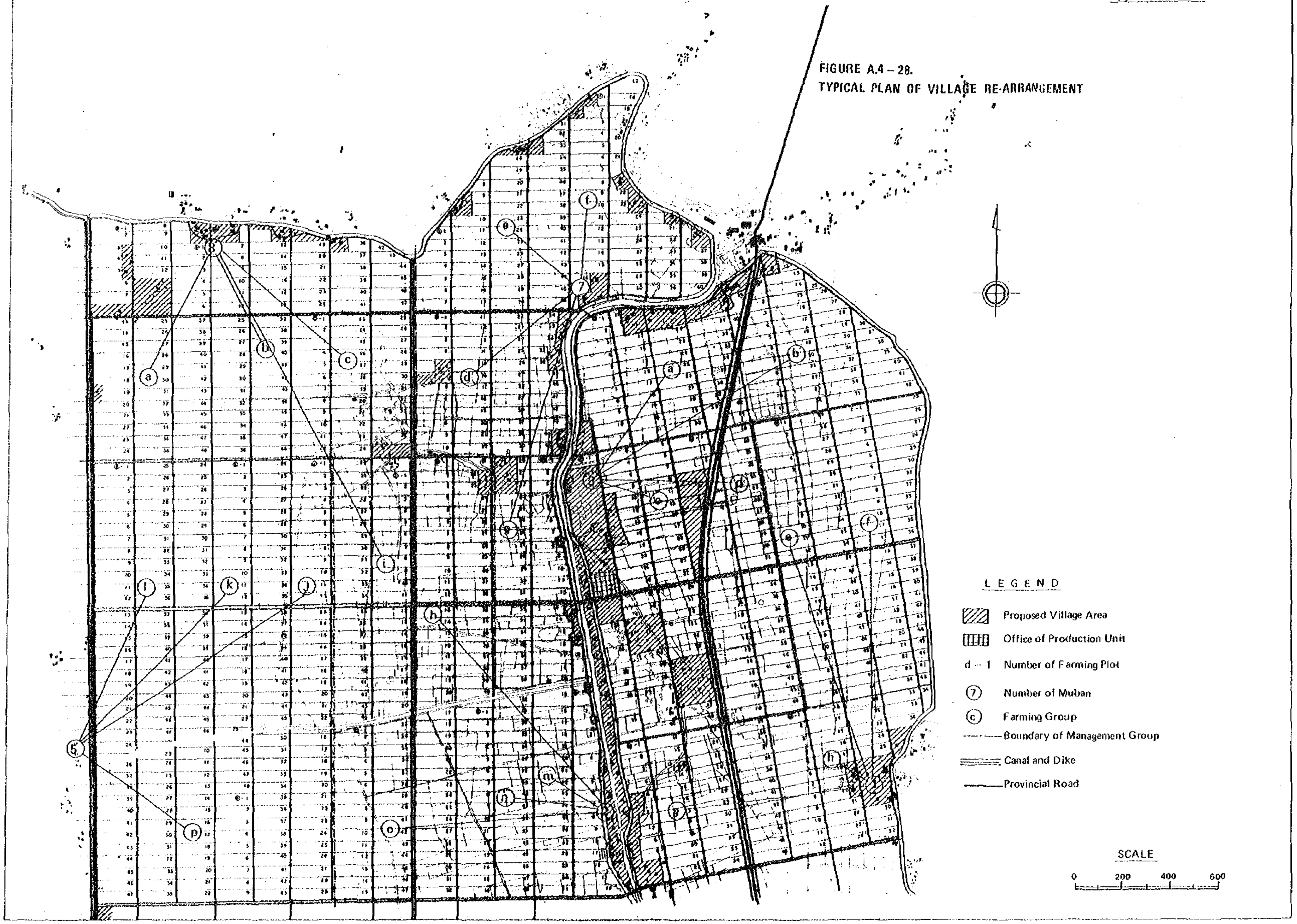
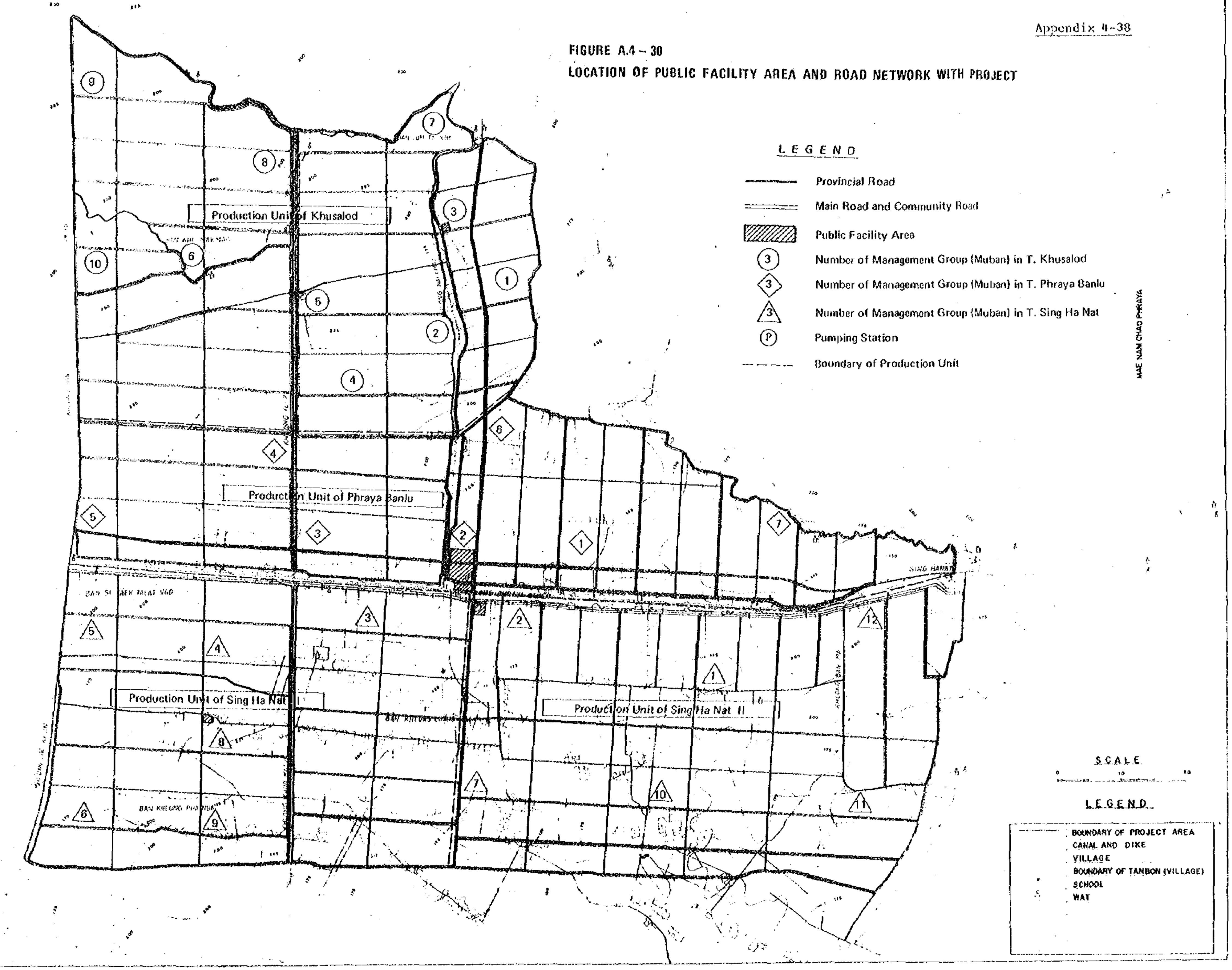


FIGURE A.4 – 30
LOCATION OF PUBLIC FACILITY AREA AND ROAD NETWORK WITH PROJECT



# FIGURE A.4-31 NAVIGATION SYSTEMS IN THE PROJECT AREA

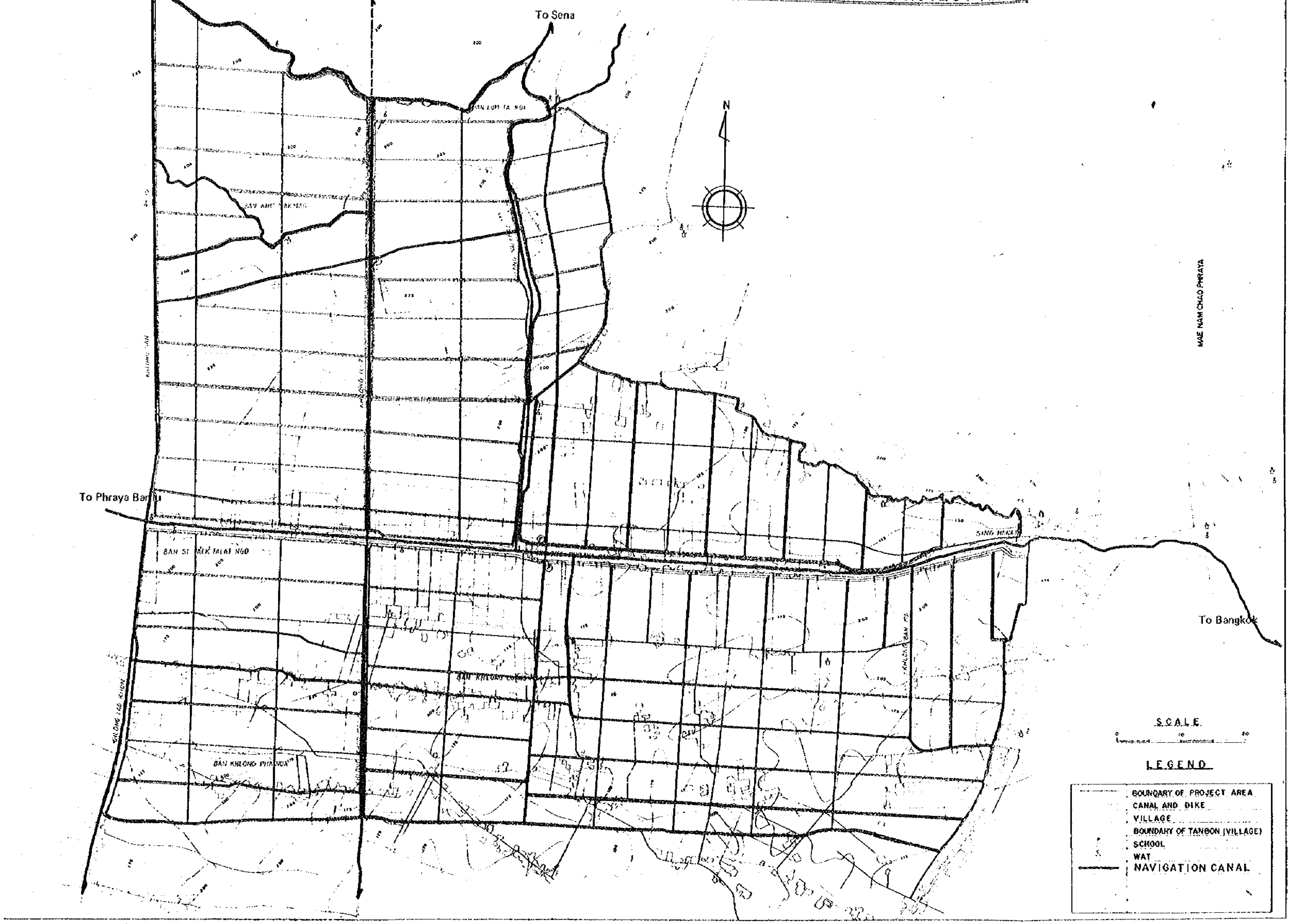
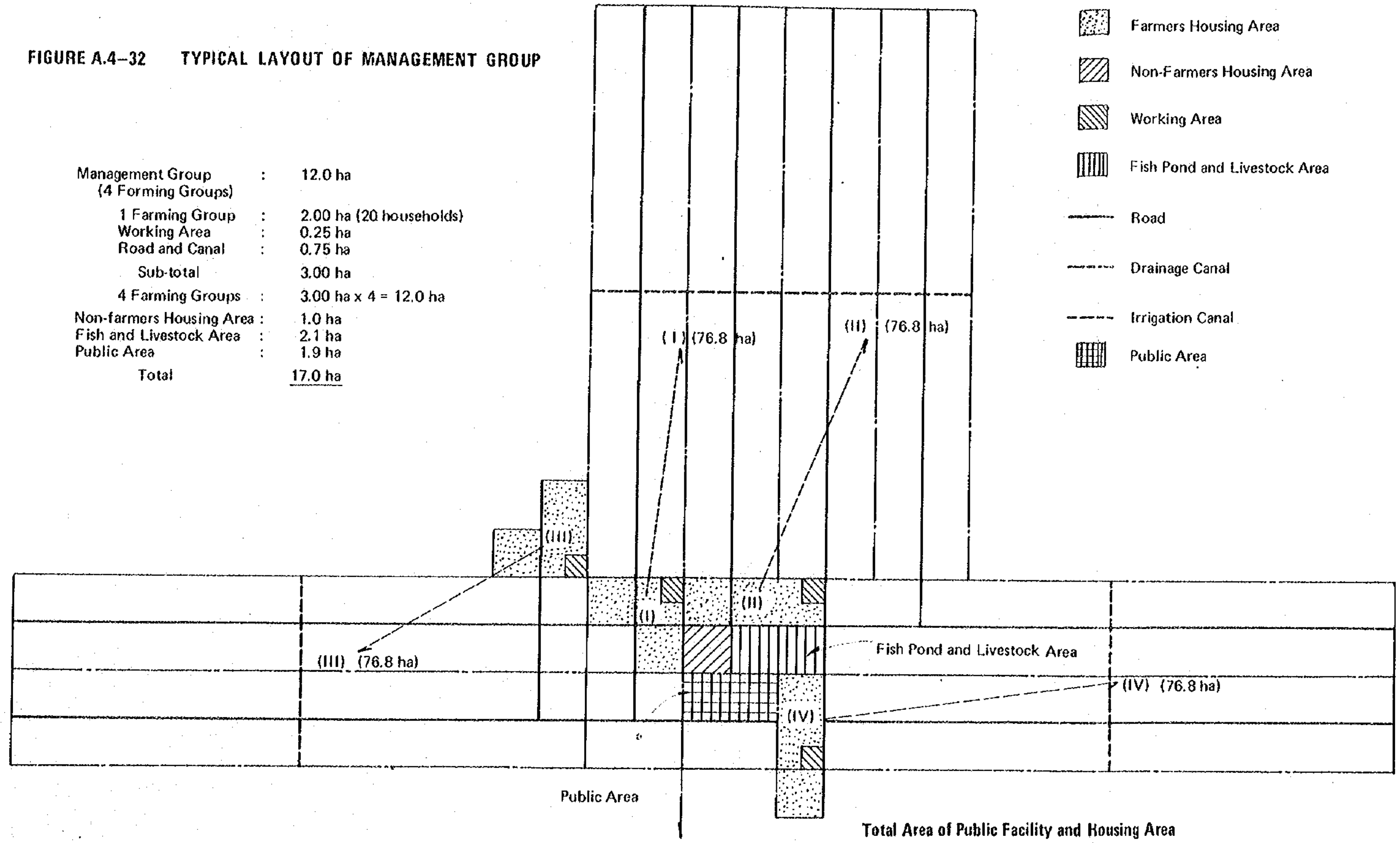


**FIGURE A.4–32 TYPICAL LAYOUT OF MANAGEMENT GROUP**

| | | |
|---|---|---|
| Management Group (4 Forming Groups) | : | 12.0 ha |
| 1 Farming Group | : | 2.00 ha (20 households) |
| Working Area | : | 0.25 ha |
| Road and Canal | : | 0.75 ha |
| Sub-total | | 3.00 ha |
| 4 Farming Groups | : | 3.00 ha x 4 = 12.0 ha |
| Non-farmers Housing Area | : | 1.0 ha |
| Fish and Livestock Area | : | 2.1 ha |
| Public Area | : | 1.9 ha |
| Total | | 17.0 ha |

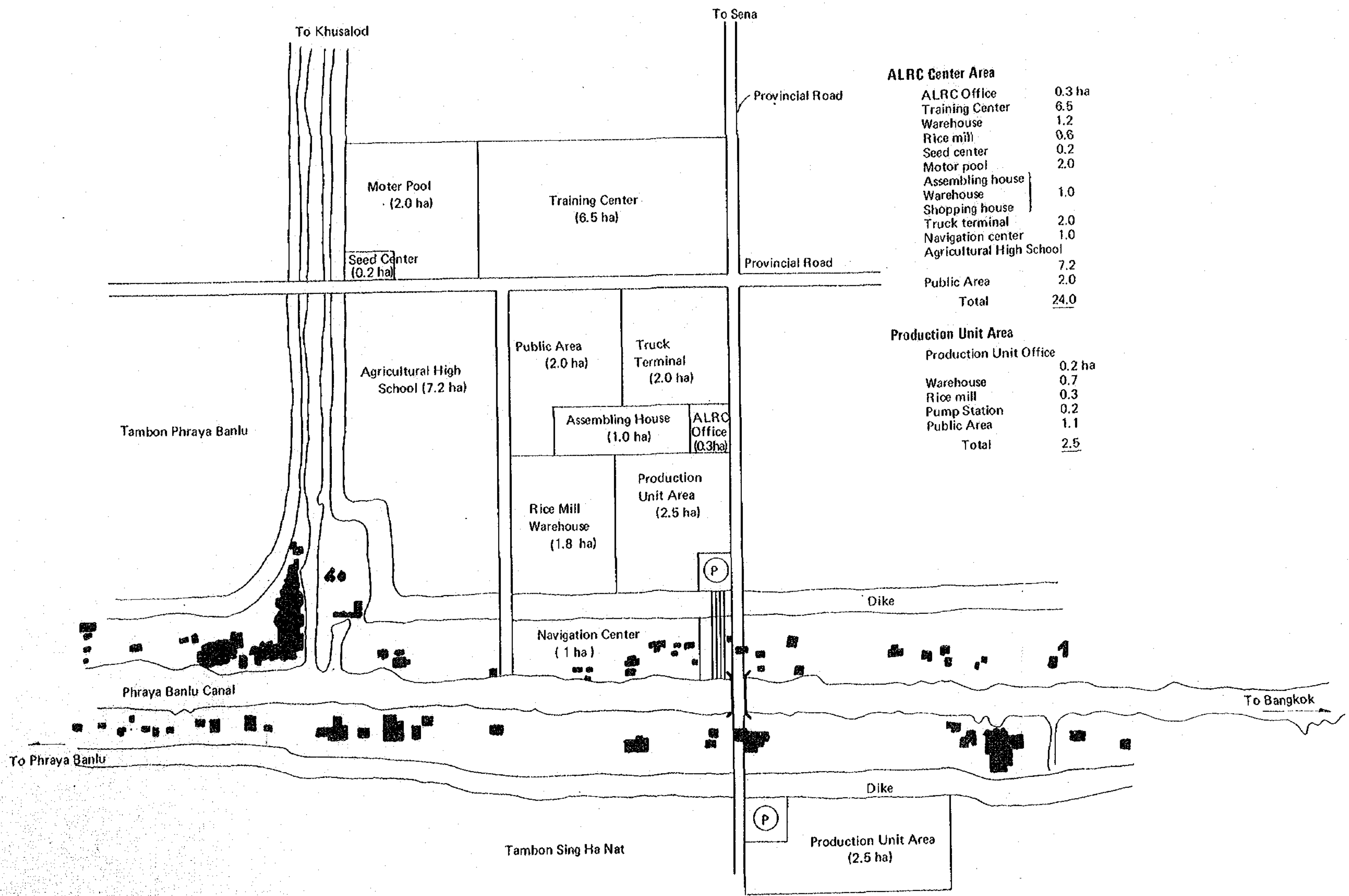



**Total Area of Public Facility and Housing Area**

| | | | |
|---|---|---|---|
| Village Area | : | 17 ha x 29 = | 493 ha |
| ALRC Center Area | : | | *24 |
| Production Unit Area | : | *2.5 ha x 4 = | 10 |
| Temple and School | : | | 85 |
| Others | | | 7 |
| Total | | | 619 ha |

(* : Refer to Figure A.4-32)

FIGURE A.4 – 33 TYPICAL LAYOUT OF PUBLIC FACILITY AREA




**ALRC Center Area**

| | |
|---|---|
| ALRC Office | 0.3 ha |
| Training Center | 6.5 |
| Warehouse | 1.2 |
| Rice mill | 0.6 |
| Seed center | 0.2 |
| Motor pool | 2.0 |
| Assembling house<br>Warehouse<br>Shopping house | 1.0 |
| Truck terminal | 2.0 |
| Navigation center | 1.0 |
| Agricultural High School | 7.2 |
| Public Area | 2.0 |
| Total | 24.0 |

**Production Unit Area**

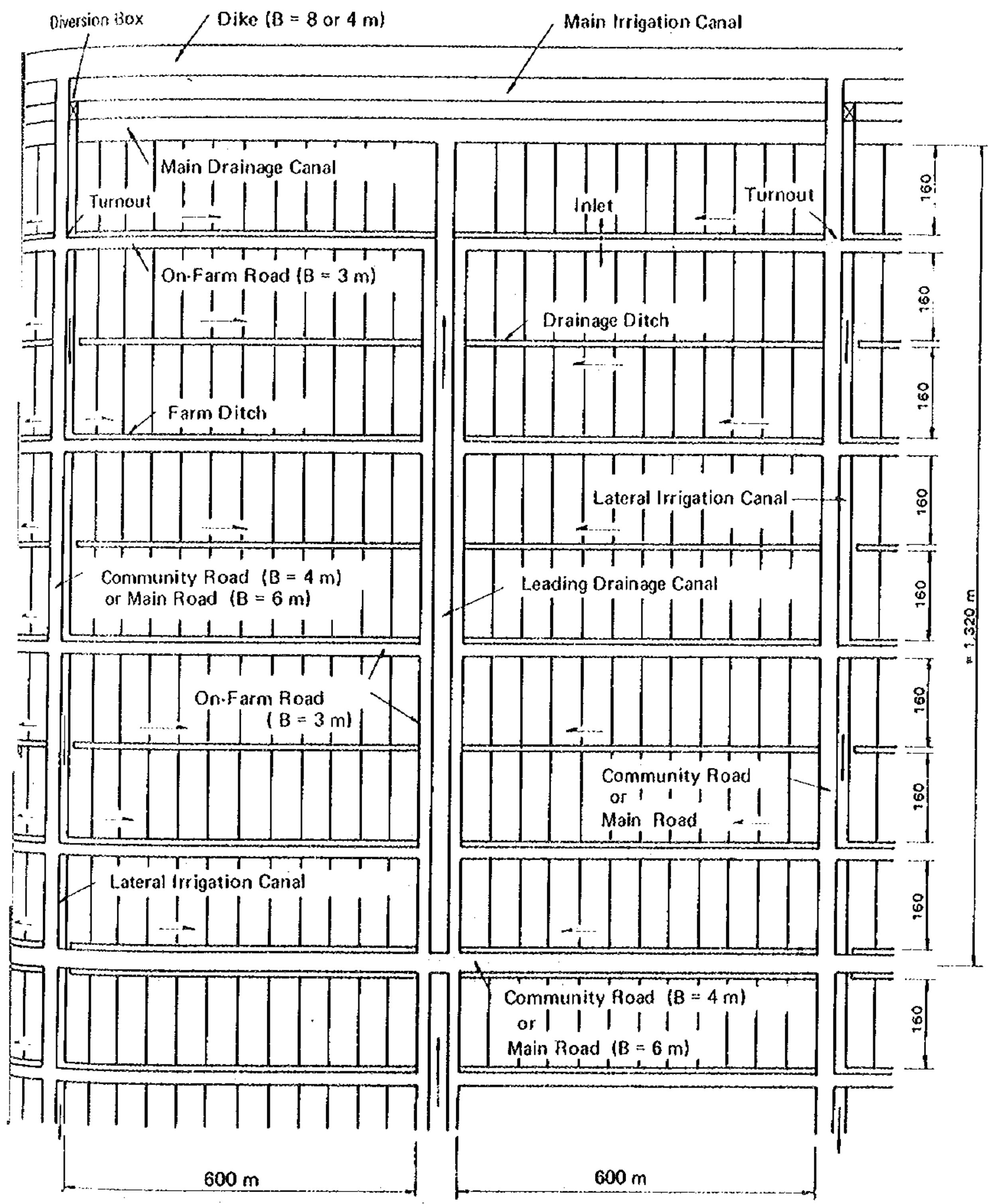
| | |
|---|---|
| Production Unit Office | 0.2 ha |
| Warehouse | 0.7 |
| Rice mill | 0.3 |
| Pump Station | 0.2 |
| Public Area | 1.1 |
| Total | 2.5 |

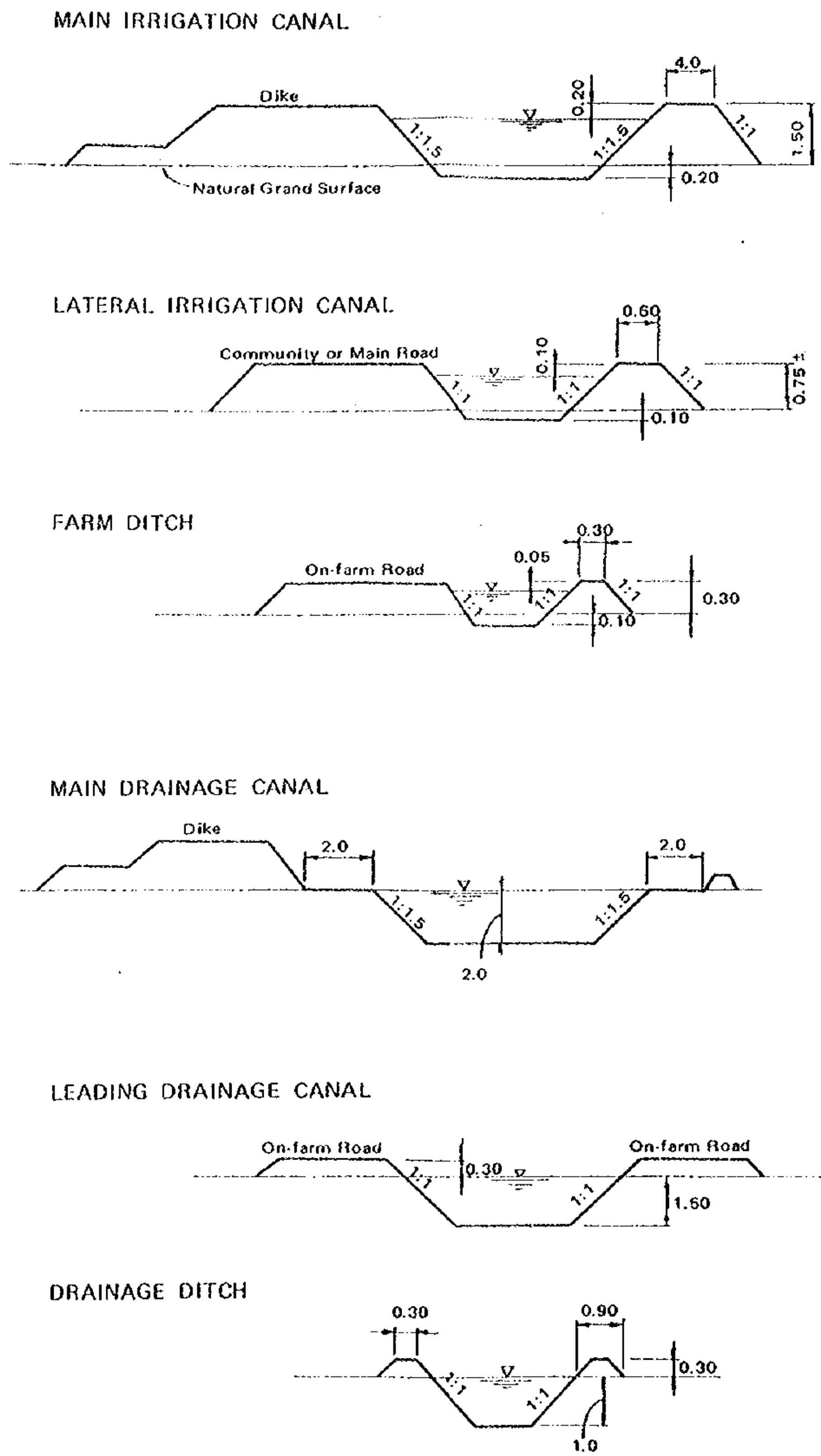
Table A.4-58. Cost for Community Development Plan

| Items | Acreage (ha) | Price per Ha. or House (฿'000) | Cost (฿'000) | Remarks |
|---|---|---|---|---|
| **Land Construction** | | | | |
| ALRC Center area | 24 | 20 | 480 | A part of this cost is included in Table A.4-57. |
| Production Unit Area | 10 | 20 | 200 | - do - |
| Rural Community Area | 375 | 5 | 1,875 | Reclamation costs are not included. |
| Fish pond & Livestock Area | 60 | (42) | (2,500) | Included in the agricultural production cost. |
| Sub-total | 469 | - | 2,555 (5,000) | |
| **House Construction** | | | | |
| Compensation for Transferring | 120* | 10 | 1,200 | Only transfer cost |
| New House | 940* | 40 | 37,600 | For new separate farm house-holds and new comers. |
| Sub-total | 893* | | 38,800 | |
| Total | | | 41,355 (42,655) | |

Note: * houses

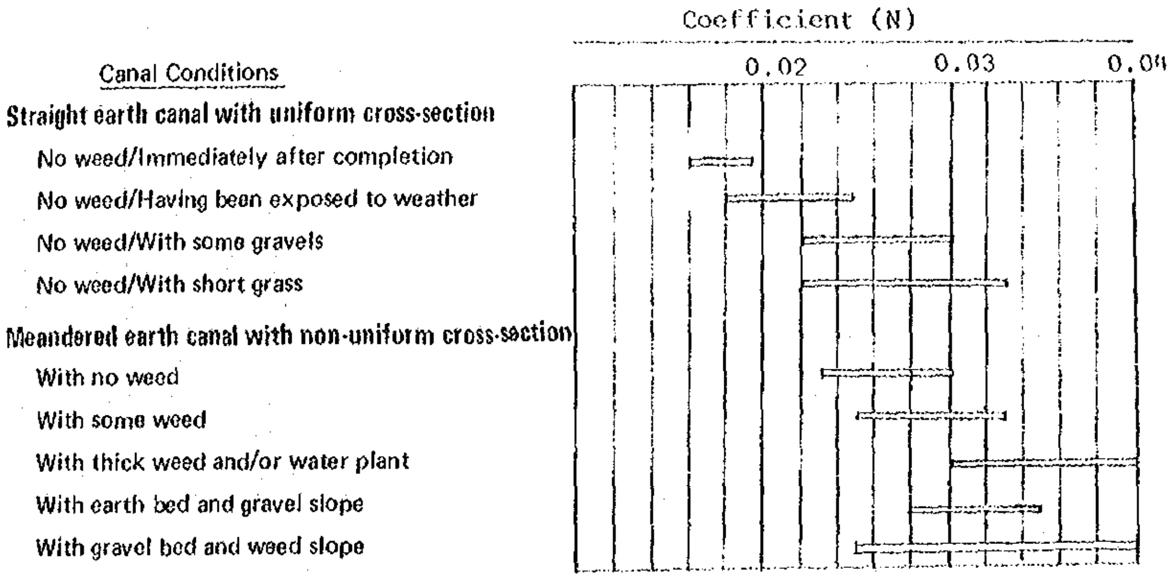
FIGURE A.4 – 34 TYPICAL LAYOUT OF CANALS AND ROADS



## Roughness Coefficient (N)

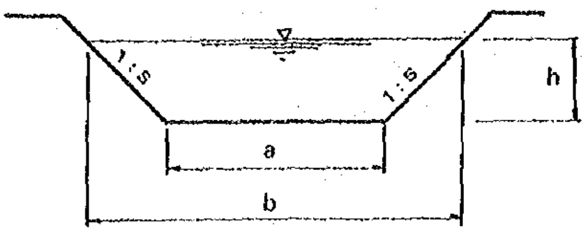
Roughness Coefficient (N) is to be determined taking into full consideration various conditions of the canals, such as roughness of canal surface, vegetation, shape and water velocity, etc. Standard roughness coefficient under various conditions in excavated and dredged canals are shown below.




In the case of natural flow canal where there is much gravel and weeds, the standard value of N is calculated to be approximately 0.035. In this project the canal will be designed on straight line and uniform cross-section in the implementation of land consolidation, and the water velocity would not be so high. Therefore, the N value has been designed as 0.035.

Table A.4-59

Design Discharge for Each Typical Section of Irrigation Canal




Roughness coefficient
n = 0.035

Main irrigation canal

S = 1.5　　b = (a + 4.5)　　$A = \frac{2a + 4.5}{2} \times 1.5 = 1.5a + 3.375$
h = 1.50 m　　p = (a + 5.41)

| a | A | P | R | $R^{2/3}$ | I=1/10,000 $I^{1/2}$=0.01 V | Q | I=1/7,500 $I^{1/2}$=0.01155 V | Q | I=1/5,000 $I^{1/2}$=0.01414 V | Q |
|---|---|---|---|---|---|---|---|---|---|---|
| m | $m^2$ | m | m | | m/s | $m^3/s$ | m/s | $m^3/s$ | m/s | $m^3/s$ |
| 2.0 | 6.375 | 7.41 | 0.860 | 0.904 | 0.258 | 1.645 | 0.298 | 1.900 | 0.365 | 2.327 |
| 3.0 | 7.875 | 8.41 | 0.936 | 0.957 | 0.273 | 2.125 | 0.316 | 2.499 | 0.387 | 3.048 |
| 4.0 | 9.375 | 9.41 | 0.996 | 0.997 | 0.285 | 2.672 | 0.329 | 3.084 | 0.403 | 3.778 |
| 5.0 | 10.875 | 10.41 | 1.045 | 1.030 | 0.294 | 3.197 | 0.340 | 3.698 | 0.416 | 4.524 |
| 6.0 | 12.375 | 11.41 | 1.085 | 1.056 | 0.302 | 3.737 | 0.348 | 4.307 | 0.427 | 5.284 |
| 7.0 | 13.875 | 12.41 | 1.118 | 1.077 | 0.308 | 4.274 | 0.355 | 4.926 | 0.435 | 6.036 |

S = 1.5　　b = (a + 3.0)　　$A = \frac{2a + 3}{2} \times 1.0 = a + 1.5$
h = 1.00 m　　p = (a + 3.61)

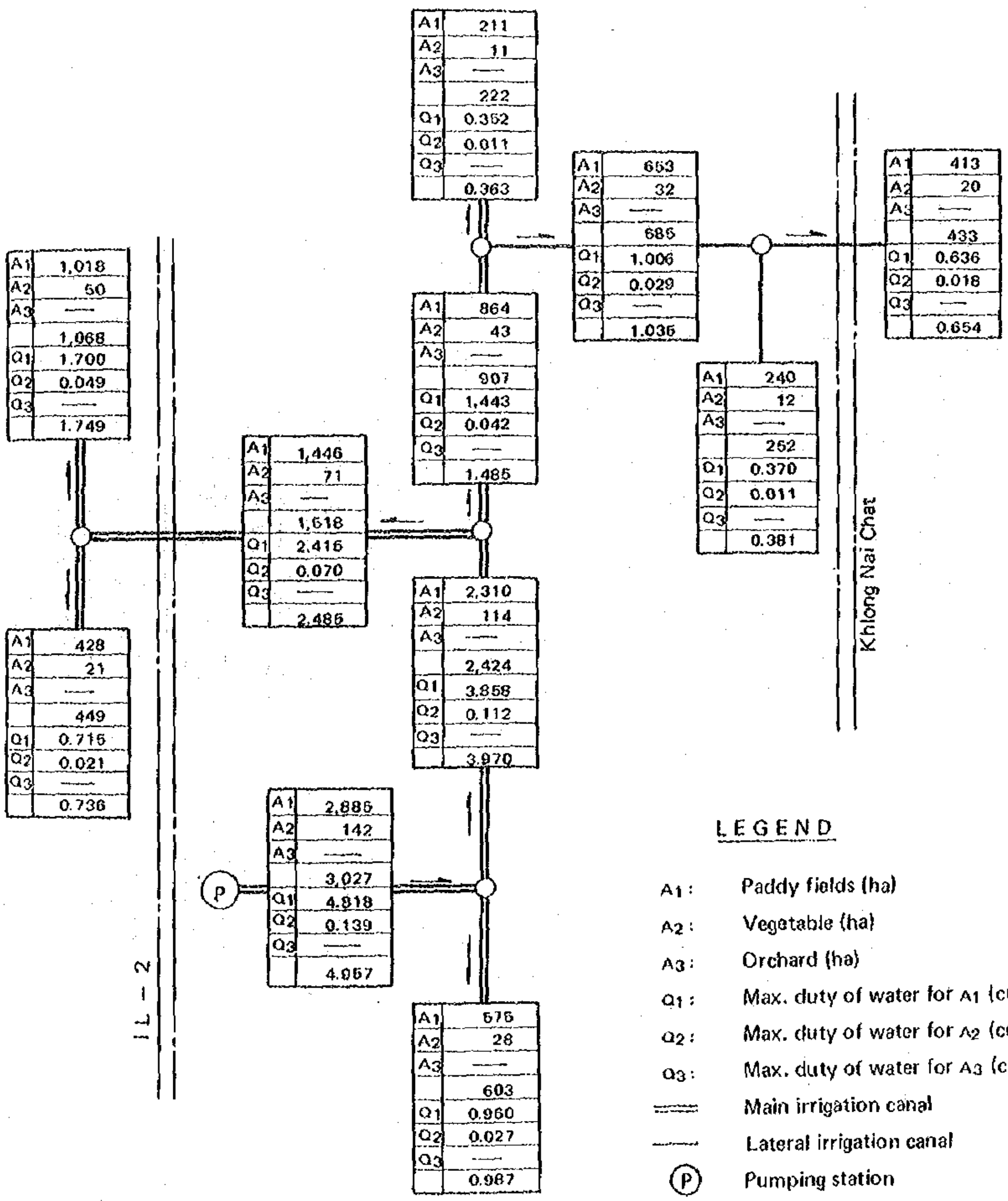
| a | A | P | R | $R^{2/3}$ | I=1/10,000 $I^{1/2}$=0.01 V | Q | I=1/7,500 $I^{1/2}$=0.01155 V | Q | I=1/5,000 $I^{1/2}$=0.01414 V | Q |
|---|---|---|---|---|---|---|---|---|---|---|
| m | $m^2$ | m | m | | m/s | $m^3/s$ | m/s | $m^3/s$ | m/s | $m^3/s$ |
| 2.0 | 3.50 | 5.61 | 0.624 | 0.730 | 0.209 | 0.730 | 0.241 | 0.844 | 0.295 | 1.032 |
| 3.0 | 4.50 | 6.61 | 0.681 | 0.774 | 0.221 | 0.995 | 0.255 | 1.148 | 0.313 | 1.407 |
| 4.0 | 5.50 | 7.61 | 0.723 | 0.805 | 0.230 | 1.266 | 0.266 | 1.463 | 0.325 | 1.789 |
| 5.0 | 6.50 | 8.61 | 0.755 | 0.829 | 0.237 | 1.540 | 0.274 | 1.781 | 0.335 | 2.177 |
| 6.0 | 7.50 | 9.61 | 0.780 | 0.848 | 0.242 | 1.816 | 0.280 | 2.100 | 0.343 | 2.569 |
| 7.0 | 8.50 | 10.61 | 0.801 | 0.863 | 0.247 | 2.100 | 0.285 | 2.423 | 0.349 | 2.967 |

Lateral irrigation canal

S = 1.0 m　　b = a + 1.5　　$A = \frac{2a + 1.5}{2} \times 0.75 = 0.75a + 0.563$
h = 0.75　　p = a + 2.21

| a | A | P | R | $R^{2/3}$ | I=1/10,000 $I^{1/2}$=0.01 V | Q | I=1/7,500 $I^{1/2}$=0.01155 V | Q | I=1/5,000 $I^{1/2}$=0.01414 V | Q |
|---|---|---|---|---|---|---|---|---|---|---|
| m | $m^2$ | m | m | | m/s | $m^3/s$ | m/s | $m^3/s$ | m/s | $m^3/s$ |
| 1.0 | 1.313 | 3.12 | 0.421 | 0.562 | 0.161 | 0.211 | 0.185 | 0.243 | 0.227 | 0.298 |
| 2.0 | 2.063 | 4.12 | 0.501 | 0.631 | 0.180 | 0.371 | 0.209 | 0.431 | 0.255 | 0.526 |
| 3.0 | 2.813 | 5.12 | 0.549 | 0.670 | 0.191 | 0.537 | 0.221 | 0.622 | 0.271 | 0.762 |
| 4.0 | 3.563 | 6.12 | 0.582 | 0.697 | 0.199 | 0.709 | 0.230 | 0.819 | 0.282 | 1.005 |
| 5.0 | 4.313 | 7.12 | 0.606 | 0.716 | 0.205 | 0.884 | 0.236 | 1.018 | 0.289 | 1.246 |
| 6.0 | 5.063 | 8.12 | 0.624 | 0.730 | 0.209 | 1.058 | 0.241 | 1.220 | 0.295 | 1.494 |

FIGURE A.4 – 35. DIAGRAM OF PROPOSED IRRIGATION SYSTEM (BLOCK A)




LEGEND

A1 : Paddy fields (ha)
A2 : Vegetable (ha)
A3 : Orchard (ha)
Q1 : Max. duty of water for A1 (cu.m/s)
Q2 : Max. duty of water for A2 (cu.m/s)
Q3 : Max. duty of water for A3 (cu.m/s)
Main irrigation canal
Lateral irrigation canal
(P) Pumping station

FIGURE A.4 – 36 DIAGRAM OF PROPOSED IRRIGATION SYSTEM (BLOCK B)

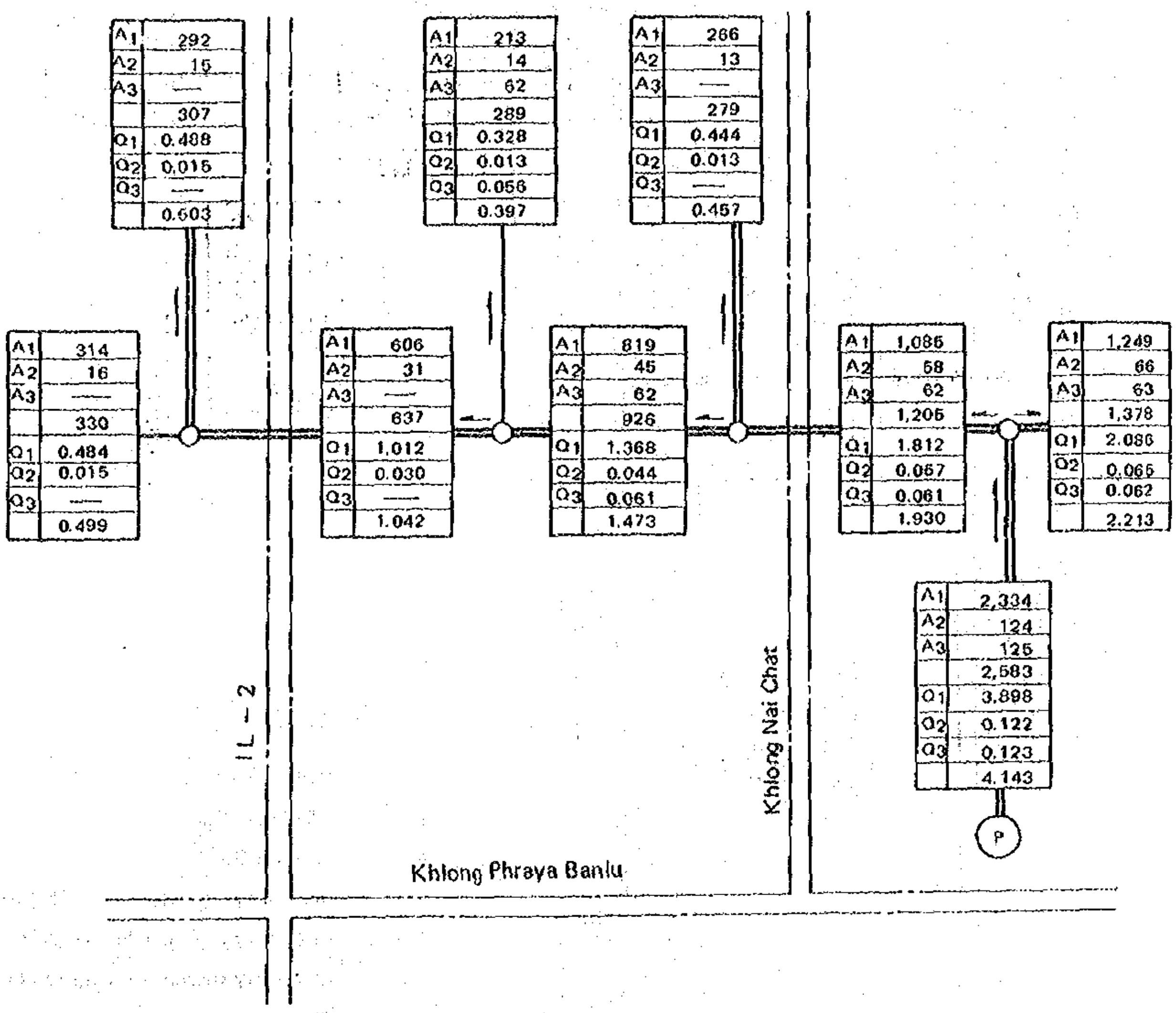
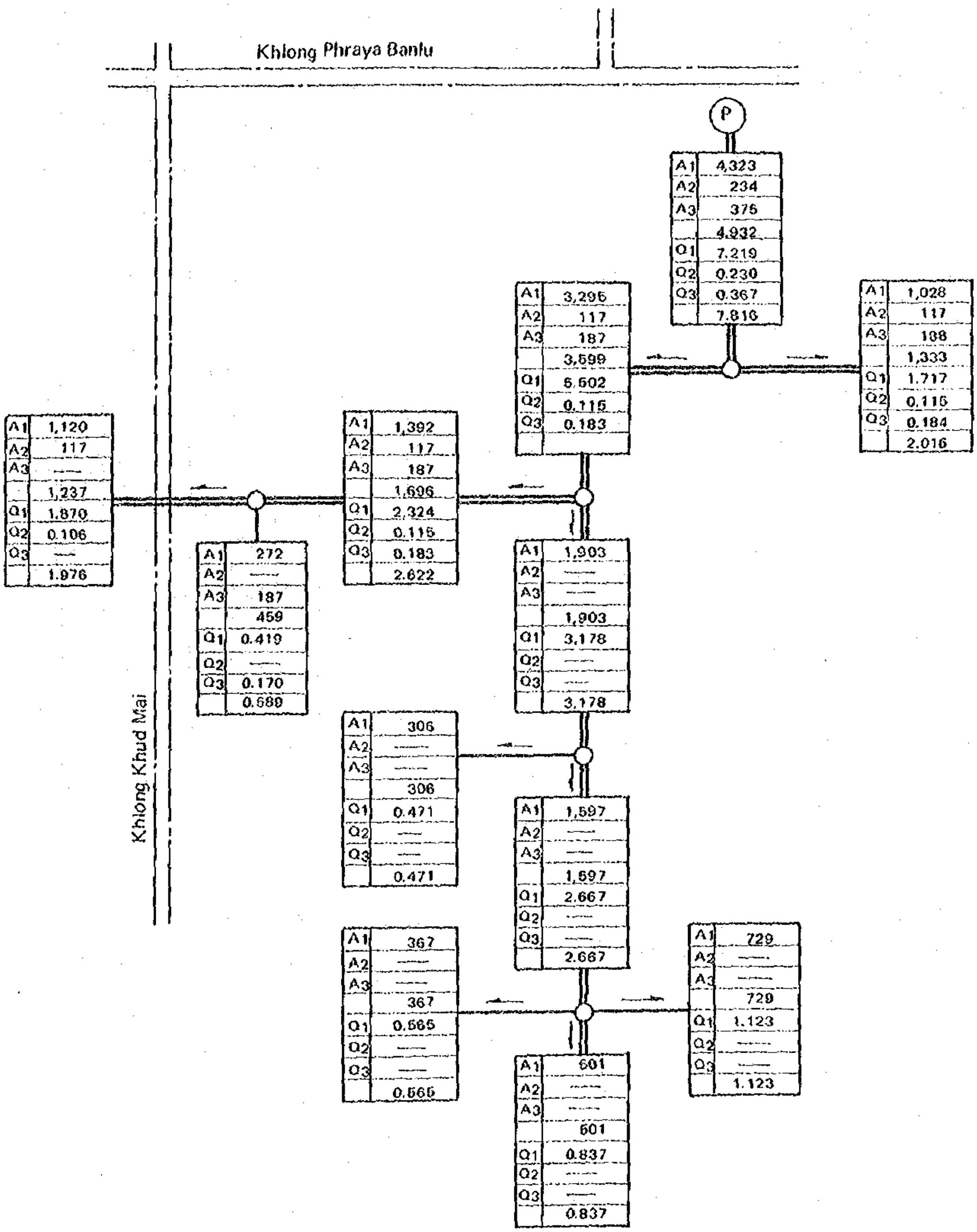


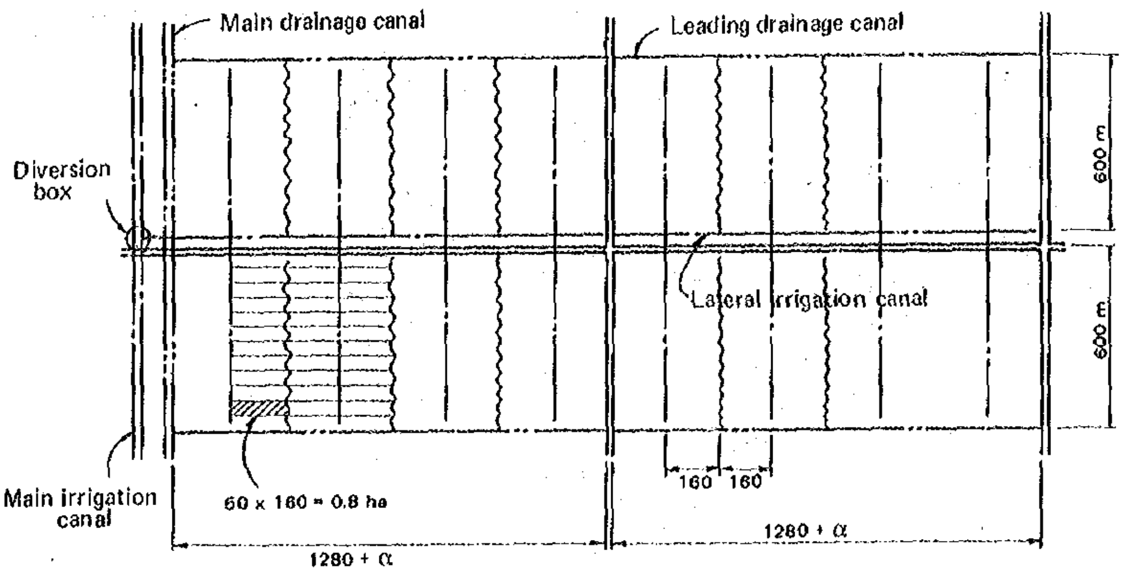
FIGURE A.4 – 37. DIAGRAM OF PROPOSED IRRIGATION SYSTEM (BLOCK C)



## Standard Design of Diversion Box

Water distribution from main irrigation canals to lateral canals will be controled by the diversion box equipped with double gates, in order to execute systematic water distribution. By operating the two gates, orifice gate and diversion gate, constant head (H) between two gates will be kept and these phenomena make it possible to divert the constant irrigation water to meet the design water demand in each irrigation system. Standard design of diversion box is as shown below:

LOCATION OF DIVERSION BOX




1 plot = 0.80 ha

Numbers of plot = 12 x 8 x 4 = 384

Accordingly,

Standard covering area of a diversion box:

= 384 x 0.8 ha = 307.2 ha

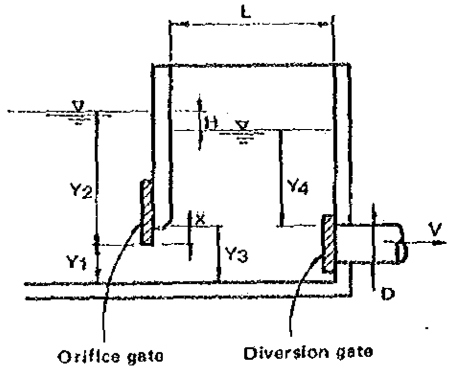
In lateral irrigation canal, a design discharge Q is:

Q = q x A = 0.00154 cu.m/s/ha x 307.2 = 0.473 cu.m/s

Diversion box, being a constant head type (double orifice), is designed by using the theory of submerged orifice, namely, an orifice gate shall be installed so that a discharge will be fixed, and then a diversion gate shall be operated in order that the difference of water level H will be 0.06 m, which is appropriate in standard design to get a required diversion water.

Following is the formula for orifice flow:

$$Q = C.A.\sqrt{2gH}$$




C: Coefficient, 0.65

A: Cross-sectional area of orifice (sq.m)

g: Acceleration of gravity, 9.8 (cu.m/sec$^2$)

Accordingly, the required cross-sectional area of orifice is:

$$A = \frac{Q}{C.\sqrt{2gH}} = \frac{0.473}{0.65 \times \sqrt{19.6 \times 0.06}} = \frac{0.473}{0.705} = 0.671 \text{ sq.m}$$

The cross-section of an orifice gate is a regular square, and the length of a side is equal to $Y_3$. Notwithstanding, the actual height of cross-sectional area of orifice will be determined so that 80 percnet of $Y_3$ may be maximum.

$$0.8Y_3 \times Y_3 = A \qquad 0.8{Y_3}^2 = 0.671$$

$$Y_3 = \sqrt{\frac{0.671}{0.8}} \fallingdotseq 0.95 \text{ m}$$

$Y_2$ will be designed to be equal to or more than $Y_1$ or $Y_3$. Inside length of water tank L will be designed to be more than 2.75 $Y_1$.

$$L > 2.75Y_1 = 2.75 \times 0.8 \times Y_3 = 2.75 \times 0.8 \times 0.95 = 2.09$$

Accordingly, $L = 2.1$ m

$Y_4$ will be designed to be more than 1.75 times of the depth which is equal to the velocity head at the full flow plus 0.08 m.

$$Y_4 > 1.75 \times \left( \frac{V^2}{2g} + 0.08 \right)$$

Where, $Y = 1.2$ m/s±

$$Y_4 > 1.75\ (1.2/19.6 + 0.08) = 0.25 \text{ m}$$

Diameter of diversion pipe is:

$$Q = V.A' = V \times \frac{\pi D^2}{4}$$

A': cross-sectional area of diversion pipe

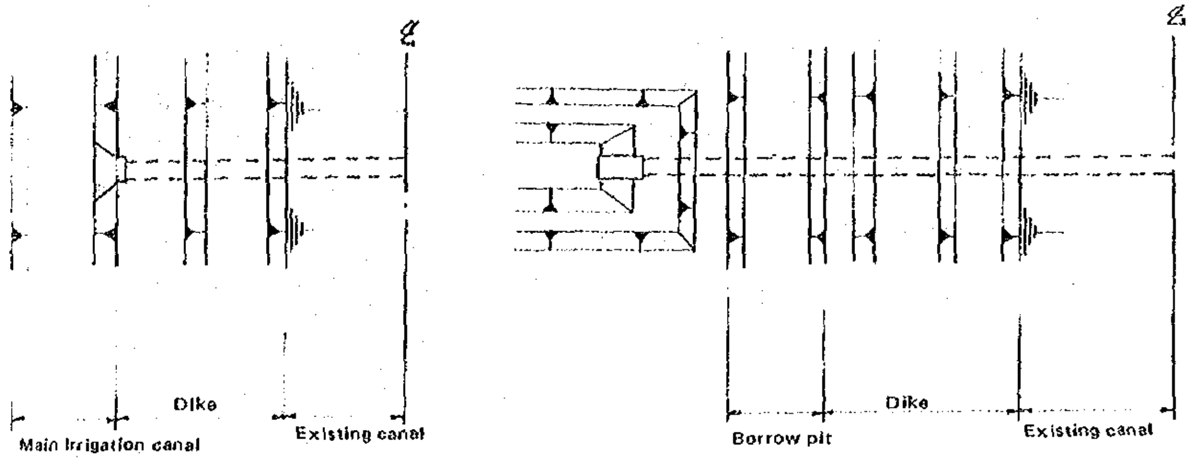
$$D = \sqrt{\frac{Q}{0.7854V}} = \sqrt{\frac{0.473}{0.7854 \times 1.2}} \fallingdotseq 0.70 \text{ m}$$

Typical design of diversion box is shown in Drawing No.6 attached to the main report.

## Design of Culverts in Irrigation Canal

(1) Design of Culvert in Main Irrigation Canal Crossing Existing Canal

Construction sites and design discharge of each block are shown in the diagram of the proposed irrigation system. As the design discharge is not much, pipe culvert with the combination of following two types has been proposed in this project from the economical point of view.




Type A　　　　Type B

As the project area is almost flat, the water head should be kept as much as possible. But protection from the sediment load should be considered in the first priority in the design of culvert for maintenance purpose. In this respect, the design will be made so that the velocity may be 1.0 m/s± for the design discharge and that its diameter may be between ∅600 and ∅1,500, the maximum diameter of ready-made pipes.

Hydraulic dimension and cross-section are summarized below:

## Hydraulic Dimension of Culvert

| Description | Block A | | Block B | | Block C |
|---|---|---|---|---|---|
| Name of existing canal | IL-2 | Nai Chat | IL-2 | Nai Chat | Khud Mai |
| Classification of canal | Main | Lateral | Main | Main | Main |
| Design discharge, Q (cu.m/s) | 2.485 | 0.654 | 1.042 | 1.930 | 1.976 |
| Diameter of culvert, D (mm) | $\phi$1500 | $\phi$900 | $\phi$1100 | $\phi$1500 | $\phi$1500 |
| Velocity V (m/s) | 1.406 | 1.028 | 1.096 | 1.092 | 1.118 |
| Velocity head, $v^2/2g$ (m) | 0.101 | 0.054 | 0.061 | 0.061 | 0.064 |
| Combination of Type | | | | | |
| Upstream | A | B | B | B | B |
| Downstream | A | B | A | A | A |
| Approximate length of culvert, $\ell$(m) | 51 | 89 | 72 | 67 | 72 |
| Loss head, h (m) | 0.20 | 0.20 | 0.17 | 0.14 | 0.15 |

$$h = (fe + fse + f\ell)\ V^2/2g$$

fe : Coefficient of inlet loss 0.5

fse: Coefficient of outlet loss 1.0

f : Coefficient of friction loss

| D(mm) | f |
|---|---|
| $\phi$ 900 | 0.0242 |
| $\phi$1100 | 0.0185 |
| $\phi$1500 | 0.0123 |

The culvert will be protected by concrete for safety purpose and at the inlet and outlet of the culvert, reinforced concrete transition will be paved. At the inlet, a gate will be installed to keep the effective water level and also to divert the water. A screen will also be necessary to protect from inflow of materials such as weed, etc.

At the foundation of culvert, concrete pile will be driven for safety purpose. Typical layout of the culvert is shown in the Drawing No.7 attached to the main report.

(2) Road Crossing for Irrigation Canal

Road crossing for irrigation canal will be made by pipe culvert. Considering the safetiness against the load of vehicles running on the road, the depth from ground surface of road to the top of culvert should be kept at a minimum of 0.6 (standard depth: 1.0 m). To keep such depth, irrigation canal bed should be lowered because of its shallow water depth. At the inlet and outlet of the culvert, a transition having a gentle bed slope of 1:5 should be provided to eliminate a sudden variation of velocity and a sediment load, for which a diameter of culvert will be designed so that the discharge velocity will be 1.0 m/s at the design discharge. To give protection to a slope of road and irrigation canal, gravels should be paved at the inlet and outlet of the culvert.

Road Crossing for Main Irrigation Canal

In case of main irrigation canal, road crossing will be made by using two pipe culverts, because if only one culvert is used, the diameter should be bigger due to much water discharge in the canal and hence lowered. At a point of the main irrigation canal crossing the main road, a gate will be installed so that it can play a role to keep the effective water level. Assuming the irrigation area is 1,000 ha as standard, loss of head is as follows:

Design discharge: $Q = q$ cu.m/s/ha $\times$ A ha
$= 0.00167 \times 1{,}000 = 1.67$ cu.m/s

Diameter of culvert: $D = 1{,}000$ mm $\times 2$

Discharge velocity for each culvert:

$V = 1.067$ m/s

Loss head: $h = (fe + fse + f\ell)\ V^2/2g$

$$= \{0.5 + 1.0 + 0.021(4 \sim 8m)\}\ \frac{1.067^2}{19.6} = 0.08 \text{ m}$$

Road Crossing for Lateral Irrigation Canal

In case of lateral canal, a gate will be installed at every crossing point having each interval of 1.20 km± and such gate will serve as a check gate at the same time. Assuming that one standard irrigation area is 150 ha and the diameter of culvert is ϕ500, the loss of head will be 0.12 m which satisfies every hydraulic dimension, as shown below.

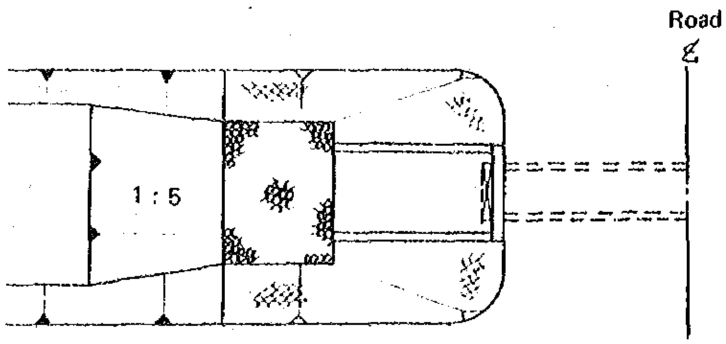
Design discharge: $Q = q$ cu.m/s/ha x A ha
$= 0.00154 \times 150 = 0.231$ cu.m/s

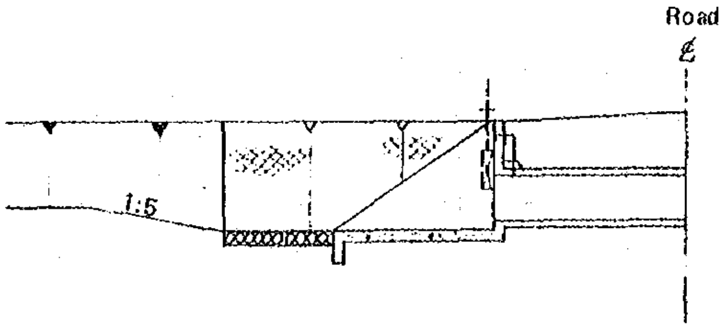
Diameter of culvert: $D = 500$ m

Discharge velocity: $V = 1.176$ m/s

Loss head: $h = (fe + fse + f\ell)\ V^2/2g$

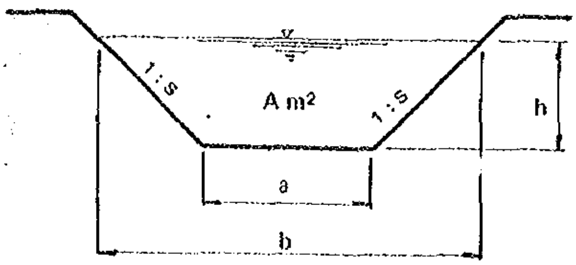
$$= (0.5 + 1.0 + 0.053\ (4 \sim 8m))\ \frac{1.176^2}{19.6} = 0.12 \text{ m}$$




Details are shown in the Drawing No.8 attached to the main report.

Table A.4-60 Design Discharge for Each Typical Section of Drainage Canal




Main drainage canal $S = 1.5$ $b = (a + 6)$ m

$h = 2.0$ m $A = \frac{2.0}{2}(2a + 6) = 2a + 6$

$P = a + 7.21$

| a (m) | A ($m^2$) | P (m) | R (m) | $R^{2/3}$ | I=1/10,000 V (m/s) | I=1/10,000 Q ($m^3/s$) | I=1/5,000 V (m/s) | I=1/5,000 Q ($m^3/s$) | I=1/7,500 V (m/s) | I=1/7,500 Q ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 | 10.0 | 9.21 | 1.086 | 1.057 | 0.302 | 3.020 | 0.427 | 4.270 | 0.349 | 3.490 |
| 4.0 | 14.0 | 11.21 | 1.249 | 1.160 | 0.331 | 4.640 | 0.469 | 6.566 | 0.383 | 5.362 |
| 6.0 | 18.0 | 13.21 | 1.363 | 1.229 | 0.351 | 6.321 | 0.497 | 8.946 | 0.406 | 7.308 |
| 8.0 | 22.0 | 15.21 | 1.446 | 1.279 | 0.365 | 8.039 | 0.517 | 11.374 | 0.422 | 9.284 |
| 10.0 | 26.0 | 17.21 | 1.511 | 1.317 | 0.376 | 9.783 | 0.532 | 13.832 | 0.435 | 11.310 |

Lateral drainage canal $S = 1.0$ $b = (a + 3)$ m

$h = 1.50$ $A = \frac{1.50}{2}(2a + 3) = 1.5a + 2.25$

$P = (a + 4.24)$ m

| a (m) | A ($m^2$) | P (m) | R (m) | $R^{2/3}$ | I=1/10,000 $I^{1/2}$=0.01 V (m/s) | I=1/10,000 $I^{1/2}$=0.01 Q ($m^3/s$) | I=1/5,000 $I^{1/2}$=0.01414 V (m/s) | I=1/5,000 $I^{1/2}$=0.01414 Q ($m^3/s$) | I=1/7,500 $I^{1/2}$=0.01155 V (m/s) | I=1/7,500 $I^{1/2}$=0.01155 Q ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 | 5.25 | 6.24 | 0.841 | 0.891 | 0.255 | 1.337 | 0.360 | 1.890 | 0.294 | 1.544 |
| 4.0 | 8.25 | 8.24 | 1.001 | 1.001 | 0.286 | 2.360 | 0.404 | 3.333 | 0.330 | 2.723 |
| 6.0 | 11.25 | 10.24 | 1.099 | 1.065 | 0.304 | 3.423 | 0.430 | 4.838 | 0.351 | 3.948 |
| 8.0 | 14.25 | 12.24 | 1.164 | 1.107 | 0.316 | 4.507 | 0.447 | 6.370 | 0.365 | 5.201 |

FIGURE A4 – 38 DIAGRAM OF PROPOSED DRAINAGE SYSTEMS (BLOCK A)

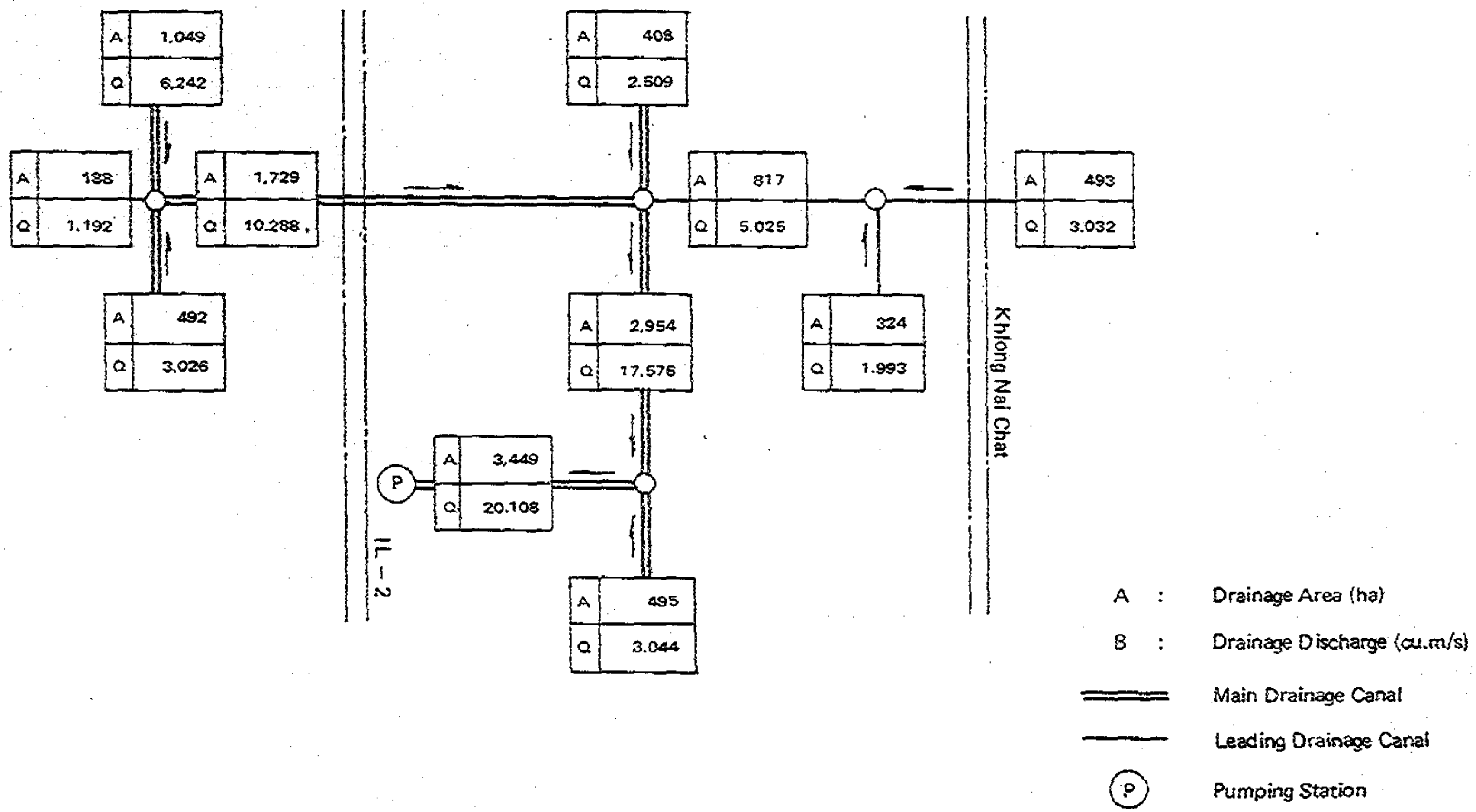


FIGURE A.4 – 39 DIAGRAM OF PROPOSED DRAINAGE SYSTEMS (BLOCK B)

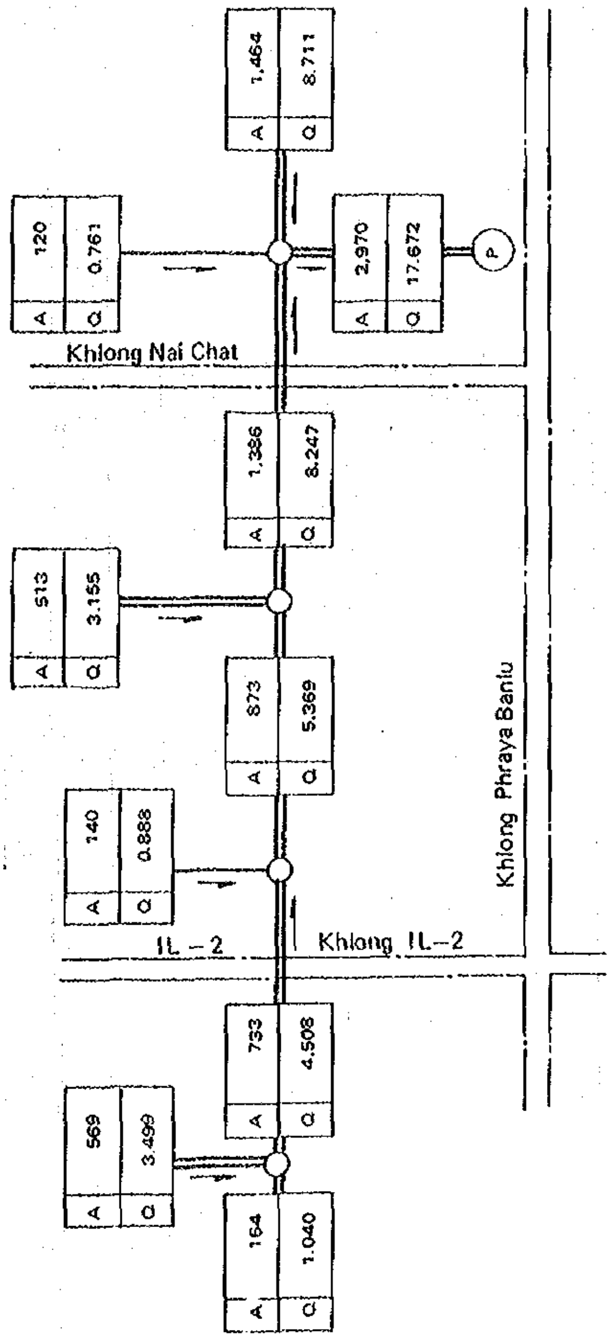
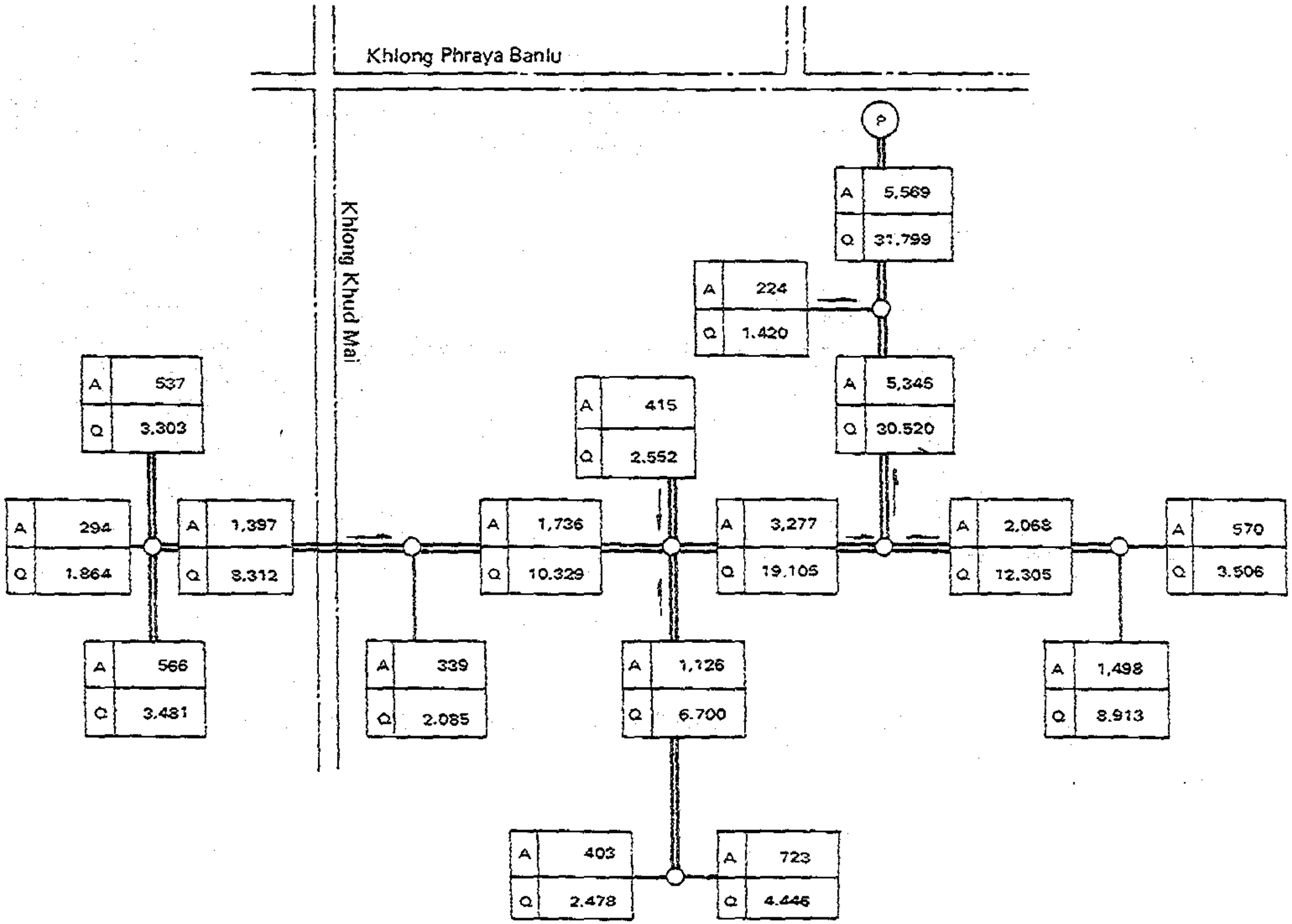


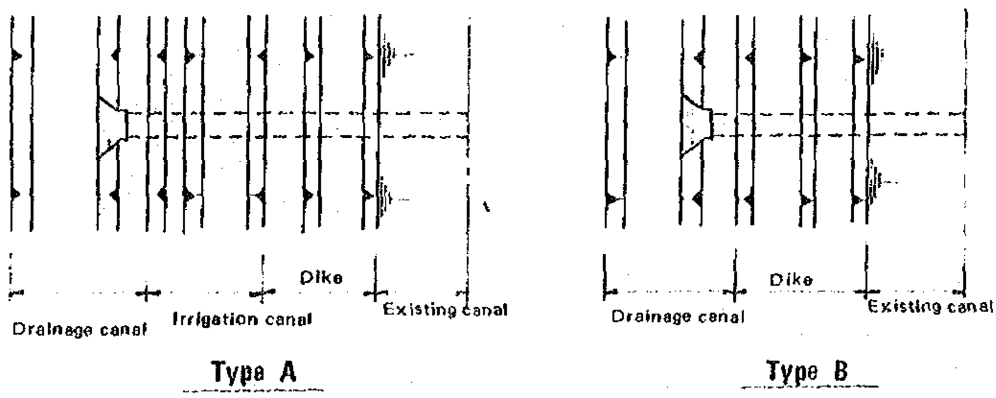
**FIGURE A.4 – 40 DIAGRAM OF PROPOSED DRAINAGE SYSTEM (BLOCK C)**



## Design of Culverts in Drainage Canal

(1) Design of Culvert in Main Drainage Canal Crossing Existing Canal

Construction sites and design discharge of each block are shown in the diagram of proposed drainage system. Because of much discharge volume of the main drainage canal, the culvert will be designed by reinforced concrete culvert with the combination of two types as follows.




For the protection from the sediment load in the culvert, the design will be made so that the discharge velocity may be 1.0 m/s± against the design discharge, and that the width of cross section of culvert may be more than 1.20 m.

The hydraulic dimension and cross section are summarized below.

## Hydraulic Dimension of Culvert

| Description | Block A | | Block B | | Block C |
|---|---|---|---|---|---|
| Name of existing canal | IL-2 | Nai Chat | IL-2 | Nai Chat | Khud Mai |
| Classification of canal | Main | Leading | Main | Main | Main |
| Design discharge, Q(cu.m/s) | 10.288 | 3.032 | 4.508 | 8.247 | 8.312 |
| Cross-section of culvert Width x Height (m) | 3.0x3.0 | 1.7x1.7 | 2.0x2.0 | 2.7x2.7 | 2.7x2.7 |
| Velocity, V (m/sec) | 1.143 | 1.049 | 1.127 | 1.131 | 1.140 |
| Velocity head, $V^2/2g$ (m) | 0.067 | 0.056 | 0.065 | 0.065 | 0.066 |
| Combination of type | | | | | |
| Upstream | A | B | B | A | A |
| Downstream | A | B | B | B | B |
| Approximate length of culvert, $\ell$(m) | 88 | 53 | 58 | 68 | 73 |
| Loss head, h (m) | 0.13 | 0.12 | 0.13 | 0.13 | 0.14 |

$$h = (fe + fse)\, V^2/2g + I.\ell$$

fe : Coefficient of inlet loss 0.5
fse: Coefficient of outlet loss 1.0
I : Hydraulic gradient

$$I = \left(\frac{N^2V^2}{R^{4/3}}\right)$$

N : Coefficient of roughness 0.015
R : Hydraulic mean depth

The culvert will be made by reinforced ready-mixed concrete, and the cross-section will be regular square. At the inlet and outlet the transition of reinforced concrete will be provided. A screen will be set for the protection from materials such as weed etc.

At the foundation at culvert piles will be driven for safety purpose.

Typical layout is shown in the Drawing No.9 attached to the main report.

(2) Road Crossing for Drainage Canal

Road crossing for drainage canal will also be made by pipe culvert, as the bed of drainage canal is deeper than that of irrigation canal, a sufficient depth from the road surface can be obtained without lowering the canal bed at the inlet and outlet of the culvert. But from the nature of drainage canal the diameter of culvert will be determined so that the discharge velocity may be 1.0 m/s± against the design discharge, to prevent from the sediment load.

At the inlet and outlet of culvert a gravel will be paved for the protection of slope of canal.

Road Crossing for Main Drainage Canal

Road crossing of main drainage canal will be made by using two or more pipes having the maximum diameter of $\phi$1,500, as the discharge in drainage canal is more than that in irrigation canal, and the drainage canal has a sufficient cross-sectional area because of its borrow pit nature.

Assuming that one standar drainage area is 1,000 ha, the loss head will be 0.10 m as shown below;

Desing discharge: $Q = q$ cu.m/s/ha x A ha

$= 0.00615 \times 1{,}000 = 6.15$ cu.m/s

Diameter of culvert: D = 1,500 mm x 3 culverts

Discharge velocity per one culvert:

$V = 1.160$ m/s

Loss head: $h = (fe + fse + f\ell)\ V^2/2g$

$$= \{0.5 + 1.0 + 0.0123\ (4 \sim 8m)\}\ \frac{1.160^2}{19.6} = 0.10 \text{ m}$$

Road Crossing for Leading Drainage Canal

Assuming that one standard drainage area is 150 ha, the loss head will be 0.12 m as shown below:

Design discharge: $Q = q$ cu.m/s/ha x A ha

$= 0.00634 \times 150 = 0.951$ cu.m/s

Diameter of culvert: $D = 1{,}000$ mm

Discharge velocity: $V = 1.210$ m/s

Loss head: $h = (fe + fse + f\ell)\ v^2/2g$

$$= \{0.5 + 1.0 + 0.021\ (4 \sim 8\text{m})\} \times \frac{1.210^2}{19.6} \doteqdot 0.12 \text{ m}$$

Typical layout is shown in Drawing No.10 attached to the main report.

## Required Units of Pumps

Maximum discharge to be required for irrigation and drainage in each block are as follows:

| Block | Drainage | | Irrigation | | | | |
|---|---|---|---|---|---|---|---|
| | | | Area | | Discharge | | |
| | Area (ha) | Discharge (cu.m/s) | Paddy (ha) | Upland (ha) | for Paddy (cu.m/s) | for Upland (cu.m/s) | Total (cu.m/s) |
| A | 3,449 | 11.97 | 2,885 | 142 | 4.818 | 0.139 | 4.957 |
| B | 2,970 | 10.31 | 2,334 | 294 | 3.898 | 0.245 | 4.143 |
| C | 5,569 | 19.32 | 4,323 | 609 | 7.219 | 0.597 | 7.816 |

Note:
Unit drainage discharge    q = 0.00347 cu.m/sec/ha (1.25 mm/hour)

Unit irrigation water requirement
Paddy q = 0.00167 cu.m/sec/ha
Upland q = 0.00098 cu.m/sec/ha

Discharge for drainage is bigger than that for irrigation, therefore the units of pumps and bore diameter should be decided based on the quantity of drainage discharge. The units of pump should also be more than two units taking trouble of pumps into consideration.

The relations between discharge and bore diameter are as follows:

| Bore, D (mm) | Discharge (cu.m/min) |
|---|---|
| 1,000 | 115 - 150 |
| 1,200 | 150 - 200 |
| 1,350 | 200 - 255 |
| 1,500 | 255 - 325 |
| 1,650 | 325 - 400 |
| 1,800 | 400 - 480 |
| 2,000 | 480 - 600 |

The required head of pumps is computed by the following formula:

Total Head = (Delivery water level - Suction water level) + Pipe loss

Total head for both irrigation and drainage are estimated as follows:

| | Delivery Water Level (m) | Suction Water Level (m) | Pipe Loss | Total Head (m) |
|---|---|---|---|---|
| Drainage | WL3.20$^{\pm}$ | WL1.50$^{\pm}$ | 1.00 | 2.70 |
| Irrigation | WL3.00$^{\pm}$ | WL0.10$^{\pm}$ | 0.70 | 3.60 |

If pumps is planned to meet the discharge in case of drainage, total head in case of irrigation will be of 3.60/2.70 = 130% and the discharge will be about 70~80 % owing to the characteristic of pump.

The following table indicates the lifting capacity for irrigation and drainage in case of various units of pumps ranging from two units to five units.

Lifting Capacity of Pumps

| Block | Unit | Drainage Lifting capacity per unit Q ($m^3/s$) | Q ($m^3/min$) | Diameter x unit | Irrigation Lifting capacity per unit Q ($m^3/s$) | Q ($m^3/min$) |
|---|---|---|---|---|---|---|
| A | 2 | 5.98 | 359 | φ1,650 x 2 | 4.19 | 251 |
| | 3 | 3.99 | 239 | φ1,350 x 3 | 2.79 | 167 |
| | 4 | 2.99 | 179 | φ1,200 x 4 | 2.09 | 125 |
| | 5 | 2.39 | 143 | φ1,000 x 5 | 1.67 | 100 |
| B | 2 | 5.15 | 309 | φ1,500 x 2 | 3.61 | 212 |
| | 3 | 3.44 | 206 | φ1,350 x 3 | 2.41 | 145 |
| | 4 | 2.58 | 155 | φ1,200 x 4 | 1.81 | 109 |
| | 5 | 2.06 | 124 | φ1,000 x 5 | 1.44 | 86 |
| C | 2 | 9.66 | 580 | φ2,000 x 2 | 6.76 | 406 |
| | 3 | 6.44 | 386 | φ1,650 x 3 | 4.51 | 271 |
| | 4 | 4.83 | 290 | φ1,500 x 4 | 3.38 | 203 |
| | 5 | 3.86 | 232 | φ1,350 x 5 | 2.70 | 162 |
| | 6 | 3.22 | 193 | φ1,200 x 6 | 2.25 | 135 |

Annual mean pumping operation hours in the normal year (return period 2-years) are shown in Figure A.4-41 to Figure A.4-43, when above pumps are operated.

# FIGURE A.4 – 41 OPERATION HOURS OF PUMPS IN NORMAL YEAR (Block A)

| Units 2/ | 1/ | 3/ | Peak | Jan. I | Jan. II | Feb. I | Feb. II | Mar. I | Mar. II | Apr. I | Apr. II | May I | May II | Jun. I | Jun. II | Jul. I | Jul. II | Aug. I | Aug. II | Sep. I | Sep. II | Oct. I | Oct. II | Nov. I | Nov. II | Dec. I | Dec. II |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1.09 | 3.35 | 4.57 | 4.30 | 3.54 | 2.96 | 3.79 | 2.39 | (1.29) | (0.81) | (2.03) | (1.33) | (1.12) | 2.43 | 2.37 | (1.09) | (0.89) | (3.02) | 1.22 | 0.67 | 0.69 | 1.00 | 0.07 | 0.09 |
| φ1,650 x 2 units | (6.98) 4.19 m³/s | 1 | 4/ | 6.2 | 19.2 | | | 20.3 | 17.0 | 21.7 | 13.7 | 5.2 | 3.3 | 8.1 | 5.3 | 4.5 | 13.9 | 13.6 | 4.4 | 3.6 | 12.1 | 7.0 | 3.8 | 3.95 | 5.7 | 0.4 | 0.5 |
| | | 2 | | | | 2.2 | 0.6 | | | | | | | | | | | | | | | | | | | | |
| φ 1,350 x 3 units | (3.99) 2.79 m³/s | 1 | | 9.4 | | | | | | | 20.6 | 7.8 | 4.9 | 12.2 | 8.0 | 6.7 | 20.9 | 20.4 | 6.6 | 5.4 | 18.2 | 10.5 | 5.8 | 5.9 | 8.6 | 0.6 | 0.8 |
| | | 2 | | | 4.8 | 15.3 | 13.0 | 6.5 | 1.5 | 8.6 | | | | | | | | | | | | | | | | | |
| | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | |
| φ1,200 x 4 units | (2.99) 2.09 m³/s | 1 | | 12.5 | | | | | | | | 10.4 | 6.5 | 16.3 | 10.7 | 9.0 | | | 8.7 | 7.1 | | 14.0 | 7.7 | 7.9 | 11.5 | 0.8 | 1.0 |
| | | 2 | | | 14.5 | | | 16.7 | 10.0 | 19.5 | 3.4 | | | | | | 3.9 | 3.2 | | | 0.2 | | | | | | |
| | | 3 | | | | 4.5 | 1.4 | | | | | | | | | | | | | | | | | | | | |
| | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| φ 1,000 x 5 units | (2.39) 1.67 m³/s | 1 | | 15.7 | | | | | | | | 13.0 | 8.1 | 20.4 | 13.4 | 11.2 | | | 10.9 | 8.9 | | 17.5 | 9.6 | 9.9 | 14.4 | 1.0 | 1.3 |
| | | 2 | | | | | | | 18.5 | | 10.3 | | | | | | 10.9 | 10.0 | | | 6.3 | | | | | | |
| | | 3 | | | 0.1 | 17.7 | 13.8 | 2.9 | | 6.5 | | | | | | | | | | | | | | | | | |
| | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |

Note: 1/ : Pumpage of one unit m³/s  ( ) : Indicates the drainage discharge
2/ : Units
3/ : The necessary water requirements m³/s (See Table A.4 - 61)
4/ : Pumping operation hours

# FIGURE A.4 – 42 OPERATION HOURS OF PUMPS IN NORMAL YEAR (Block B)

| Units | 1/ | 2/ | Peak | Jan. I | Jan. II | Feb. I | Feb. II | Mar. I | Mar. II | Apr. I | Apr. II | May I | May II | Jun. I | Jun. II | Jul. I | Jul. II | Aug. I | Aug. II | Sep. I | Sep. II | Oct. I | Oct. II | Nov. I | Nov. II | Dec. I | Dec. II |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3/ | | 0.98 | 2.81 | 3.30 | 3.57 | 2.99 | 2.49 | 3.19 | 1.99 | (1.12) | (0.70) | (1.75) | (1.14) | (0.97) | 2.02 | 1.92 | (0.95) | (0.78) | (2.59) | 0.99 | 0.54 | 0.59 | 0.90 | 0.12 | 0.12 |
| ϕ1,500 x 2 units | (6.15) 3.61 m³/s | 1 | 4/ | 6.5 | 18.7 | | 23.7 | 19.9 | 16.6 | 21.2 | 13.2 | 5.2 | 3.3 | 8.2 | 5.3 | 4.5 | 13.4 | 12.8 | 4.4 | 3.6 | 12.1 | 6.6 | 3.6 | 3.9 | 6.0 | 0.8 | 0.8 |
| | | 2 | | | | 1.3 | | | | | | | | | | | | | | | | | | | | | |
| ϕ 1,350 x 3 units | (3.44) 2.41 m³/s | 1 | | 9.8 | | | | | | | 19.8 | 7.8 | 4.9 | 12.2 | 8.0 | 6.8 | 20.1 | 19.1 | 6.6 | 5.4 | 18.1 | 9.9 | 5.4 | 5.9 | 9.0 | 1.2 | 1.2 |
| | | 2 | | | 4.0 | 13.8 | 11.6 | 5.8 | 0.8 | 7.8 | | | | | | | | | | | | | | | | | |
| | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | |
| ϕ 1,200 x 4 units | (2.68) 1.81 m³/s | 1 | | 13.0 | | | | | | | | 10.4 | 6.5 | 16.3 | 10.6 | 9.0 | | | 8.8 | 7.3 | | 13.1 | 7.2 | 7.8 | 11.9 | 1.6 | 1.6 |
| | | 2 | | | 13.3 | | 23.3 | 15.6 | 9.0 | 18.3 | 2.4 | | | | | | 2.8 | 1.5 | | | 0.1 | | | | | | |
| | | 3 | | | | 2.4 | | | | | | | | | | | | | | | | | | | | | |
| | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| ϕ 1,000 x 5 units | (2.08) 1.44 m³/s | 1 | | 16.3 | | | | | | | | 13.0 | 8.2 | 20.4 | 13.3 | 11.3 | | | 11.1 | 9.1 | | 16.5 | 9.0 | 9.8 | 15.0 | 2.0 | 2.0 |
| | | 2 | | | 22.8 | | | | 10.2 | | 9.1 | | | | | | 9.7 | 8.0 | | | 6.2 | | | | | | |
| | | 3 | | | | 15.3 | 11.5 | 1.8 | | 5.2 | | | | | | | | | | | | | | | | | |
| | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |

Note: 1/ : Pumpage of one unit m³/s ( ) : Indicates the drainage discharge
2/ : Units
3/ : The necessary water requirements m³/s (See Table A.4 - 61)
4/ : Pumping operation hours

FIGURE A.4 – 43 OPERATION HOURS OF PUMPS IN NORMAL YEAR (Block C)

| Units 1/ | 2/ | Month 3/ | Peak | Jan. I | Jan. II | Feb. I | Feb. II | Mar. I | Mar. II | Apr. I | Apr. II | May I | May II | Jun. I | Jun. II | Jul. I | Jul. II | Aug. I | Aug. II | Sep. I | Sep. II | Oct. I | Oct. II | Nov. I | Nov. II | Dec. I | Dec. II |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1.90 | 5.28 | 7.16 | 6.71 | 5.66 | 4.71 | 6.05 | 3.76 | (2.07) | (1.30) | (3.29) | (2.14) | (1.81) | 3.80 | 3.55 | (1.75) | (1.43) | (4.87) | 1.83 | 1.00 | 1.13 | 1.77 | 0.30 | 0.40 |
| φ2,000 × 2 units | (9.66) 6.76 $m^3/s$ | 1 | 4/ | 6.7 | 18.7 | | 23.8 | 20.1 | 16.7 | 21.5 | 13.3 | 5.1 | 3.2 | 8.2 | 5.3 | 4.5 | 13.5 | 12.6 | 4.3 | 3.6 | 12.1 | 6.5 | 3.6 | 4.0 | 6.3 | 1.1 | 1.4 |
| | | 2 | | | | 1.4 | | | | | | | | | | | | | | | | | | | | | |
| φ1,650 × 3 units | (6.44) 4.51 $m^3/s$ | 1 | | 10.1 | | | | | | | 20.0 | 7.7 | 4.8 | 12.3 | 8.0 | 6.7 | 20.2 | 18.9 | 6.5 | 5.3 | 18.1 | 9.7 | 5.3 | 6.0 | 9.4 | 1.6 | 2.7 |
| | | 2 | | | 4.1 | 14.1 | 11.7 | 6.1 | 1.1 | 8.2 | | | | | | | | | | | | | | | | | |
| | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | |
| φ1,500 × 4 units | (4.83) 3.38 $m^3/s$ | 1 | | 13.5 | | | | | | | | 10.3 | 6.5 | 15.3 | 10.6 | 9.0 | | | 8.7 | 7.1 | | 13.0 | 7.1 | 8.0 | 12.6 | 2.1 | 2.8 |
| | | 2 | | | 13.5 | | 23.6 | 16.2 | 9.4 | 19.0 | 2.7 | | | | | | 3.0 | 1.2 | | | 0.1 | | | | | | |
| | | 3 | | | | 2.8 | | | | | | | | | | | | | | | | | | | | | |
| | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| φ1,350 × 5 units | (3.86) 2.70 $m^3/s$ | 1 | | 16.9 | | | | | | | | 12.9 | 8.1 | 20.5 | 13.3 | 11.3 | | | 10.9 | 8.9 | | 16.3 | 8.9 | 10.0 | 15.7 | 2.7 | 3.6 |
| | | 2 | | | 22.9 | | | | 17.9 | | 9.4 | | | | | | 9.8 | 7.5 | | | 6.3 | | | | | | |
| | | 3 | | | | 15.6 | 11.6 | 2.3 | | 5.8 | | | | | | | | | | | | | | | | | |
| | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |

Note: 1/ : Pumpage of one unit $m^3/s$     ( ) : Indicates the drainage discharge

2/ : Units

3/ : The necessary water requirements $m^3/s$ (See Table A.4 - 61)

4/ : Pumping operation hours

Table A.4-61 Design Capacity for Irrigation and Drainage (Normal year)

(Unit: cu.m/s)

| | | Block A | Block B | Block C |
|---|---|---|---|---|
| Jan. | I | 1.09 | 0.98 | 1.90 |
| | II | 3.35 | 2.81 | 5.28 |
| Feb. | I | 4.57 | 3.80 | 7.16 |
| | II | 4.30 | 3.57 | 6.71 |
| Mar. | I | 3.54 | 2.99 | 5.66 |
| | II | 2.96 | 2.49 | 4.71 |
| Apr. | I | 3.79 | 3.19 | 6.05 |
| | II | 2.39 | 1.99 | 3.76 |
| May | I | (1.29) | (1.12) | (2.07) |
| | II | (0.81) | (0.70) | (1.30) |
| Jun. | I | (2.03) | (1.75) | (3.29) |
| | II | (1.33) | (1.14) | (2.14) |
| Jul. | I | (1.12) | (0.97) | (1.81) |
| | II | 2.43 | 2.02 | 3.80 |
| Aug. | I | 2.37 | 1.92 | 3.55 |
| | II | (1.09) | (0.95) | (1.75) |
| Sep. | I | (0.89) | (0.78) | (1.43) |
| | II | (3.02) | (2.59) | (4.87) |
| Oct. | I | 1.22 | 0.99 | 1.83 |
| | II | 0.67 | 0.54 | 1.00 |
| Nov. | I | 0.69 | 0.59 | 1.13 |
| | II | 1.00 | 0.90 | 1.77 |
| Dec. | I | 0.07 | 0.12 | 0.30 |
| | II | 0.09 | 0.12 | 0.40 |

Note: ( ): indicate the design capacity for drainage

Table A.4-62 Irrigation Water Requirement and Drainage Discharge
(Normal year)

Irrigation Water Requirement

(Unit: cu.m/s)

| | Block A | | | Block B | | | Block C | | |
|---|---|---|---|---|---|---|---|---|---|
| | Paddy 2,885ha $Q_1$ | Upland 142 ha $Q_2$ | Total Q | Paddy 2,334ha $Q_1$ | Upland 249 ha $Q_2$ | Total Q | Paddy 4,323ha $Q_1$ | Upland 609 ha $Q_2$ | Total Q |
| Jan. I | 1.00 | 0.09 | 1.09 | 0.81 | 0.17 | 0.98 | 1.50 | 0.40 | 1.90 |
| II | 3.26 | 0.09 | 3.35 | 2.64 | 0.17 | 2.81 | 4.88 | 0.40 | 5.28 |
| Feb. I | 4.46 | 0.11 | 4.57 | 3.61 | 0.19 | 3.80 | 6.69 | 0.47 | 7.16 |
| II | 4.20 | 0.10 | 4.30 | 3.40 | 0.17 | 3.57 | 6.29 | 0.42 | 6.71 |
| Mar. I | 3.42 | 0.12 | 3.54 | 2.77 | 0.22 | 2.99 | 5.13 | 0.53 | 5.66 |
| II | 2.86 | 0.10 | 2.96 | 2.31 | 0.18 | 2.49 | 4.28 | 0.43 | 4.71 |
| Apr. I | 3.66 | 0.13 | 3.79 | 2.96 | 0.23 | 3.19 | 5.49 | 0.56 | 6.05 |
| II | 2.32 | 0.07 | 2.39 | 1.87 | 0.12 | 1.99 | 3.47 | 0.29 | 3.76 |
| May I | - | - | - | - | - | - | - | - | - |
| II | - | 0.03 | 0.03 | - | 0.05 | 0.05 | - | 0.13 | 0.13 |
| Jun. I | - | - | - | - | - | - | - | - | - |
| II | - | 0.02 | 0.02 | - | 0.04 | 0.04 | - | 0.94 | 0.94 |
| Jul. I | - | - | - | - | - | - | - | - | - |
| II | 2.38 | 0.05 | 2.43 | 1.93 | 0.09 | 2.02 | 3.57 | 0.23 | 3.80 |
| Aug. I | 2.37 | - | 2.37 | 1.92 | - | 1.92 | 3.55 | - | 3.55 |
| II | 0.06 | - | 0.06 | 0.05 | - | 0.05 | 0.09 | - | 0.09 |
| Sep. I | 0.05 | - | 0.05 | 0.04 | - | 0.04 | 0.07 | - | 0.07 |
| II | - | - | - | - | - | - | - | - | - |
| Oct. I | 1.22 | - | 1.22 | 0.99 | - | 0.99 | 1.83 | - | 1.83 |
| II | 0.67 | - | 0.67 | 0.54 | - | 0.54 | 1.00 | - | 1.00 |
| Nov. I | 0.66 | 0.03 | 0.69 | 0.53 | 0.06 | 0.59 | 0.99 | 0.14 | 1.13 |
| II | 0.90 | 0.10 | 1.00 | 0.73 | 0.17 | 0.90 | 1.35 | 0.42 | 1.77 |
| Dec. I | - | 0.07 | 0.07 | - | 0.12 | 0.12 | - | 0.30 | 0.30 |
| II | - | 0.09 | 0.09 | - | 0.16 | 0.12 | - | 0.40 | 0.40 |

Drainage Discharge (Cont'd)

| | Block A | | | Block B | | | Block C | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cultivat-ed Area 3,027ha | Others 422ha | Total | Cultivat-ed Area 2,583ha | Others 387ha | Total | Cultivat-ed Area 4,932ha | Others 637ha | Total |
| May I | 1.05 | 0.24 | 1.29 | 0.90 | 0.22 | 1.12 | 1.71 | 0.36 | 2.07 |
| II | 0.67 | 0.14 | 0.81 | 0.57 | 0.13 | 0.70 | 1.09 | 0.21 | 1.30 |
| Jun. I | 1.85 | 0.18 | 2.03 | 1.58 | 0.17 | 1.75 | 3.01 | 0.28 | 3.29 |
| II | 1.21 | 0.12 | 1.33 | 1.03 | 0.11 | 1.14 | 1.96 | 0.18 | 2.14 |
| Jul. I | 0.97 | 0.15 | 1.12 | 0.83 | 0.14 | 0.97 | 1.58 | 0.23 | 1.81 |
| II | - | 0.07 | 0.07 | - | 0.06 | 0.06 | - | 0.11 | 0.11 |
| Aug. I | - | 0.15 | 0.15 | - | 0.14 | 0.14 | - | 0.22 | 0.22 |
| II | 0.82 | 0.27 | 1.09 | 0.70 | 0.25 | 0.95 | 1.34 | 0.41 | 1.75 |
| Sep. I | 0.67 | 0.22 | 0.89 | 0.57 | 0.21 | 0.78 | 1.09 | 0.34 | 1.43 |
| II | 2.61 | 0.41 | 3.02 | 2.22 | 0.37 | 2.59 | 4.25 | 0.62 | 4.87 |
| Oct. I | - | 0.15 | 0.15 | - | 0.14 | 0.14 | - | 0.23 | 0.23 |
| II | 0.06 | 0.17 | 0.23 | 0.05 | 0.16 | 0.21 | 0.10 | 0.26 | 0.36 |

Subsequent paragraph deals with the selection of most desirable units of pumps from view point of cost and operation and maintenance,

Cost:

Running cost;

Electric power charge in Thailand is only the consumed electric power charge, and it is not necessary to pay the contract charge.

Initial cost;

The total bore diameter of pumps gradually increases in accordance with the increase of number of pumps. Therefore, construction cost including civil works and building gradually increases as units of pumps increases.

From the result, it is found out that less units of pumps are more effective from economic view point.

Operation and Maintenance:

The pumps, which will be used for both purposes of irrigation and drainage, are operated throughout a year in the Project. All units of pump will be operated when the drainage discharge is at peak, but in the case of operation for irrigation, it is desireble that each station has spare units of one or two from operation point of view, because the durability of pumps gets more longer by alternate using of the pumps. If the plan having two units is adopted, there would be no spare units, when the water requirements is at peak, and the bore diameter becomes large and the farmers in the Project Area have no experienced in operating such pumps with the large scale bore. Therefore, the plan having two units is not recommendable. Also, in case that the number of units for each block is more than five units in ordre to adopt the smaller bore diameter than $\phi$1,000 mm, it will not be efficient from economic and operation and maintenance points of view.

As mentioned above, three units of pump is the most effective plan considering the economy, safty for operation, the durability and the operation and maintenance. Therefore, plan of the three units installed will be adopted in each block, and following table shows the features of pumps in each block.

| Block | Delivery discharge per unit | | Diameter | Units |
|---|---|---|---|---|
| A | 3.99 cu.m/sec | (239 cu.m/min) | $\phi$1,350 mm | 3 |
| B | 3.44 " | (206 " ) | $\phi$1,350 " | 3 |
| C | 6.44 " | (386 " ) | $\phi$1,650 " | 3 |

## Selection of Prime Mover

### Disel engine

Heavy oil and lubricating oil will be used for fuel, and the fuel consumptions are as follows:

| | Heavy oil | Lubricating oil |
|---|---|---|
| Fuel consumption (g/ps/hr) | 190 | 5 |
| Price (฿/ℓ) | 2.6 | 18.0 |
| Specific gravity | 0.9 | 0.9 |

| Output (ps) | Rate of fuel consumption (g/ps/hr.) |
|---|---|
| 100 - 200 | 200 |
| 200 - 500 | 190 |
| more 500 | 180 |

| Block | Output per unit (ps) | Units | Fuel consumption per hour(ℓ/hr/unit) Heavy oil | Lubricating oil | Operation costs for hour per unit(฿/hr/unit) Heavy oil | Lubricating oil | Total |
|---|---|---|---|---|---|---|---|
| A | 240 | 3 | 50.7 | 1.3 | 131.8 | 23.4 | 155.2 |
| B | 200 | 3 | 42.2 | 1.1 | 109.7 | 19.8 | 129.5 |
| C | 440 | 3 | 92.9 | 2.4 | 241.5 | 43.2 | 284.7 |
| Total | | | | | 494.0 | 86.4 | 569.4 |

Annual operating hours in the normal year are as follows.

| Block | Total annual operating hours (hr) | Annual operating hours per unit (hr) 1/ |
|---|---|---|
| A | 5,226 | 1,742 |
| B | 5,406 | 1,802 |
| C | 5,451 | 1,817 |

1/ : Total annual operation hours/ unit.

| Block | Annual operating hours per unit(hr) | Annual operation costs per unit (฿'000) | | | Annual operation costs per three units (฿'000) | | |
|---|---|---|---|---|---|---|---|
| | | Heavy oil | Lubricating oil | Total | Heavy oil | Lubricating oil | Total |
| A | 1,842 | 242.7 | 43.1 | 285.8 | 728.1 | 129.3 | 857.4 |
| B | 1,802 | 197.6 | 35.7 | 233.3 | 592.8 | 107.1 | 699.9 |
| C | 1,817 | 438.8 | 78.5 | 517.3 | 1,316.4 | 235.5 | 1,551.9 |
| Total | | | | 1,036.4 | 2,637.3 | 471.9 | 3,109.2 |

Motor

| Block | Output per unit (kw) | Annual operating hours per unit (hr) | Annual operating costs per unit (฿'000) | Annual operating costs per three units (฿'000) |
|---|---|---|---|---|
| A | 170 | 1,842 | 156.6 1/ | 469.8 |
| B | 140 | 1,802 | 126.1 | 378.3 |
| C | 300 | 1,817 | 272.6 | 817.8 |
| Total | | | 555.3 | 1,665.9 |

1/: 170kw x 1,842hr x 0.5 ฿/kwh

Following table indicate the approximate comparison of both type of prive mover from view point of annual cost required.

(Unit: ฿'000)

| Items | Diesel Engine | Motor |
|---|---|---|
| Amortization 1/ | 6,420 | 7,350 |
| Replacement cost 2/ | 2,290 | 2,420 |
| Operation cost | 3,110 | 1,670 |
| Total | 11,820(103) | 11,440(100) |

Note: 1/ : cost (see Table A.4-63) x 0.08335 (i=10%)
2/ : pump cost x 0.02978 (i=10%)

As is seen in the above table, although an annual cost is almost same, motor is recommended in the project considering the easy operation.

Table A. 4-63 Cost of Pumping Facilities

| Items | Diesel engine | | Motor | |
|---|---|---|---|---|
| | ϕ1,350 x 3 units ('000฿) | ϕ1,650 x 3 units ('000฿) | ϕ1,350 x 3 units ('000฿) | ϕ1,650 x 3 units ('000฿) |
| Pump & Accessories | 6,260 | 9,660 | 6,260 | 9,660 |
| Prime mover | 1,118 | 1,680 | 1,240 | 2,320 |
| Reduction gear | 1,287 | 1,456 | 1,220 | 1,780 |
| Value & Pipe | 4,680 | 7,733 | 4,680 | 7,733 |
| Switch board | 1,096 | 1,331 | 2,193 | 2,663 |
| Auxiliary equipments | 52 | 48 | 114 | 127 |
| Installation & Arrangement | 4,531 | 5,753 | 4,067 | 5,353 |
| Packing & Freightage | 1,167 | 1,680 | 1,167 | 1,680 |
| Other costs | 2,088 | 3,063 | 2,273 | 3,393 |
| Total | 22,279 | 32,404 | 23,214 | 34,709 |

The construction costs for electric power transmission and supplying facilities is ฿7,026,000 (from PEA)

Total costs for pumping facilities of Project Area is as follows;

| Block | | Motor ('000฿) | Diesel engine ('000฿) |
|---|---|---|---|
| A | ϕ1,350 x 3 units | 23,214 | 22,279 |
| B | ϕ1,350 x 3 units | 23,214 | 22,279 |
| C | ϕ1,650 x 3 units | 34,709 | 32,404 |
| Total | | 81,137 | 76,962 |

The construction costs in case of motor

= Construction cost of pumping facilities
+ Costs of the electric power transmission faiclities

=฿81,137,000 +฿7,026,000

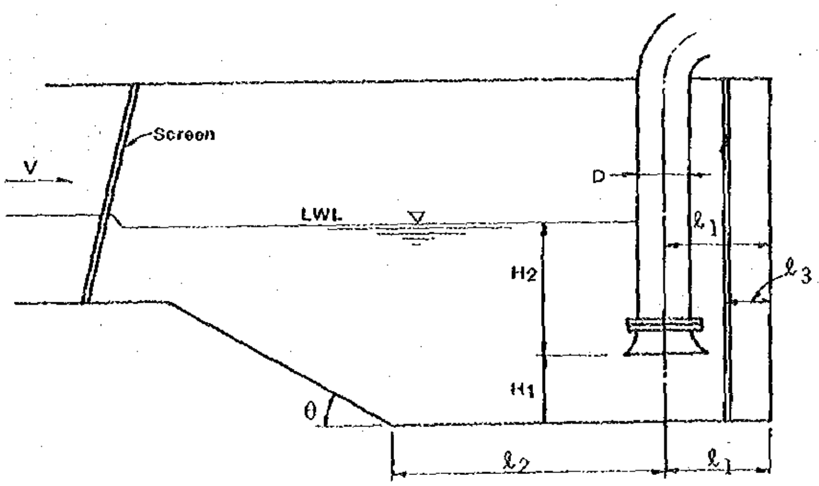
= ฿88,163,000

## Plan of Pumping Stations

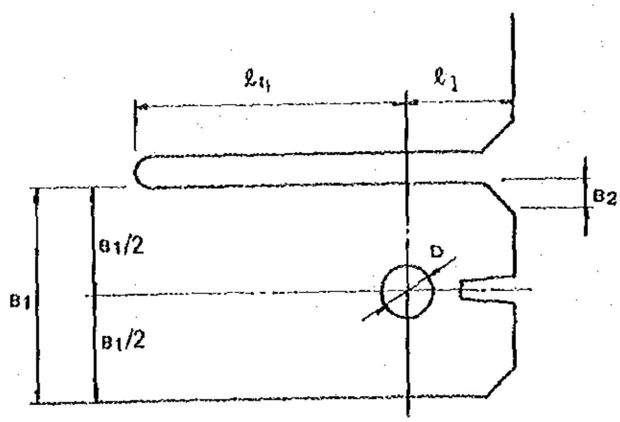
Dimensions of the proposed pumps are as follows;

| Block | Design Capacity Drainage | Design Capacity Irrigation | units | Borediameter | Design Capacity per unit $m^3/s$ | Design Capacity per unit $m^3/min$ | Type of pump |
|---|---|---|---|---|---|---|---|
| A | 11.97 | 4.96 | 3 | φ1,350 | 3.99 | 239 | Horizontal mixed flow pump |
| B | 10.31 | 4.14 | 3 | φ1,350 | 3.44 | 206 | " |
| C | 19.32 | 7.82 | 3 | φ1,650 | 6.44 | 386 | " |

(1) Design of suction tank



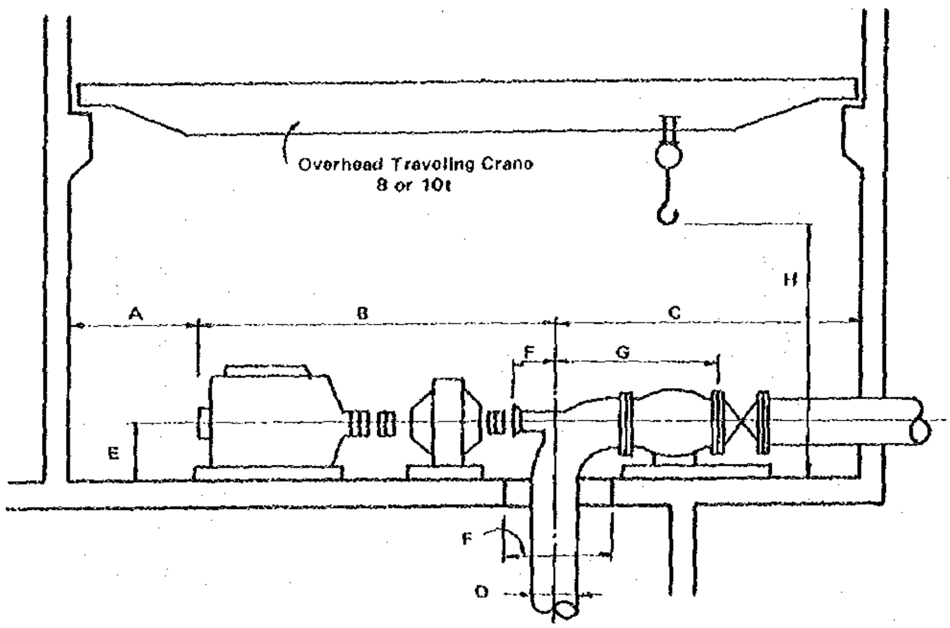

V : <0.5 m/s
$\ell_1$ : 1.5 D
$\ell_2$ : >3 D
$\ell_3$ : 0.8 D
$\ell_4$ : 3 D±
H1 : 1 D
H2 : 1.5 – 2 D
B1 : >3 D
B2 : 0.75 D±




$\ell_2$ = ( θ = 30° ) > 3D
( θ = 45° ) > 4.5D

(2) Design of Pumping House

The building of pumping station is composed of three rooms, namely pumping machine room, frame work room, and operation room. Main facilities set in the machine room are composed of pumps, reduction gear, motor and regulating values, and the width of the machine room is planned as follows. Also, the overhead travelling crane will be installed in the pumping house.




(Unit: mm)

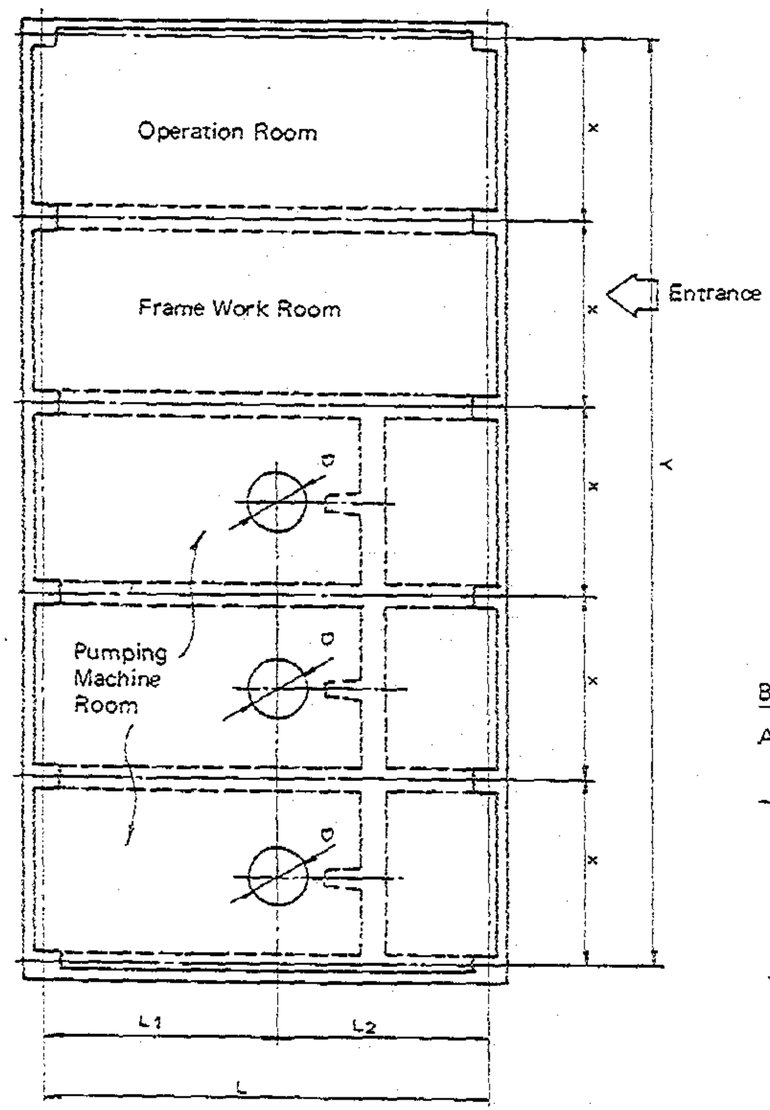
| Block | D | A | B | C | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| A, B | $\phi$1,350 | over 1,500 | 4,000± | 6,500 | 1,300 | 1,350 | 3,360 | over 4,100 |
| C | $\phi$1,650 | over 1,500 | 4,500± | 6,500 | 1,400 | 1,600 | 4,000 | over 4,800 |

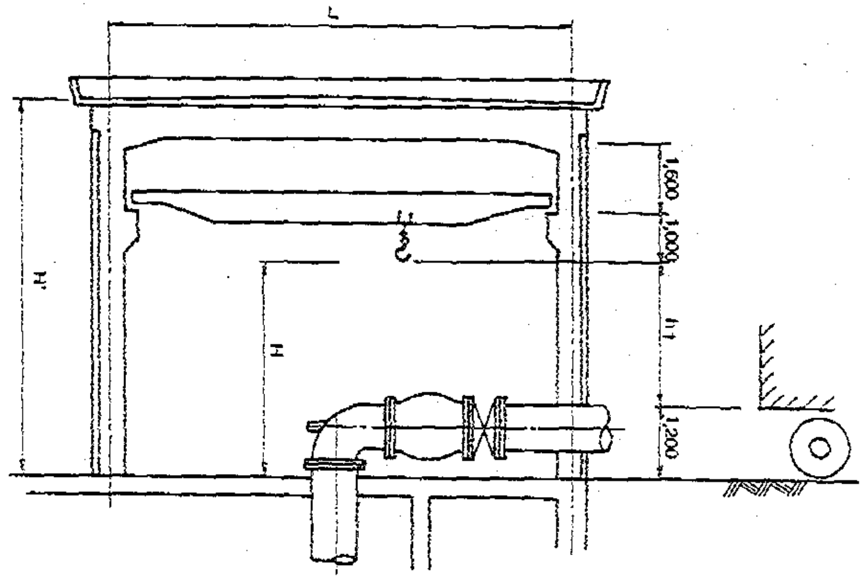
Capacity of the overhead travelling crane is as follows;

$\phi$1,350 ---------- 8 t crane

$\phi$1,650 ---------- 10 t crane

FIGURE A.4 – 44
DIMENSION OF PUMPING HOUSE

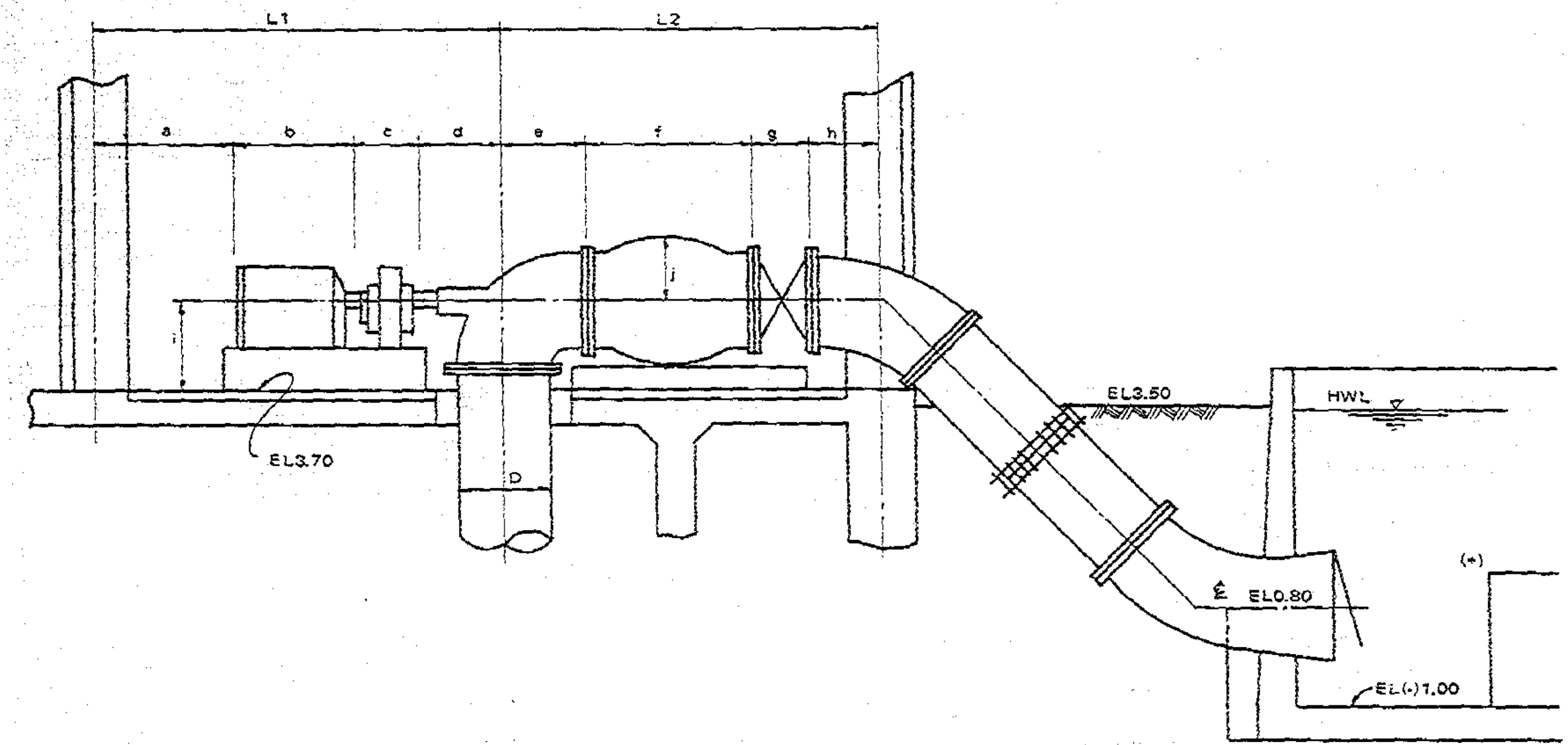



(Unit: mm)

| Block | D | L1 | L2 | L | X | Y | h1 | H | H' |
|---|---|---|---|---|---|---|---|---|---|
| A, B | φ1,350 | 6,000 | 5,500 | 11,500 | 5,000 | 25,000 | 3,800 | 5,000 | 8,700 |
| C | φ1,650 | 6,500 | 6,500 | 13,000 | 6,000 | 30,000 | 4,300 | 5,500 | 9,200 |

FIGURE A4-45 DIMENSION OF PUMP



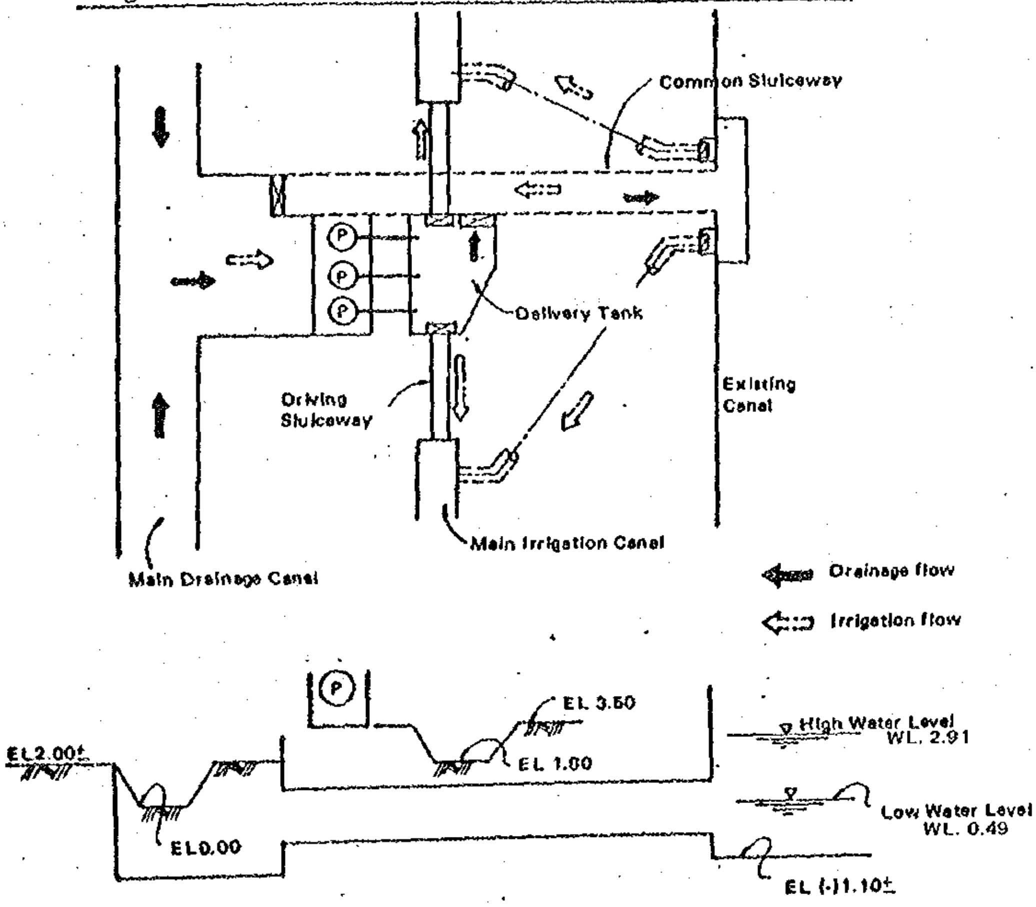

(Unit: mm)

| Block | D | L1 | L2 | a | b | c | d | e | f | g | h | i | j |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A, B | $\phi$1,350 | 6,000 | 5,500 | 1,850 | 1,800 | 1,000 | 1,350 | 1,200 | 2,160 | 1,300 | 840 | 1,300 | 1,100 |
| C | $\phi$1,650 | 6,500 | 6,500 | 1,800 | 2,000 | 1,100 | 1,600 | 1,500 | 2,500 | 1,400 | 1,100 | 1,400 | 1,200 |

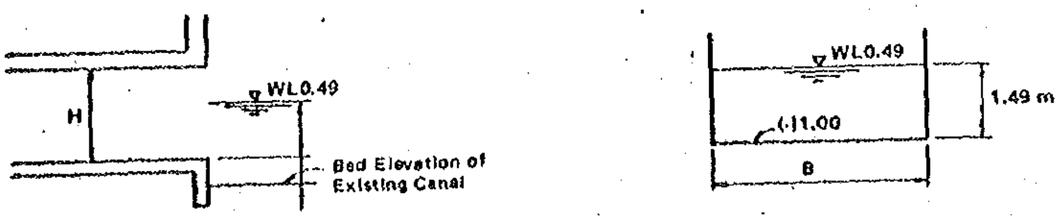
## Hydraulic Calculation of Pumps

As already discussed previousely, the proposed pumps have the dual purposes for irrigation and drainage, and their systems of water flow are illustrated as shown below:

Diagram of Water Flow for Irrigation and Drainage




Section of common sluiceway is as follows:

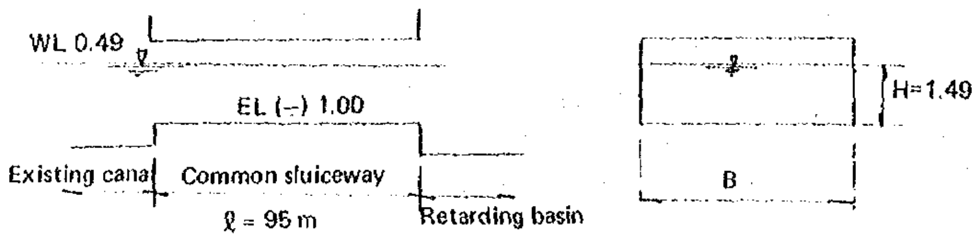



| Diameter of pump | $\phi$1,350 | $\phi$1,650 |
|---|---|---|
| B m | 4.40 | 5.40 |

(1) Decision of Suction Water Level

In case of irrigation water supply:

The suction water level in case of irrigation water supply is calculated by deducting the loss head caused by common sluiceway and screen provided in the suction tank from the low water level of 0.49 m.




| Description | Unit | Block A | Block B | Block C |
|---|---|---|---|---|
| Design water requirements, Q | $m^3/s$ | 4.96 | 4.14 | 7.82 |
| Width of the common sluiceway, B | m | 4.40 | 4.40 | 5.40 |
| Cross-sectional area of flow, A | $m^2$ | 6.56 | 6.56 | 8.05 |
| Hydraulic radius, R | m | 0.557 | 0.557 | 0.584 |
| Velocity, V | m/s | 0.756 | 0.631 | 0.971 |
| Velocity head, hv | m | 0.029 | 0.020 | 0.048 |
| Hydraulic gradient, I | | $2.8 \times 10^{-4}$ | $2.0 \times 10^{-4}$ | $4.3 \times 10^{-4}$ |
| Loss head, h | m | 0.071 | 0.049 | 0.113 |

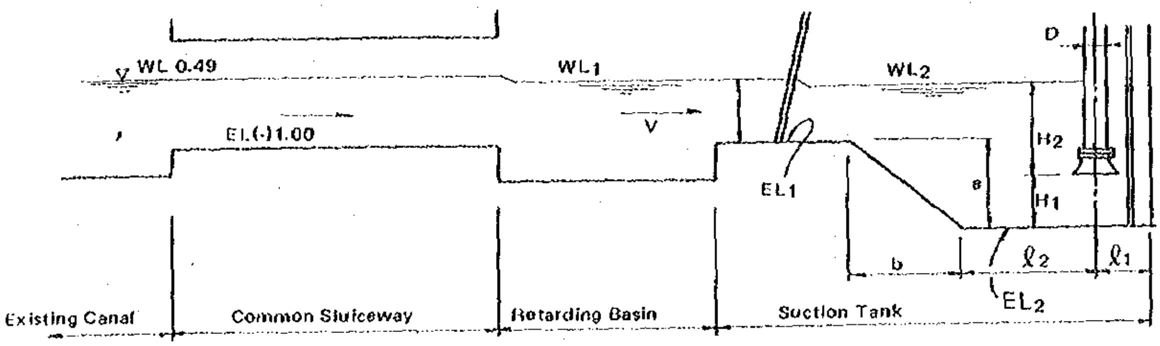
$$h = (fe + fse)hv + I.\ell$$

fe : coefficient of inlet loss 0.5
fse: coefficient of outlet loss 1.0

$$I = \frac{N^2 V^2}{R^{4/3}}$$

N : Roughness coefficient 0.015
(Reinforced concrete)

The suction water level and the bed elevation of the suction tank are calculated as follows;




| | Unit | Block A | Block B | Block C |
|---|---|---|---|---|
| Suction Water Level $WL_2$ | m | ≒ 0.20 | ≒ 0.20 | ≒ 0.10 |
| $WL_1$ | " | 0.41 | 0.44 | 0.37 |
| $EL_1$ | " | (-) 1.35 | (-) 1.35 | (-) 2.00 |
| $EL_2$ | " | (-) 3.80 | (-) 3.80 | (-) 4.60 |
| D | " | 1.35 | 1.35 | 1.65 |
| $H_1$ | " | 1.35 | 1.35 | 1.65 |
| $H_2$ | " | 2.65 | 2.65 | 3.05 |
| $\ell_1$ | " | 2.05 | 2.05 | 2.50 |
| $\ell_2$ | " | 4.10 | 4.10 | 5.00 |
| a | " | 2.45 | 2.45 | 2.60 |
| b | " | 5.00 | 5.00 | 6.00 |
| V | m/s | 0.32 | 0.26 | 0.31 |

In case of drainage:

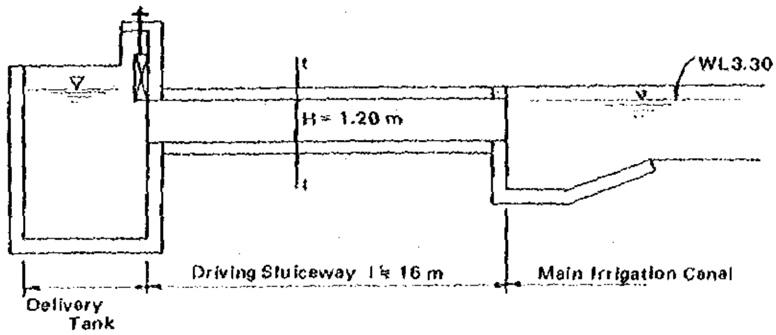
Assuming that the water level of the retarding basin is WL 1.50± in all blocks, the suction water level will be WL 1.20 after reducing the loss head of 0.30± m at the part of suction tank.

From the result of study, design bed elevation of suction tank and the depth of suction tube are decided based on the irrigation water supply.

(2) Decision of Delivery Water Level

In case of irrigation water supply:

Assuming that half of design irrigation water requirement is to be distributed from the suction tank to each main irrigation canal, the delivery water level will be roughly calculated as follows;




The water level of the delivery tank is calculated by adding the loss head caused by the driving sluiceway to the design water level of WL 3.30 for the main irrigation canal.

| Description | Unit | Block A | Block B | Block C |
|---|---|---|---|---|
| Design water requirements, Q | $m^3/s$ | 2.48 | 2.07 | 3.91 |
| Cross-sectional width of the driving sluiceway, B | m | 2.0 | 2.0 | 3.0 |
| Cross-sectional area of flow, A | $m^2$ | 2.4 | 2.4 | 3.6 |
| Hydraulic radius, R | m | 0.387 | 0.387 | 0.429 |
| Velocity of flow, V | m/s | 1.033 | 0.863 | 1.086 |
| Velocity head, hv | m | 0.054 | 0.038 | 0.060 |
| Hydraulic gradient, I | | $8.5\times10^{-4}$ | $5.9\times10^{-4}$ | $6.2\times10^{-4}$ |
| Loss head, h | m | 0.094 | 0.066 | 0.099 |
| Delivery water level, HWL | | ≒ 3.40 | ≒ 3.40 | ≒ 3.40 |

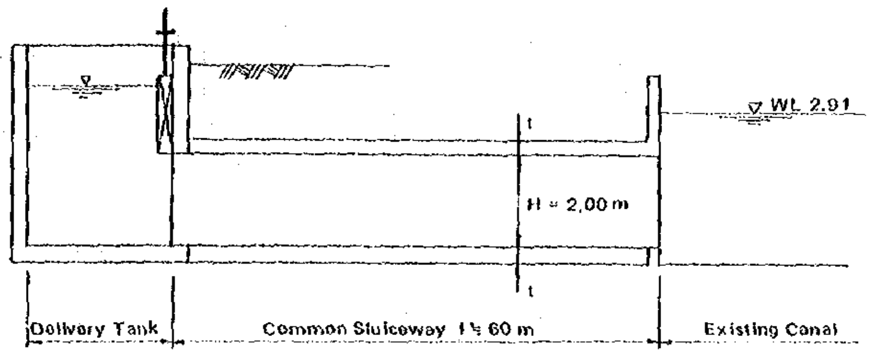
$$h = (fe + fse)hv + I.\ell = 1.5hv + I.\ell$$

Roughness coefficient

$N = 0.015$

$$I = \frac{N^2V^2}{R^{4/3}}$$

Incase of drainage:



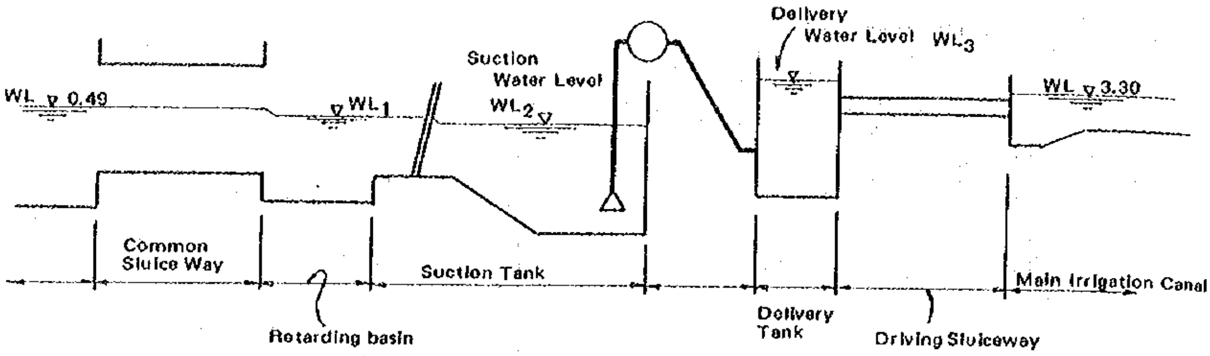

The delivery water level is calcuated by adding the loss head caused by the common sluiceway to the design outer water level of WL 3.00±.

| Description | Unit | Block A | Block B | Block C |
|---|---|---|---|---|
| Design drainage discharge, Q | $m^3/s$ | 11.97 | 10.31 | 19.32 |
| Cross-sectional width of the common sluiceway, B | m | 4.4 | 4.4 | 5.4 |
| Cross-sectional area of flow, A | $m^2$ | 8.8 | 8.8 | 10.8 |
| Hydraulic radius, R | m | 0.688 | 0.688 | 0.730 |
| Velocity of flow, V | m/s | 1.360 | 1.172 | 1.789 |
| Velocity head, hv | m | 0.094 | 0.070 | 0.163 |
| Hydraulic gradient, I | | $6.9\times10^{-4}$ | $5.1\times10^{-4}$ | $1.1\times10^{-3}$ |
| Loss head, h | m | 0.182 | 0.136 | 0.311 |
| Delivery water level, HWL | | ≒ 3.10 | ≒ 3.10 | ≒ 3.10 |

Figure A.4-46 indicates the results of design suction and delivery water level.

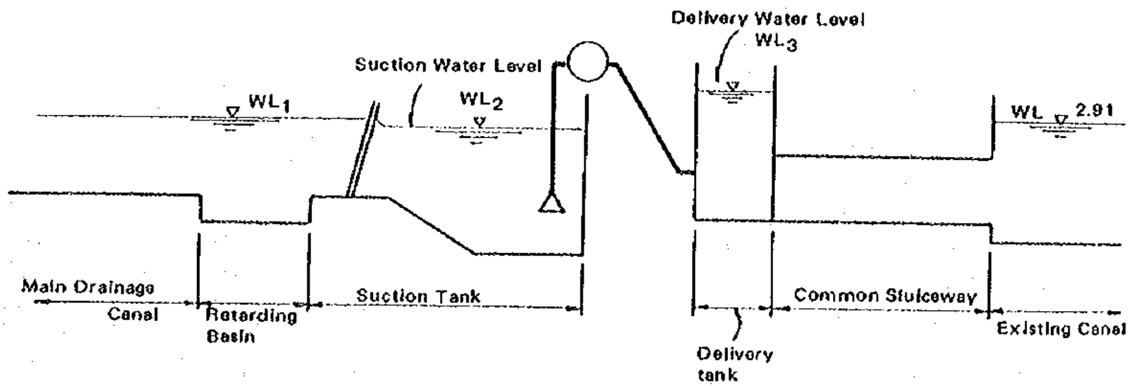
# FIGURE A.4 – 46 DESIGN SUCTION AND DELIVERY WATER LEVEL

## for Irrigation




| Block | Delivery Water Level $WL_3$ | Suction Water Level $WL_2$ | $WL_1$ |
|---|---|---|---|
| A | 3.40 | 0.20 | 0.41 |
| B | 3.40 | 0.20 | 0.44 |
| C | 3.40 | 0.10 | 0.37 |

## for Drainage



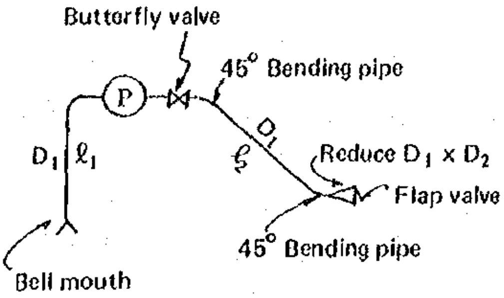

| Block | Delivery Water Level $WL_3$ | Suction Water Level $WL_2$ | $WL_1$ |
|---|---|---|---|
| A | 3.10 | 1.20 | 1.50 |
| B | 3.10 | 1.20 | 1.50 |
| C | 3.30 | 1.20 | 1.50 |

So, actual heads of pump ($WL_3 - WL_2$) are calculated as follows;

| | Block A | Block B | Block C |
|---|---|---|---|
| for irrigation | 3.20 | 3.20 | 3.30 |
| for drainage | 1.90 | 1.90 | 2.10 |

## (3) Calculation of Total Head

The total head of pump can be calculated by adding the total loss head in the pipe to the actual head of pump. The loss heads in the pipe are calculated as follows;




| | | Block A.B | Block C |
|---|---|---|---|
| $D_1$ | m | $\phi$1.35 | $\phi$1.65 |
| $D_2$ | m | $\phi$1.65 | $\phi$2.00 |
| $\ell_1$ | m | 6.0 | 6.6 |
| $\ell_2$ | m | 4.0 | 4.0 |

(1) Suction loss head (he)

$he = fe.V_1^2/2g$ fe: 0.3 (Bell mouth)

(2) Bending loss head (hb)

$hb = n.fb.V_1^2/2g$ fb: 0.13 n: Number of bending pipe

(3) Reducer loss head (hgd)

$hgd = fgd.(V_1 - V_2')^2/2g$ fgd: 0.13
V': Velocity of flow after reducing

(4) Valve loss head (hv)

$hv = fu.V_1^2/2g$ fv: 0.30 (Butterfly valve)

(5) Delivery loss head (hse)

$hse = fse.V_2^2/2g$ fse: 1.5 (In case of flap Valve)

(6) Friction loss head (hf)

$hf = f.(\ell_1 + \ell_2).V_1^2/2g$ f: 0.0141 ($\phi$1,350)
f: 0.0108 ($\phi$1,650)

If pumps are planned for the purpose of drainage, total loss head for the irrigation will be nearly 130% of that in case of drainage, resulting in 70% of discharge in the drainage. Therefore, the loss heads in pipes in case of irrigation purpose are calculated based on the 70% of drainage discharge.

| Items | Unit | Block A Irrigation | Block A Drainage | Block B Irrigation | Block B Drainage | Block C Irrigation | Block C Drainage |
|---|---|---|---|---|---|---|---|
| Lifting capacity, Q | $m^3/s$ | 3.99 | 2.79 | 3.44 | 2.41 | 6.44 | 4.51 |
| Diameter of pipe, $D_1$ | mm | ϕ1,350 | | ϕ1,350 | | ϕ1,650 | |
| Diameter of pipe, $D_2$ | mm | ϕ1,650 | | ϕ1,650 | | ϕ1,800 | |
| Velocity at $D_1$, $V_1$ | m/s | 2.787 | 1.949 | 2.403 | 1.684 | 3.012 | 2.109 |
| Velocity at $D_2$, $V_2$ | m/s | 1.866 | 1.304 | 1.609 | 1.127 | 2.531 | 1.772 |
| Velocity head of $V_1$, $hv_1$ | m | 0.396 | 0.194 | 0.295 | 0.145 | 0.463 | 0.227 |
| Velocity head of $V_1$, $hv_2$ | m | 0.178 | 0.098 | 0.132 | 0.065 | 0.327 | 0.160 |
| Suction loss head, he | m | 0.119 | 0.058 | 0.089 | 0.044 | 0.139 | 0.068 |
| Bending loss head, hb | m | 0.154 | 0.075 | 0.116 | 0.057 | 0.180 | 0.089 |
| Valve loss head, hv | m | 0.119 | 0.059 | 0.089 | 0.044 | 0.140 | 0.068 |
| Reducer loss head, hgd | m | 0.009 | 0.005 | 0.006 | 0.003 | 0.003 | 0.002 |
| Friction loss head, hf | m | 0.084 | 0.041 | 0.063 | 0.030 | 0.080 | 0.039 |
| Delivery loss head, hse | m | 0.267 | 0.147 | 0.198 | 0.098 | 0.491 | 0.240 |
| Total | | 0.752 | 0.385 | 0.561 | 0.276 | 1.033 | 0.506 |
| | | 0.80 | 0.40 | 0.60 | 0.30 | 1.10 | 0.50 |

Therefore, the total loss head in each blocks are as follows;

| | Block A Irrigation | Block A Drainage | Block B Irrigation | Block B Drainage | Block C Irrigation | Block C Drainage |
|---|---|---|---|---|---|---|
| Actual head | 1.90 | 3.20 | 1.90 | 3.20 | 2.10 | 3.30 |
| Loss head in pipe | 0.80 | 0.40 | 0.60 | 0.30 | 1.10 | 0.50 |
| Total (loss head) | 2.70 | 3.60 | 2.50 | 3.50 | 3.20 | 3.80 |

## Study on the Suction Performance of Pump (Cavitation)

If high vacuum is partly formed in water flow, the water vaporizes and fine bubble of vapor arises. This phenomenon called cavitation, which arises around the entrance of the impeller of pump, and causes noise and vibration, reduces the pumping efficiencies and the delivery discharge, and at last causes the stop of operation. In order to prevent from this penomenon, the suction head and the type of pump must be decided considering that the pump is able to endure against the high pressure more than the required minimum pressure, that is, the reducing pressure at the entrance of the impeller plus the saturated stream pressure of water.

The study on cavitation was made for the horizontal axial flow pump and the horizontal mixed flow pump in each case of the operating for irrigation and/or drainage. In the study, following two values of Net Possitive Suction Head (NPSH) are estimated;

NPSH which the pump requires .............. (hsv)
NPSH which the pump is able to avail ....... (Hsv)

In order that the pump does not cause the cavitation

Hsv > hsv is sufficient condition.

### Calculation of hsv;

hsv is calculated by the following arithmetical formula.

$$hsv = \left(\frac{N \cdot \sqrt{Q}}{S}\right)^{4/3}$$

$$N = \frac{Ns \cdot H^{3/4}}{Q^{1/2}}$$

where,
- Q : Delivery discharge (cu.m/min)
- S : Suction specific velocity
  Mixed flow pump ≒ 1,300, Axial flow pump ≒ 1,200
- N : Number of impeller turning (rpm)

H : Total pump head

Ns: Specific velocity
Mixed flow pump: 900 - 1,000
Axial flow pump: 1,500 - 1,600

| Block | $Q(m^3/min)$ | $Q^{1/2}$ | H(m) | $H^{3/4}$ | N(rpm) Axial flow pump | N(rpm) Mixed flow pump | hsv (m) Axial flow pump | hsv (m) Mixed flow pump |
|---|---|---|---|---|---|---|---|---|
| A | 239 | 15.46 | 2.7 | 2.11 | 220 | 140 | 4.01 | 1.97 |
| B | 206 | 14.35 | 2.5 | 1.99 | 220 | 140 | 3.63 | 1.79 |
| C | 386 | 19.65 | 3.2 | 2.39 | 200 | 120 | 4.86 | 2.21 |

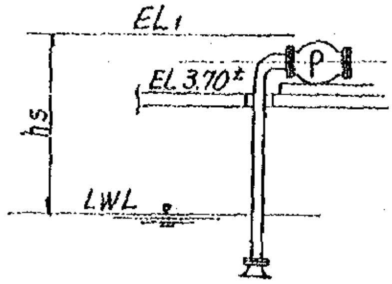
Calculation of Hsv:

Hsv is calculated by the following formula:

$$Hsv = Ha - hs - hv - ht - h = 9.5 - hs - ht$$

Ha : Atmospheric pressure (10.33 m)
hs : Actual suction head (m)
hv : Saturated stream pressure (0.33 m)
ht : Suction loss head (m)
h : Allowance 0.5 (m)

Actual suction head indicates the height from the suction water level to the upper end of pump.




| Item | Unit | Drainage Block A | Drainage Block B | Drainage Block C | Irrigation Block A | Irrigation Block B | Irrigation Block C |
|---|---|---|---|---|---|---|---|
| LWL | m | 1.20 | 1.20 | 1.20 | 0.20 | 0.20 | 0.10 |
| $EL_1$ | m | 6.10 | 6.10 | 6.30 | 6.10 | 6.10 | 6.30 |
| hs | m | 4.90 | 4.90 | 5.10 | 5.90 | 5.90 | 6.20 |
| ht | m | 0.25 | 0.19 | 0.28 | 0.13 | 0.10 | 0.15 |
| Hsv | m | 4.35 | 4.41 | 4.12 | 3.47 | 3.50 | 3.15 |

| Block | Horizontal axial flow pump | | | | | Horizontal mixed flow pump | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Drainage | | Irrigation | | | Drainage | | Irrigation | |
| | hsv (m) | Hsv | Judgment | Hsv | Judgment | hsv (m) | Hsv | Judgment | Hsv | Judgment |
| A | 4.01 | 4.35 | P | 3.47 | I | 1.97 | 4.35 | P | 3.47 | P |
| B | 3.63 | 4.41 | P | 3.50 | I | 1.79 | 4.41 | P | 3.50 | P |
| C | 4.86 | 4.12 | I | 3.15 | I | 2.21 | 4.12 | P | 3.15 | P |

Note: P; Possible I; Impossible

From the table mentioned above, the axial flow pump is able to be operated for the purpose of drainage, but it can not be operated for the purpose of irrigation, therefore, the horizontal mixed flow pump are recommended in all blocks in the Project.

## Decision of the Pumping Dimensions

The pumping dimensions should be decided in the case of drainage, because the delivery discharge is bigger than that in case of irrigation.

° Number of impeller turning (N)

The number of impeller turning is calculated by the following formula;

$$N = Ns \frac{H^{3/4}}{Q^{1/2}}$$

Ns : Specific velocity (mixed flow pump Ns = 900 - 1,000)

Q : Design delivery discharge (cu.m/min)

H : Design total head (m)

| Block | Q ($m^3$/min) | H(m) | $H^{3/4}$ | N |
|---|---|---|---|---|
| A | 239 | 2.70 | 2.11 | 140 |
| B | 206 | 2.50 | 1.99 | 140 |
| C | 386 | 3.20 | 2.39 | 120 |

° Number of poles and revolutions, and the type of motor.

| | |
|---|---|
| Number of poles, P | 6 |
| Number of revolutions, rpm | 1,000 |
| Type | Three-phase motor |

° Required output of the motor

The required output of motor is calculated by the following;

$$RHP = \frac{K.r.Q.H(1+\alpha)}{\eta_p \cdot \eta_G}$$

PHP : Required output (KW) (PS)

K : Coefficient In case of kw ..... 0.163
In case of PS ..... 0.222

r : Specific gravity of water 1.0

Q : Delivery discharge (cu.m/min)

H : Total pumping head (m)

$\alpha$ : Surplus coefficient 0.15

$\eta p$ : Pumping efficiency
$\phi$1,350 $\eta P$ = 78 %
$\phi$1,650 $\eta P$ = 81 %

$\eta_G$ : Conduction efficiency in case of using the reduction gear, 0.95

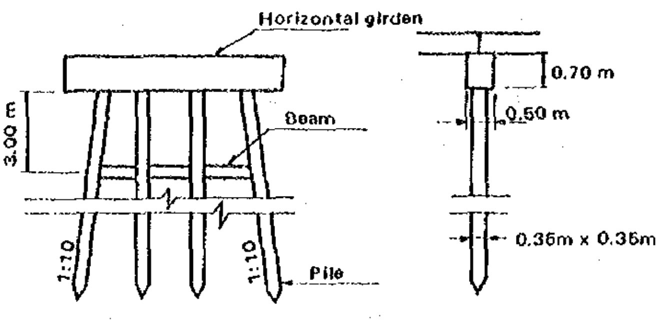
| Block | Borediameter (mm) | Units | Delivery discharge per unit ($m^3$/min) | Total Head | Required output KW | Required output PS |
|---|---|---|---|---|---|---|
| A | $\phi$1,350 | 3 | 239 | 2.70 | 170 | 240 |
| B | $\phi$1,350 | 3 | 206 | 2.50 | 140 | 200 |
| C | $\phi$1,650 | 3 | 386 | 3.20 | 300 | 440 |

## Typical Design of Bridge

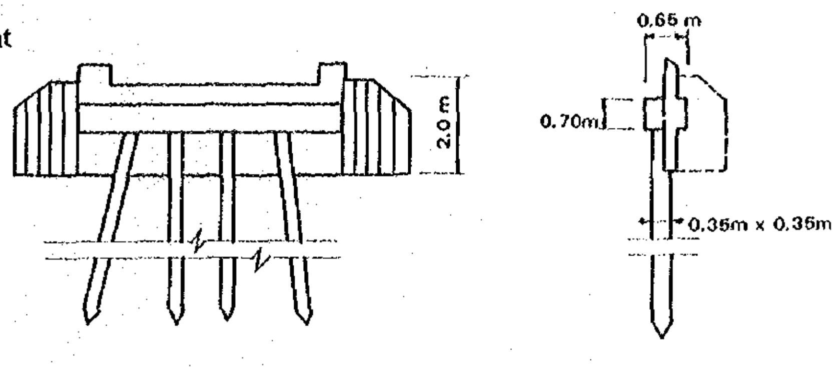
Bridges will be constructed across the eixsting canals, that is, Phraya Banlu, IL-2, Khud Mai and Nai Chat in the Project Area. Automobile can not pass to the existing wooden bridges except in a few bridges, but after completion of this Project, it is considered that the traffic will be increased owing to the development of road function, and therefore stable bridges, that is, steel bridges, prestressed concrete bridge and slub bridge will be necessary. Slub bridge is adopted in this planning from economical point of view. After completion of the Project, the existing canals will be used for the navigation canals, so the central portion of bridge should be high in order that a ship will be able to a through under the bridges.

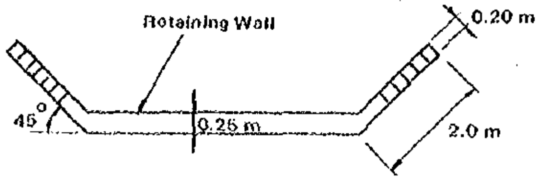
Generally speaking, maximum span length of slub bridge is ten meters. So the length of it is planned to be eight meters in considering the safty and the span division. Typical designs are as follows, after making reference to the typical designs which belong to the Department of Highway, RID.

**Pier**

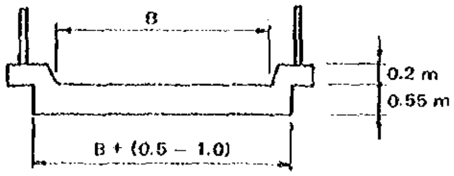



**Abutment**

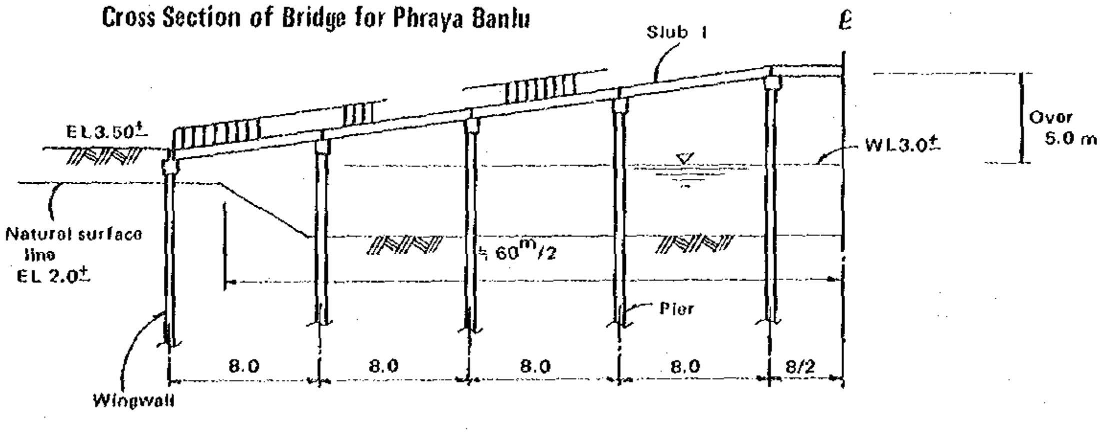




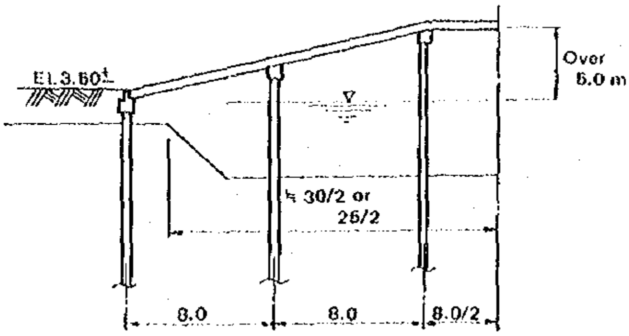

Slub




Cross Section of Bridge for Phraya Banlu




Cross Section of Bridge for IL-2, Khud Mai and Nai Chat



Estimation of Deduction Ratio

The deduction ratio after the project equipped with necessary facilities can be estimated by applying the following equation;

$$\text{Reduction Ratio (\%)} = \frac{\text{area to be reducted by on-farm facilities}}{\text{objective area for on-farm facilities}} \times 100$$

On farm facilities include the all irrigation and drainage canals and roads except the provincial roads, and of which reduction ratio of each block amounts as follows;

| Description | Block A | Block B | Block C | Total |
|---|---|---|---|---|
| Area of on-farm facilities (ha) (a) | 223 | 181 | 341 | 745 |
| Objective area for on-farm facilities (ha) (b) 1/ | 3,250 | 2,764 | 5,273 | 11,287 |
| Reduction Ratio (%) (c)=(a)/(b)x100 | 6.9 | 6.5 | 6.5 | 6.6 |

Note:

| | Block A | Block B | Block C |
|---|---|---|---|
| Gross area (1) | 3,493 ha | 3,057 ha | 5,744 ha |
| Area of existing canal (2) | 26 | 12 | 93 |
| Area of public facilities (3) 2/ | 121 | 125 | 198 |
| River side land (4) 3/ | 18 | 75 | 82 |
| Dike (5) | 50 | 43 | 62 |
| Borrow pit (6) | 24 | 22 | 32 |
| Provincial road (7) | 4 | 16 | 4 |

1/ : (b) = (1) - {(2) + (3) + (4) + (5) + (6) + (7)}

2/ : consists of homestead, school, supporting services, fish pond and animal husbandry.

3/ : areas between dikes to be provided along the Khlong Phraya Banlu, Khud Mai and Nai Chat.

Table A.4-64 Length and Area of Bed Width for Proposed Facilities (Block A)

| Type | Length | Dike | | | Borrow pit | | | | | | Provincial road | | Main road | | Community road | | On-farm road | | Main irrigation canal | | Lateral irrigation canal | | d |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | B.P | | M.D.C | | L.D.C | | | | | | | | | | | | | | |
| | km | U.W m/m | R.A ha | U.W m/m | ℓ km | R.A ha | ℓ km | R.A ha | ℓ km | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U m |
| Dike (8m) (with M.I.C) | - | 17.25 | | 26.10 | | | | | | | - | - | - | - | - | - | - | - | 14.50 | | - | - | - |
| " (4m) (with M.I.C) | 7.5 | 13.25 | 9.9 | 23.60 | | | 7.5 | 17.7 | | | - | - | - | - | - | - | - | - | 14.50 | 10.9 | - | - | - |
| " (8m) (without M.I.C) | - | 17.25 | | 19.40 | | | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - |
| " (4m) (without M.I.C) | 29.9 | 13.25 | 39.6 | 16.80 | 14.0 | 23.5 | 1.5 | 2.5 | 14.4 | 24.2 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Main road (6m) (with L.I.C) | 2.75 | - | - | - | - | - | - | - | - | - | - | - | 8.38 | 2.3 | - | - | - | - | - | - | 4.30 | 1.2 | - |
| " (with D.D) | 10.45 | - | - | - | - | - | - | - | - | - | - | - | 8.50 | 8.9 | - | - | - | - | - | - | - | - | - |
| " (with L.D.C) | 5.60 | - | - | - | - | - | - | - | - | - | - | - | 8.50 | | - | - | - | - | - | - | - | - | - |
| " (with L.I.C and L.D.C) | 1.30 | - | - | - | - | - | - | - | - | - | - | - | 8.88 | 1.2 | - | - | - | - | - | - | 3.30 | 0.4 | - |
| Community road (4.0m) (with M.I.C) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.75 | | - | - | 7.78 | | - | - | - |
| " (with L.I.C) | 25.05 | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.38 | 16.0 | - | - | - | - | 4.30 | 10.8 | - |
| " (with D.D) | 6.55 | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.50 | 4.3 | - | - | - | - | - | - | - |
| " (with L.I.C and L.D.C) | | | | | | | | | | | | | | | | | | | | | | | |
| | 1.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.88 | 0.7 | - | - | - | - | 3.30 | 0.3 | - |
| Leading drainage canal (with O.F.R) | 9.75 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.6x2 | 7.0 | - | - | - | - | - |
| Existing provincial road (with M.I.C) | - | - | - | - | - | - | - | - | - | - | 11.0 | | - | - | - | - | - | - | 10.10 | | - | - | - |
| " (with L.I.C) | 4.15 | - | - | - | - | - | - | - | - | - | 10.5 | 4.4 | - | - | - | - | - | - | - | - | 4.10 | 1.7 | - |
| " | - | - | - | - | - | - | - | - | - | - | 11.0 | | - | - | - | - | - | - | - | - | - | - | - |
| Proposed provincial road (with M.I.C and M.D.C) | | | | | | | | | | | | | | | | | | | | | | | |
| | - | - | - | - | - | - | - | - | - | - | 12.0 | | - | - | - | - | - | - | 8.10 | | - | - | 12. |
| " (with M.D.C) | - | - | - | - | - | - | - | - | - | - | 11.5 | | - | - | - | - | - | - | - | - | - | - | 12. |
| " (with M.I.C) | - | - | - | - | - | - | - | - | - | - | 11.0 | | - | - | - | - | - | - | 10.10 | | - | - | - |
| Existing Dike (with L.D.C) | - | 10.0 | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Existing Road (with L.I.C) | - | - | - | - | - | - | - | - | - | - | - | - | 9.25 | | - | - | - | - | - | - | 4.30 | | - |
| Total | | (37.4) | 49.5 | | (14.0) | 23.5 | (9.0) | 20.2 | (14.4) | 24.2 | (4.15) | 4.4 | (14.5) | 12.4 | (32.6) | 21.0 | (19.50) | 7.0 | (7.50) | 10.9 | (34.25) | 14.4 | |

Note: ( ) shows the total length of facilities

U.W : Unit width (m)
R.A : Required area (ha)
M.I.C : Main irrigation canal
L.I.C : Lateral irrigation canal
M.D.C : Main drainage canal
L.D.C : Leading drainage canal
D.D : Drainage ditch
O.F.R : On-farm road

Length and Area of Bed Width for Proposed Facilities (Block A)

| Borrow pit B.P R.A ha | Borrow pit M.D.C ℓ km | Borrow pit M.D.C R.A ha | Borrow pit L.D.C ℓ km | Borrow pit L.D.C R.A ha | Provincial road U.W m/m | Provincial road R.A ha | Main road U.W m/m | Main road R.A ha | Community road U.W m/m | Community road R.A ha | On-farm road U.W m/m | On-farm road R.A ha | Main irrigation canal U.W m/m | Main irrigation canal R.A ha | Lateral irrigation canal U.W m/m | Lateral irrigation canal R.A ha | Main drainage canal U.W m/m | Main drainage canal R.A ha | Leading drainage canal U.W m/m | Leading drainage canal R.A ha | Drainage ditch U.W m/m | Drainage ditch R.A ha | Total U.W m/m | Total R.A ha | Number of Unit Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | - | - | - | - | - | - | - | - | 14.50 | | - | - | - | - | - | - | - | - | 57.85 | - | D-1, MIC-1 |
| | 7.5 | 17.7 | | | - | - | - | - | - | - | - | - | 14.50 | 10.9 | - | - | - | - | - | - | - | - | 51.35 | 38.5 | D-2, MIC-2 |
| | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 36.65 | - | D-3 |
| 23.5 | 1.5 | 2.5 | 14.4 | 24.2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 30.05 | 89.8 | D-4 |
| - | - | - | - | - | - | - | 8.38 | 2.3 | - | - | - | - | - | - | 4.30 | 1.2 | - | - | - | - | - | - | 12.68 | 3.5 | MR-1, LIC-1 |
| - | - | - | - | - | - | - | 8.50 | 8.9 | - | - | - | - | - | - | - | - | - | - | - | - | 3.4x2 | 7.1 | 15.30 | 16.0 | MR-2, DD-1 |
| - | - | - | - | - | - | - | 8.50 | | - | - | - | - | - | - | - | - | - | - | 5.4x2 | 3.0 | - | - | 19.30 | 3.0 | MR-3, LDC-2 |
| - | - | - | - | - | - | - | 8.88 | 1.2 | - | - | - | - | - | - | 3.30 | 0.4 | - | - | 5.90 | 0.8 | - | - | 18.08 | 2.4 | MR-4, LDC-3, LIC-3 |
| - | - | - | - | - | - | - | - | - | 6.75 | | - | - | 7.78 | | - | - | - | - | - | - | - | - | 14.53 | - | CR-4, MIC-4 |
| - | - | - | - | - | - | - | - | - | 6.38 | 16.0 | - | - | - | - | 4.30 | 10.8 | - | - | - | - | - | - | 10.68 | 26.8 | CR-1, LIC-2 |
| - | - | - | - | - | - | - | - | - | 6.50 | 4.3 | - | - | - | - | - | - | - | - | - | - | 3.4x2 | 4.4 | 13.30 | 8.7 | CR-2, DD-2 |
| - | - | - | - | - | - | - | - | - | 6.88 | 0.7 | - | - | - | - | 3.30 | 0.3 | - | - | 5.90 | 0.6 | - | - | 16.08 | 1.6 | CR-3, LDC-4, LIC-4 |
| - | - | - | - | - | - | - | - | - | - | - | 3.6x2 | 7.0 | - | - | - | - | - | - | 7.00 | 6.8 | - | - | 14.20 | 13.8 | OFR-1, LDC-1 |
| - | - | - | - | - | 11.0 | | - | - | - | - | - | - | 10.10 | | - | - | - | - | - | - | - | - | 21.10 | - | PR-2, MIC-3 |
| - | - | - | - | - | 10.5 | 4.4 | - | - | - | - | - | - | - | - | 4.10 | 1.7 | - | - | - | - | - | - | 14.60 | 6.1 | PR-1, LIC-5 |
| - | - | - | - | - | 11.0 | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 11.00 | - | PR-5 |
| - | - | - | - | - | 12.0 | | - | - | - | - | - | - | 8.10 | | - | - | 12.05 | | - | - | - | - | 32.15 | - | PR-3, MIC-5, MDC-1 |
| - | - | - | - | - | 11.5 | | - | - | - | - | - | - | - | - | - | - | 12.05 | | - | - | - | - | 23.55 | - | PR-4, MDC-2 |
| - | - | - | - | - | 11.0 | | - | - | - | - | - | - | 10.10 | | - | - | - | - | - | - | - | - | 21.10 | - | PR-6, MIC-3 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.0 | | - | - | 15.00 | - | D-5, LDC-5 |
| - | - | - | - | - | - | - | 9.25 | | - | - | - | - | - | - | 4.30 | | - | - | - | - | - | - | 13.55 | - | MR-5, LIC-6 |
| 23.5 | (9.0) | 20.2 | (14.4) | 24.2 | (4.15) | 4.4 | (14.5) | 12.4 | (32.6) | 21.0 | (19.50) | 7.0 | (7.50) | 10.9 | (34.25) | 14.4 | | | (17.65) | 11.2 | (34.0) | 11.5 | | 210.2 | |

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Table A.4-65 Length and Area of Bed Width of Proposed Facilities (Block B)

| Type | Length km | Dike U.W m/m | Dike R.A ha | U.W m/m | Borrow pit B.P ℓ km | Borrow pit B.P R.A ha | Borrow pit M.D.C ℓ km | Borrow pit M.D.C R.A ha | Borrow pit L.D.C ℓ km | Borrow pit L.D.C R.A ha | Provincial road U.W m/m | Provincial road R.A ha | Main road U.W m/m | Main road R.A ha | Community road U.W m/m | Community road R.A ha | On-farm road U.W m/m | On-farm road R.A ha | Main irrigation canal U.W m/m | Main irrigation canal R.A ha | Lateral irrigati canal U.W m/m | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dike (8m) (with M.I.C) | - | 17.25 | | 26.10 | | | | | | | - | - | - | - | - | - | - | - | 14.50 | | - | |
| " (4m) (with M.I.C) | 9.45 | 13.25 | 12.5 | 23.60 | | | 9.45 | 22.3 | | | - | - | - | - | - | - | - | - | 14.50 | 13.7 | - | |
| " (8m) (without M.I.C) | - | 17.25 | | 19.40 | | | | | | | - | - | - | - | - | - | - | - | - | - | - | |
| " (4m) (without M.I.C) | 22.4 | 13.25 | 29.7 | 16.80 | 13.1 | 22.0 | 4.0 | 6.7 | 5.3 | 8.9 | - | - | - | - | - | - | - | - | - | - | - | |
| Main road (6m) (with L.I.C) | 2.4 | - | - | - | - | - | - | - | - | - | - | - | 8.38 | 2.0 | - | - | - | - | - | - | 4.30 | 1 |
| " (with D.D) | 8.3 | - | - | - | - | - | - | - | - | - | - | - | 8.50 | 7.1 | - | - | - | - | - | - | - | |
| " (with L.D.C) | 5.6 | - | - | - | - | - | - | - | - | - | - | - | 8.50 | 4.8 | - | - | - | - | - | - | - | |
| " (with L.I.C and L.D.C) | - | - | - | - | - | - | - | - | - | - | - | - | 8.88 | | - | - | - | - | - | - | 3.30 | |
| Community road (4.0m) (with M.I.C) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.75 | | - | - | 7.78 | | - | |
| " (with L.I.C) | 12.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.38 | 7.6 | - | - | - | - | 4.30 | 5 |
| " (with D.D) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.50 | | - | - | - | - | - | |
| " (with L.I.C and L.D.C) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.88 | | - | - | - | - | 3.30 | |
| Leading drainage canal (with O.F.R) | 12.35 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.6x2 | 8.9 | - | - | - | |
| Existing provincial road (with M.I.C) | 2.65 | - | - | - | - | - | - | - | - | - | 11.0 | 2.9 | - | - | - | - | - | - | 10.10 | 2.7 | - | |
| " (with L.I.C) | 5.45 | - | - | - | - | - | - | - | - | - | 10.5 | 5.7 | - | - | - | - | - | - | - | - | 4.10 | 2 |
| " | 6.50 | - | - | - | - | - | - | - | - | - | 11.0 | 7.2 | - | - | - | - | - | - | - | - | - | |
| Proposed provincial road (with M.I.C and M.D.C) | - | - | - | - | - | - | - | - | - | - | 12.0 | | - | - | - | - | - | - | 8.10 | | - | |
| " (with M.D.C) | - | - | - | - | - | - | - | - | - | - | 11.5 | | - | - | - | - | - | - | - | - | - | |
| " (with M.I.C) | - | - | - | - | - | - | - | - | - | - | 11.0 | | - | - | - | - | - | - | 10.10 | | - | |
| Existing Dike (with L.D.C) | 1.2 | 10.0 | 1.2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| Existing Road (with L.I.C) | - | - | - | - | - | - | - | - | - | - | - | - | 9.25 | | - | - | - | - | - | - | 4.30 | |
| Total | | (33.05) | 43.4 | | (13.1) | 22.0 | (13.45) | 29.0 | (5.3) | 8.9 | (14.6) | 15.8 | (16.3) | 13.9 | (12.0) | 7.6 | (24.7) | 8.9 | (12.10) | 16.4 | (19.85) | 8 |

Note: ( ) shows the total length of facilities

U.S : Unit width (m)
R.A : Required area (ha)
M.I.C : Main irrigation canal
L.I.C : Lateral irrigation canal
M.D.C : Main drainage canal
L.D.C : Leading drainage canal
D.D : Drainage ditch
O.F.R : On-farm road

Area of Bed Width of Proposed Facilities (Block B)

| ..pit | | | Provincial road | | Main road | | Community road | | On-farm road | | Main irrigation canal | | Lateral irrigation canal | | Main drainage canal | | Leading drainage canal | | Drainage ditch | | Total | | Number of Unit Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .C | L.D.C | | | | | | | | | | | | | | | | | | | | | | |
| R.A ha | ℓ km | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | |
| | | | - | - | - | - | - | - | - | - | 14.50 | | - | - | - | - | - | - | - | - | 57.85 | - | D-1, MIC-1 |
| 22.3 | | | - | - | - | - | - | - | - | - | 14.50 | 13.7 | - | - | - | - | - | - | - | - | 51.35 | 48.5 | D-2, MIC-2 |
| | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 36.65 | - | D-3 |
| 6.7 | 5.3 | 8.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 30.05 | 67.3 | D-4 |
| - | - | - | - | - | 8.38 | 2.0 | - | - | - | - | - | - | 4.30 | 1.0 | - | - | - | - | - | - | 12.68 | 3.0 | MR-1, LIC-1 |
| - | - | - | - | - | 8.50 | 7.1 | - | - | - | - | - | - | - | - | - | - | - | - | 3.4x2 | 5.6 | 15.30 | 12.7 | MR-2, DD-1 |
| - | - | - | - | - | 8.50 | 4.8 | - | - | - | - | - | - | - | - | - | - | 5.4x2 | 3.0 | - | - | 19.30 | 7.8 | MR-3, LDC-2 |
| - | - | - | - | - | 8.88 | | - | - | - | - | - | - | 3.30 | | - | - | 5.90 | | - | - | 18.08 | - | MR-4, LDC-3, LIC-3 |
| - | - | - | - | - | - | - | 6.75 | | - | - | 7.78 | | - | - | - | - | - | - | - | - | 14.53 | - | CR-4, MIC-4 |
| - | - | - | - | - | - | - | 6.38 | 7.6 | - | - | - | - | 4.30 | 5.2 | - | - | - | - | - | - | 10.68 | 12.8 | CR-1, LIC-2 |
| - | - | - | - | - | - | - | 6.50 | | - | - | - | - | - | - | - | - | - | - | 3.4x2 | | 13.30 | - | CR-2, DD-2 |
| - | - | - | - | - | - | - | 6.88 | | - | - | - | - | 3.30 | | - | - | 5.90 | | - | - | 16.08 | - | CR-3, LDC-4, LIC-4 |
| - | - | - | - | - | - | - | - | - | 3.6x2 | 8.9 | - | - | - | - | - | - | 7.00 | 8.6 | - | - | 14.20 | 17.5 | OFR-1, LDC-1 |
| - | - | - | 11.0 | 2.9 | - | - | - | - | - | - | 10.10 | 2.7 | - | - | - | - | - | - | - | - | 21.10 | 5.6 | PR-2, MIC-3 |
| - | - | - | 10.5 | 5.7 | - | - | - | - | - | - | - | - | 4.10 | 2.3 | - | - | - | - | - | - | 14.60 | 8.0 | PR-1, LIC-5 |
| - | - | - | 11.0 | 7.2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 11.00 | 7.2 | PR-5 |
| - | - | - | 12.0 | | - | - | - | - | - | - | 8.10 | | - | - | 12.05 | | - | - | - | - | 32.15 | - | PR-3, MIC-5, MDC-1 |
| - | - | - | 11.5 | | - | - | - | - | - | - | - | - | - | - | 12.05 | | - | - | - | - | 23.55 | - | PR-4, MDC-2 |
| - | - | - | 11.0 | | - | - | - | - | - | - | 10.10 | | - | - | - | - | - | - | - | - | 21.10 | - | PR-6, MIC-3 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.0 | 0.6 | - | - | 15.00 | 1.8 | D-5, LDC-5 |
| - | - | - | - | - | 9.25 | | - | - | - | - | - | - | 4.30 | | - | - | - | - | - | - | 13.55 | - | MR-5, LIC-6 |
| 29.0 | (5.3) | 8.9 | (14.6) | 15.8 | (16.3) | 13.9 | (12.0) | 7.6 | (24.7) | 8.9 | (12.10) | 16.4 | (19.85) | 8.5 | | | (19.15) | 12.2 | (16.6) | 5.6 | | 192.2 | |

Table A.4-66 Length and Area of Bed Width for Proposed Facilities (Block C)

| Type | Length | Dike | | | Borrow pit B.P | | Borrow pit M.D.C | | Borrow pit L.D.C | | Provincial road | | Main road | | Community road | | On-farm road | | i |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | km | U.W m/m | R.A ha | U.W m/m | ℓ km | R.A ha | ℓ km | R.A ha | ℓ km | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U.W m/m | R.A ha | U. m/ |
| Dike (8m) (with M.I.C) | 7.0 | 17.25 | 12.1 | 26.10 | 6.5 | 17.0 | 0.5 | 1.3 | | | - | - | - | - | - | - | - | - | 14. |
| " (4m) (with M.I.C) | 3.0 | 13.25 | 4.0 | 23.60 | | | 3.0 | 7.1 | | | - | - | - | - | - | - | - | - | 14. |
| " (8m) (without M.I.C) | 6.6 | 17.25 | 11.4 | 19.40 | 0.4 | 0.8 | | | 6.2 | 12.0 | - | - | - | - | - | - | - | - | - |
| " (4m) (without M.I.C) | 22.8 | 13.25 | 30.2 | 16.80 | 8.4 | 14.1 | 1.0 | 1.7 | 13.4 | 22.5 | - | - | - | - | - | - | - | - | - |
| Main road (6m) (with L.I.C) | 5.0 | - | - | - | - | - | - | - | - | - | - | - | 8.38 | 4.2 | - | - | - | - | - |
| " (with D.D) | 16.9 | - | - | - | - | - | - | - | - | - | - | - | 8.50 | 14.4 | - | - | - | - | - |
| " (with L.D.C) | - | - | - | - | - | - | - | - | - | - | - | - | 8.50 | | - | - | - | - | - |
| " (with L.I.C and L.D.C) | - | - | - | - | - | - | - | - | - | - | - | - | 8.88 | | - | - | - | - | - |
| Community road (4.0m) (with M.I.C) | 3.2 | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.75 | 2.2 | - | - | 7.: |
| " (with L.I.C) | 28.2 | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.38 | 18.0 | - | - | - |
| " (with D.D) | 11.55 | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.50 | 7.5 | - | - | - |
| " (with L.I.C and L.D.C) | 11.55 | - | - | - | - | - | - | - | - | - | - | - | - | - | 6.88 | 8.0 | - | - | - |
| Leading drainage canal (with O.F.R) | 15.20 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3.6x2 | 10.9 | - |
| Existing Provincial road (with M.I.C) | - | - | - | - | - | - | - | - | - | - | 11.0 | | - | - | - | - | - | - | 10.1 |
| " (with L.I.C) | - | - | - | - | - | - | - | - | - | - | 10.5 | | - | - | - | - | - | - | - |
| " | - | - | - | - | - | - | - | - | - | - | 11.0 | | - | - | - | - | - | - | - |
| Proposed provincial road (with M.I.C and M.D.C) | 2.0 | - | - | - | - | - | - | - | - | - | 12.0 | 2.4 | - | - | - | - | - | - | 8.1 |
| " (with M.D.C) | 0.5 | - | - | - | - | - | - | - | - | - | 11.5 | 0.6 | - | - | - | - | - | - | - |
| " (with M.I.C) | 1.3 | - | - | - | - | - | - | - | - | - | 11.0 | 1.4 | - | - | - | - | - | - | 10.1 |
| Existing Dike (with L.D.C) | 4.6 | 10.0 | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Existing Road (with L.I.C) | 3.0 | - | - | - | - | - | - | - | - | - | - | - | 9.25 | 2.8 | - | - | - | - | - |
| Total | | (44.0) | 62.3 | | (15.3) | 31.9 | (4.5) | 10.1 | (19.6) | 34.5 | (3.8) | 4.4 | (24.9) | 21.4 | (54.5) | 35.7 | (30.4) | 10.9 | (16.5 |

Note: ( ) shows the total length of facilities

U.W : Unit width (m)
R.A : Required area (ha)
M.I.C : Main irrigation canal
L.I.C : Lateral irrigation canal
M.D.C : Main drainage canal
L.D.C : Leading drainage canal
D.D : Drainage ditch
O.F.R : On-farm road

th and Area of Bed Width for Proposed Facilities (Block C)

| Borrow pit M.D.C ℓ km | Borrow pit M.D.C R.A ha | Borrow pit L.D.C ℓ km | Borrow pit L.D.C R.A ha | Provincial road U.W m/m | Provincial road R.A ha | Main road U.W m/m | Main road R.A ha | Community road U.W m/m | Community road R.A ha | On-farm road U.W m/m | On-farm road R.A ha | Main irrigation canal U.W m/m | Main irrigation canal R.A ha | Lateral irrigation canal U.W m/m | Lateral irrigation canal R.A ha | Main drainage canal U.W m/m | Main drainage canal R.A ha | Leading drainage canal U.W m/m | Leading drainage canal R.A ha | Drainage ditch U.W m/m | Drainage ditch R.A ha | Total U.W m/m | Total R.A ha | Number of Unit Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | 1.3 | | | - | - | - | - | - | - | - | - | 14.50 | 10.1 | - | - | - | - | - | - | - | - | 57.85 | 40.5 | D-1, MIC-1 |
| 3.0 | 7.1 | | | - | - | - | - | - | - | - | - | 14.50 | 4.3 | - | - | - | - | - | - | - | - | 51.35 | 15.4 | D-2, MIC-2 |
| | | 6.2 | 12.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 36.65 | 24.2 | D-3 |
| 1.0 | 1.7 | 13.4 | 22.5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 30.05 | 68.5 | D-4 |
| - | - | - | - | - | - | 8.38 | 4.2 | - | - | - | - | - | - | 4.30 | 2.1 | - | - | - | - | - | - | 12.68 | 6.3 | MR-1, LIC-1 |
| - | - | - | - | - | - | 8.50 | 14.4 | - | - | - | - | - | - | - | - | - | - | - | - | 3.4x2 | 11.5 | 15.30 | 25.9 | MR-2, DD-1 |
| - | - | - | - | - | - | 8.50 | | - | - | - | - | - | - | - | - | - | - | 5.4x2 | | - | - | 19.30 | - | MR-3, LDC-2 |
| - | - | - | - | - | - | 8.88 | | - | - | - | - | - | - | 3.30 | | - | - | 5.90 | | - | - | 18.08 | - | MR-4, LDC-3, LIC-3 |
| - | - | - | - | - | - | - | - | 6.75 | 2.2 | - | - | 7.78 | 2.5 | - | - | - | - | - | - | - | - | 14.53 | 4.7 | CR-4, MIC-4 |
| - | - | - | - | - | - | - | - | 6.38 | 18.0 | - | - | - | - | 4.30 | 12.1 | - | - | - | - | - | - | 10.68 | 30.1 | CR-1, LIC-2 |
| - | - | - | - | - | - | - | - | 6.50 | 7.5 | - | - | - | - | - | - | - | - | - | - | 3.4x2 | 7.9 | 13.30 | 15.4 | CR-2, DD-2 |
| - | - | - | - | - | - | - | - | 6.88 | 8.0 | - | - | - | - | 3.30 | 3.8 | - | - | 5.90 | 6.8 | - | - | 16.08 | 18.6 | CR-3, LDC-4, LIC-4 |
| - | - | - | - | - | - | - | - | - | - | 3.6x2 | 10.9 | - | - | - | - | - | - | 7.00 | 10.7 | - | - | 14.20 | 21.6 | OFR-1, LDC-1 |
| - | - | - | - | 11.0 | | - | - | - | - | - | - | 10.10 | | - | - | - | - | - | - | - | - | 21.10 | - | PR-2, MIC-3 |
| - | - | - | - | 10.5 | | - | - | - | - | - | - | - | - | 4.10 | | - | - | - | - | - | - | 14.60 | - | PR-1, LIC-5 |
| - | - | - | - | 11.0 | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 11.00 | - | PR-5 |
| - | - | - | - | 12.0 | 2.4 | - | - | - | - | - | - | 8.10 | 1.6 | - | - | 12.05 | 2.4 | - | - | - | - | 32.15 | 6.4 | PR-3, MIC-5, MDC-1 |
| - | - | - | - | 11.5 | 0.6 | - | - | - | - | - | - | - | - | - | - | 12.05 | 0.6 | - | - | - | - | 23.55 | 1.2 | PR-4, MDC-2 |
| - | - | - | - | 11.0 | 1.4 | - | - | - | - | - | - | 10.10 | 1.3 | - | - | - | - | - | - | - | - | 21.10 | 2.7 | PR-6, MIC-3 |
| - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.0 | 2.3 | - | - | 15.00 | 6.9 | D-5, LDC-5 |
| - | - | - | - | - | - | 9.25 | 2.8 | - | - | - | - | - | - | 4.30 | 1.3 | - | - | - | - | - | - | 13.55 | 4.1 | MR-5, LIC-6 |
| (4.5) | 10.1 | (19.6) | 34.5 | (3.8) | 4.4 | (24.9) | 21.4 | (54.5) | 35.7 | (30.4) | 10.9 | (16.50) | 19.8 | (47.75) | 19.3 | (2.5) | 3.0 | (31.35) | 19.8 | (56.9) | 19.4 | | 292.5 | |

ities

Table A.4-67 Investment Cost of the Project

| | Description | Foreign Currency (฿'000) | Foreign Currency (US$'000) | Local Currency (฿'000) | Local Currency (US$'000) | Total (฿'000) | Total (US$'000) |
|---|---|---|---|---|---|---|---|
| 1. | Civil Works | 94,020 | ( 4,701.0) | 177,080 | ( 8,854.0) | 271,100 | (13,555.0) |
| | 1-1. Preparation | 330 | ( 16.5) | 18.580 | ( 929.0) | 18,910 | ( 94.5) |
| | 1-2. Pumping Station | 83,590 | ( 4,179.5) | 31,760 | ( 1,588.0) | 115,350 | ( 5,767.5) |
| | 1-3. Dike | 1,340 | ( 67.0) | 20,600 | ( 1,030.0) | 21,940 | ( 1,097.0) |
| | 1-4. On-Farm Facilities | 8,320 | ( 416.0) | 101,500 | ( 5,075.0) | 109,820 | ( 5,491.0) |
| | 1-5. Provincial Road | 440 | ( 22.0) | 4,640 | ( 232.0) | 5,080 | ( 254.0) |
| 2. | Construction Equipment | 133,100 | ( 6,655.0) | 1,300 | ( 65.0) | 134,400 | ( 6,720.0) |
| 3. | Agricultural Development | - | - | 14,860 | ( 743.0) | 14,860 | ( 743.0) |
| 4. | Project Administration & Facilities | 1,280 | ( 64.0) | 21,460 | ( 1,073.0) | 22,740 | ( 1,137.0) |
| 5. | Consulting Services | 22,700 | ( 1,135.0) | 8,620 | ( 431.0) | 31,320 | ( 1,566.0) |
| 6. | Land Acquisition | - | - | 3,640 | ( 182.0) | 3,640 | ( 182.0) |
| | Sub-total (1 to 6) | 251,100 | (12,555.0) | 226,960 | (11,348.0) | 478,060 | (23,903.0) |
| 7. | Contingency | 37,665 | ( 1,883.2) | 34,045 | ( 1,702.3) | 71,710 | ( 3,585.5) |
| | Total | 288,765 | (14,438.2) | 261,005 | (13,050.3) | 549,770 | (27,488.5) |
| 8. | Price Escalation | 82,269 | ( 4,113.5) | 91,846 | ( 4,592.3) | 174,115 | ( 8,705.8) |
| | Grand Total | 371,034 | (18,551.7) | 352,851 | (17,642.6) | 723,885 | (36,194.3) |

1. Civil Works

| Item | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-1. | Preparation | | | | | | | |
| 1-1-1. | Pumping Station | | | | | | | |
| | Dry works by pump ϕ4" | 1,620 | day | 20 | 80 | 32.40 | 129.60 | Pr-1[a/] |
| | Setting & withdrawing of a concrete plant 0.5 $m^3$ | 3 | L.S | 2,000 | 23,000 | 6.00 | 69.00 | Pr-2 |
| | Retaining wall | 90 | m | 200 | 290 | 18.00 | 26.10 | Pr-3 |
| | Temporary road | 150 | m | 4 | 101 | 0.60 | 15.15 | 12 |
| | Foothold | 17,400 | $m^3$ | - | 40 | - | 696.00 | Pr-4 |
| | Curing concrete | 11,600 | $m^2$ | - | 10 | - | 116.00 | Pr-5 |
| | Sub-total | | | | | 57.00 | 1,051.85 | |
| | | | | | | ≒ 60 | 1,050 | |
| 1-1-2. | Dike | | | | | | | |
| | Temporary pier | 16.0 | m | - | 6,000 | - | 960.00 | Pr-6 |
| | Foothold | 7,000 | $m^3$ | - | 40 | - | 280.00 | Pr-4 |
| | Curing concrete | 2,200 | $m^2$ | - | 10 | - | 22.00 | Pr-5 |
| | Temporary road | 200 | m | 4 | 101 | 0.80 | 20.20 | 12 |
| | Sub-total | | | | | 0.80 | 1,282.20 | |
| | | | | | | ≒ - | 1,280 | |
| 1-1-3. | On-Farm | | | | | | | |
| | Backfill of canal | 116.0 | km | 1,880 | 18,750 | 218.08 | 2,175.00 | Pr-7 |
| | Sheet-piling cofferdam | 1,400 | m | - | 600 | - | 840.00 | Pr-8 |
| | Temporary road | 300 | m | 4 | 101 | 1.20 | 30.30 | 12 |
| | Dry works by pump ϕ4" | 2,400 | day | 20 | 80 | 48.00 | 192.00 | Pr-1 |
| | Foothold | 9,500 | $m^2$ | - | 40 | - | 380.00 | Pr-4 |
| | Curing concrete | 3,000 | $m^2$ | - | 10 | - | 30.00 | Pr-5 |
| | Sub-total | | | | | 267.28 | 3,647.30 | |
| | | | | | | ≒ 270 | 3,650 | |

Note: a/ ; Number of unit cost (see Appendix 4-64)

| Item | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-1-4. | Provincial Road | | | | | | | |
| | Temporary pier | 210 | m | - | 6,000 | - | 1,260.00 | Pr-6 |
| | Foothold | 9,300 | $m^3$ | - | 40 | - | 372.00 | Pr-4 |
| | Curing concrete | 3,000 | $m^2$ | - | 10 | - | 30.00 | Pr-5 |
| | Temporary road | 150 | m | 4 | 101 | 0.60 | 15.15 | 12 |
| | Sub-total | | | | | 0.60 | 1,677.15 | |
| | | | | | | ≒ - | 1,680 | |
| 1-1-5. | Other preparation | | | | | | | |
| | Field Office | 1,000 | $m^2$ | - | 3,000 | - | 3,000.00 | Pr-9 |
| | Motor pool | 5,000 | $m^2$ | - | 20 | - | 100.00 | Pr-10 |
| | Indirect labor cost | L.S | | | | - | 4,050.00 | L.C x 3% |
| | Other | L.S | | | | - | 50.00 | |
| | Sub-total | | | | | - | 7,200.00 | |
| | | | | | | ≒ - | 7,200 | |
| 1-1-6. | Overhead | L.S | | | | | 3,720 | L.C x 25% |
| | Total | | | | | 330 | 18,580 | |
| 1-2. | Pumping Station | | | | | | | |
| 1-2-1. | Block A | | | | | | | |
| | Pump ϕ1,350 mm | 3 | set | | | 21,600 | 2,700 | |
| | Earthwork & other | L.S | | | | 800 | 4,400 | 1-2-1-1 b/ |
| | Overhead | L.S | | | | | 1,780 | L.C x 25% |
| | Sub-total | | | | | 22,400 | 8,880 | |

Note: b/ ; Number of construction cost of works (see Appendix 4-63)

| Item | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-2-2. | Block B | | | | | | | |
| | Pump $\phi$1,350 mm | 3 | set | | | 21,600 | 2,700 | |
| | Earthwork & other | L.S | | | | 800 | 4,400 | 1-2-2-1 |
| | Overhead | L.S | | | | - | 1,780 | L.C x 25% |
| | Sub-total | | | | | 22,400 | 8,880 | |
| 1-2-3. | Block C | | | | | | | |
| | Pump $\phi$1,650 mm | 3 | set | | | 33,400 | 3,600 | |
| | Earthwork & other | L.S | | | | 960 | 5,510 | 1-2-3-1 |
| | Overhead | L.S | | | | - | 2,280 | L.C x 25% |
| | Sub-total | | | | | 34,360 | 11,390 | |
| 1-2-4. | Electric facility | L.S | | | | 4,430 | 2,610 | |
| | Sub-total | | | | | 4,430 | 2,610 | |
| | Total | | | | | 83,590 | 31,760 | |
| 1-3. | Dike | | | | | | | |
| 1-3-1. | Block A | | | | | | | |
| | Dike, Type D-2 | 7,500 | m | 10 | 120 | 75.00 | 900.00 | |
| | Dike, Type D-4 | 29,900 | m | 10 | 130 | 299.00 | 3,887.00 | |
| | Bridge, Type Br-4 | 2 | unit | 50,200 | 204,500 | 100.40 | 409.00 | |
| | Overhead | L.S | | | | - | 1,299.00 | L.C x 25% |
| | Sub-total | | | | | 474.40 | 6,495.00 | |
| | | | | | | ≒ 480 | 6,490 | |
| 1-3-2. | Block B | | | | | | | |
| | Dike, Type D-2 | 9,450 | m | 10 | 120 | 94.50 | 1,134.00 | |
| | Dike, Type D-4 | 22,400 | m | 10 | 130 | 224.00 | 2,912.00 | |

| Item | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| | Dike, Type D-5 | 1,200 | m | 1 | 46 | 1.20 | 55.20 | |
| | Overhead | L.S | | | | - | 1,025.00 | L.C x 25% |
| | Sub-total | | | | | 319.70 | 5,126.20 | |
| | | | | | | ≒ 320 | 5,130 | |
| 1-3-3. | Block C | | | | | | | |
| | Dike, Type D-1 | 7,000 | m | 10 | 220 | 70.00 | 1,540.00 | |
| | Dike, Type D-2 | 3,000 | m | 10 | 120 | 30.00 | 360.00 | |
| | Dike, Type D-3 | 6,600 | m | 10 | 230 | 66.00 | 1,518.00 | |
| | Dike, Type D-4 | 22,800 | m | 10 | 130 | 228.00 | 2,964.00 | |
| | Dike, Type D-5 | 4,600 | m | 1 | 46 | 4.60 | 211.60 | |
| | Bridge, Type Br-2 | 1 | unit | 93,600 | 386,300 | 93.60 | 386.30 | |
| | Bridge, Type Br-4 | 1 | unit | 50,200 | 204,500 | 50.20 | 204.50 | |
| | Overhead | L.S | | | | - | 1,796.00 | L.C x 25% |
| | Sub-total | | | | | 542.40 | 8,980.40 | |
| | | | | | | ≒ 540 | 8,980 | |
| | Total | | | | | 1,340 | 20,600 | |
| 1-4. | On-Farm | | | | | | | |
| 1-4-1. | Block A | | | | | | | |
| | Survey | 3,027 | ha | - | 60 | - | 181.62 | |
| | Land clearing | 3,027 | ha | 20 | 240 | 60.54 | 726.48 | On-1 |
| | Land leveling | 3,027 | ha | 480 | 3,740 | 1,452.96 | 11,320.98 | On-2 |
| | Road | L.S | | | | 180.19 | 2,769.2 | 1-4-1-1 |
| | Canal & ditch | L.S | | | | 241.20 | 3,168.90 | 1-4-1-2 |
| | Terminal facilities | L.S | | | | 557.70 | 5,638.47 | 1-4-1-3 |
| | Overhead | L.S | | | | - | 5,951.00 | L.C x 25% |
| | Sub-total | | | | | 2,492.59 | 29,756.05 | |
| | | | | | | ≒ 2,490 | 29,760 | |

| Item | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-4-2. | Block B | | | | | | | |
| | Survey | 2,583 | ha | - | 60 | - | 154.98 | |
| | Land clearing | 2,583 | ha | 20 | 240 | 51.66 | 619.92 | On-1 |
| | Land leveling | 2,583 | ha | 480 | 3,740 | 1,239.84 | 9,660.42 | On-2 |
| | Road | L.S | | | | 142.12 | 2,519.90 | 1-4-2-1 |
| | Canal & ditch | L.S | | | | 242.75 | 2,988.05 | 1-4-2-2 |
| | Terminal facilities | L.S | | | | 524.48 | 5,074.82 | 1-4-2-3 |
| | Overhead | L.S | | | | | 5,254.00 | L.C x 25% |
| | Sub-total | | | | | 2,200.85 | 26,272.09 | |
| | | | | | | ≒ 2,200 | 26,270 | |
| 1-4-3. | Block C | | | | | | | |
| | Survey | 4,932 | ha | - | 60 | - | 295.92 | |
| | Land clearing | 4,932 | ha | 20 | 240 | 98.64 | 1,183.68 | On-1 |
| | Land leveling | 4,932 | ha | 480 | 3,740 | 2,367.36 | 18,445.68 | On-2 |
| | Road | L.S. | | | | 288.28 | 4,500.20 | 1-4-3-1 |
| | Canal & ditch | L.S. | | | | 396.46 | 5,115.88 | 1-4-3-2 |
| | Terminal facilities | L.S | | | | 479.62 | 6,837.59 | 1-4-3-3 |
| | Overhead | L.S | | | | | 9,094.00 | L.C x 25% |
| | Sub-total | | | | | 3,630.36 | 45,472.95 | |
| | | | | | | ≒ 3,630 | 45,470 | |
| | Total | | | | | 8,320 | 101,500 | |
| 1-5. | Provincial Road | | | | | | | |
| 1-5-1. | Block A | | | | | | | |
| | Road, Type PR-1 | 4,150 | m | 4 | 102 | 16.60 | 423.30 | |
| | Overhead | L.S | | | | | 105.00 | L.C x 25% |
| | Sub-total | | | | | 16.60 | 528.30 | |
| | | | | | | ≒ 20 | 530 | |

| Item | Description | Quantity | Unit | Rate F.C. (B) | Rate L.C. (B) | Amount F.C. (B1,000) | Amount L.C. (B1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-5-2. | Block B | | | | | | | |
| | Road, Type PR-1 | 5,450 | m | 4 | 102 | 21.80 | 555.90 | |
| | Road, Type PR-2 | 2,650 | m | 4 | 103 | 10.60 | 272.95 | |
| | Road, Type PR-5 | 6,500 | m | 4 | 103 | 26.00 | 669.50 | |
| | Bridge, Type Br-1 | 1 | unit | 164,800 | 633,600 | 164.80 | 633.60 | |
| | Bridge, Type Br-2 | 2 | unit | 93,600 | 386,300 | 187.20 | 772.00 | |
| | Overhead | L.S | | | | - | 726.00 | L.C x 25% |
| | Sub-total | | | | | 410.40 | 3,630.55 | |
| | | | | | | ≒ 410 | 3,630 | |
| 1-5-3. | Block C | | | | | | | |
| | Road, Type PR-3 | 2,000 | m | 3 | 94 | 6.00 | 188.00 | |
| | Road, Type PR-4 | 500 | m | 3 | 92 | 1.50 | 46.00 | |
| | Road, Type PR-6 | 1,300 | m | 6 | 119 | 7.80 | 154.70 | |
| | Overhead | L.S | | | | - | 97.00 | L.C x 25% |
| | Sub-total | | | | | 15.30 | 485.70 | |
| | | | | | | ≒ 10 | 480 | |
| | Total | | | | | 440 | 4,640 | |

## 2. Construction Equipment

(Unit: ₽'000)

| Equipments | Specification | | No. | Unit Price | Amount | Remarks |
|---|---|---|---|---|---|---|
| Bulldozer | 15t | 140ps | 18 | 1,000 | 18,000 | |
| Bulldozer | 16t | 140ps | 11 | 1,050 | 11,550 | Swampy type |
| Bulldozer | 21t | 200ps | 11 | 1,600 | 17,600 | |
| Backhoe | $0.3m^3$ | 60ps | 7 | 730 | 5,110 | |
| Backhoe | $0.6m^3$ | 100ps | 5 | 1,450 | 7,250 | |
| Dragline | $0.6m^3$ | | 2 | 90 | 180 | Backhoe attachment |
| Fronted loader | $1.6m^3$ | 125ps | 1 | 770 | 770 | |
| Scrape-dozer | $6.4m^3$ | 183ps | 22 | 1,850 | 40,700 | |
| Motor grader | 3.7m | 125ps | 1 | 1,150 | 1,150 | |
| Tire roller | 10t | 40ps | 6 | 350 | 2,100 | |
| Dump truck | 8t | 196ps | 3 | 310 | 930 | |
| Water tank truck | 6t | | 1 | 230 | 230 | |
| Fuel truck | 8t | | 2 | 380 | 760 | |
| Agitator truck | $1.6m^3$ | 135ps | 2 | 250 | 500 | |
| Agitator truck | $3.0m^3$ | 195ps | 2 | 420 | 840 | |
| Mixing pland | $0.5m^3$ | 30ps | 1 | 580 | 580 | |
| Pot mixer | $0.3m^3$ | 7.5ps | 3 | 60 | 180 | |
| Diesel hammer | 2.2t | | 1 | 690 | 690 | Backhoe attachment |
| Diesel hammer | 1.25t | | 1 | 410 | 410 | Backhoe attachment |
| Vibrator | 2.5ps | | 10 | 11 | 110 | |
| Rammer | 100kg | | 10 | 27 | 270 | |
| Belt conveyor | 7m | 3ps | 5 | 9 | 45 | |
| Concrete conveyor | 10m | 3.5ps | 2 | 90 | 180 | |
| Pump | $\phi 4''$ | 7ps | 10 | 15 | 150 | |
| Jeep | | | 5 | 120 | 600 | |
| Motor cycle | 90cc | | 5 | 12 | 60 | |
| Sub-total | | | | | 110,945 | |
| Spare parts | | | L.S. | | 22,155 | 20% |
| Transportation | | | L.S. | | 1,300 | 1% |
| Total | | | | | 134,400 | |

Note: Required Numbers of construction equipments are refered to Appendix 4-65.

3. Agricultural Development

| Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|
| AIRC Office | L.S | | | | | 2,000 | |
| Production unit Office | L.S | | | | | 1,200 | |
| Training center | L.S | | | | | 2,000 | |
| Seed center | L.S | | | | | 2,000 | |
| Motor pool | L.S | | | | | 1,225 | |
| Spare machine | L.S | | | | | 1,461 | |
| Assemble house & ware house | L.S | | | | | 2,000 | |
| Truck & motor bycicle | L.S | | | | | 1,576 | |
| Water supply | L.S | | | | | 1,400 | |
| Total | | | | | | 14,862 | |
| | | | | | | ≒ 14,860 | |

## 4. Project Administration & Facilities

| Item | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 4-1. | Pre-Engineering | | | | | | | |
| | Surveying works | | | | | | | |
| | Topographical survey | 10,000 | ha | | 500 | | 5,000 | |
| | Rout survey1/ | 153.05 | km | | 5,000 | | 762.25 | |
| | Plain survey | L.S | | | | | 400 | |
| | Core-boring | L.S | | | | | 300 | |
| | Sub-total | | | | | | 6,462.25 | |
| | | | | | | - | 6,470 | |
| 4-2. | Project Facilities | | | | | | | |
| | Building | 600 | $m^2$ | | 3,000 | | 1,800 | |
| | Funiture | L.S | | | | | 540 | |
| | Office equipments | L.S | | | | 1,280 | | |
| | Sub-total | | | | | 1,280 | 2,340 | |
| 4-3. | Overhead (Staff of project office) | | | | | | | |
| | Administration Division | | | | | | | |
| | University grad | 2 x 72 | man-month | | 4,000 | | 576 | |
| | Collage grad | 3 x 72 | man-month | | 3,000 | | 648 | |
| | High school grad | 6 x 72 | man-month | | 2,000 | | 864 | |
| | Others | 5 x 72 | man-month | | 1,500 | | 540 | |
| | Engineering Division | | | | | | | |
| | University grad | 5 x 12, 10 x 60 | man-month | | 4,000 | | 2,640 | |
| | Collage grad | 5 x 12, 10 x 60 | man-month | | 3,000 | | 1,980 | |
| | High school grad | 5 x 12, 20 x 60 | man-month | | 2,000 | | 2,520 | |
| | Others | 10 x 12, 30 x 60 | man-month | | 1,500 | | 2,880 | |
| | Sub-total | | | | | | 12,648 | |
| | | | | | | | ≒ 12,650 | |
| | Total | | | | | 1,280 | 21,460 | |

Note: 1/ Rout surveying

| | |
|---|---|
| Dike | 114.45 km |
| Main irrigation canal | 36.1 |
| Main drainage canal | 2.5 |
| Total | 153.05 km |

## 5. Consulting Services

| Item | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 5-1. | Foreign Exchange Cost | | | | | | | |
| | Final Design | | | | | | | |
| | Consultant remuneration | 62 | man-month | 120,000 | | 7,440 | | |
| | International travel expense | 12 | trip | 15,500 | | 186 | | |
| | Miscellaneous & communication | L.S | | | | 67 | | |
| | Sub-total | | | | | 7,693<br>≒ 7,690 | - | |
| | Construction Supervision | | | | | | | |
| | Consultant remuneration | 120 | man-month | 120,000 | | 14,400 | | |
| | Internation travel expense | 18 | trip | 15,500 | | 279 | | |
| | Miscellaneous & communication | L.S | | | | 333 | | |
| | Sub-total | | | | | 15,012<br>≒ 15,010 | - | |
| 5-2. | Local Currency Cost | | | | | | | |
| | To be borne by the Government; | | | | | | | |
| | Local transportation, office accomodation and consultants per diem | | | | | | | |
| | Final Design | | | | | | 1,440 | |
| | Construction supervision | | | | | | 7,180 | |
| | Sub-total | | | | | - | 8,620 | |
| | Total | | | | | 22,700 | 8,620 | |

## 6. Land Aquisition

| Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|
| Block A | | | | | | | |
| Area of Dike | 73.2 | ha | | 15,600 | | 1,141.92 | |
| Block B | | | | | | | |
| Area of Dike | 65.6 | ha | | 15,600 | | 1,023.36 | |
| Block C | | | | | | | |
| Area of Dike | 94.4 | ha | | 15,600 | | 1,472.64 | |
| Total | | | | | | 3,637.92 | |
| | | | | | | ≒ 3,640 | |

Table A.4-68 Construction Cost of Works

Earth Work & Other (pumping station)

| No. | Description | Quantity | Unit | Rate F.C. (B) | Rate L.C. (B) | Amount F.C. (B1,000) | Amount L.C. (B1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-2-1-1. | Block A | | | | | | | |
| | (a) Public Works | | | | | | | |
| | Earth works | | | | | | | |
| | Excavation | 12,900 | $m^3$ | 1.0 | 5.9 | 12.90 | 76.11 | EE-8 |
| | Embankment | 2,700 | $m^3$ | 0.7 | 10.2 | 1.89 | 27.54 | EB-4 |
| | Removal of excess soil | 9,930 | $m^3$ | 0.2 | 1.1 | 1.986 | 10.923 | EF-1 |
| | Concrete works | | | | | | | |
| | Concrete | 2,200 | $m^3$ | 70 | 450 | 154.00 | 990.00 | CO-9 |
| | Form works | 3,700 | $m^2$ | - | 110 | - | 407.00 | CO-12 |
| | Reinforcement bar | 160,000 | kg | 3.9 | 3.0 | 624.00 | 480.00 | CO-2 |
| | Foundation works | | | | | | | |
| | Pile 220 x 220 m/m | 545 | pile | 10 | 1,070 | 5.45 | 583.15 | CP-1 |
| | Pipe work | | | | | | | |
| | Pipe $\phi$700 mm | 120 | m | - | 550 | - | 66.00 | Pr-11 |
| | Other | L.S | | | | | 344.00 | (F.C+L.C)x10% |
| | Sub-total | | | | | 800.226 | 2,984.723 | |
| | (b) Pumping Station | | | | | | | |
| | Building | 312.5 | m | - | 3,000 | - | 937.50 | Pr-9 |
| | Sub-total | | | | | - | 937.50 | |
| | (c) Gate Works | | | | | | | |
| | Roller-gate $4.0^m \times 4.0^m$ | 1 | gate | - | 134,400 | - | 134.40 | |
| | Roller-gate $4.0^m \times 2.0^m$ | 1 | gate | - | 67,200 | - | 67.20 | |
| | Slush-gate $2.0^m \times 1.6^m$ | 2 | gate | - | 42,500 | - | 85,00 | |

| No. | Description | Quantity | Unit | Rate F.C. (B) | Rate L.C. (B) | Amount F.C. (B1,000) | Amount L.C. (B1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| | Slush-gate ϕ700 mm | 2 | gate | - | 4,400 | - | 8.80 | |
| | Screen | 90 | $m^2$ | - | 2,000 | - | 180.00 | |
| | Sub-total | | | | | - | 475.40 | |
| | Total | | | | | 800.226 ≒ 800 | 4,397.623 ≒ 4,400 | |
| 1-2-2-1. | Block B | L.S | | | | 800 | 4,400 | same to |
| | Total | | | | | 800 | 4,400 | Block A |
| 1-2-3-1. | Block C | | | | | | | |
| | (a) Public Works | | | | | | | |
| | Earth works | | | | | | | |
| | Excavation | 16,300 | $m^3$ | 1.0 | 5.9 | 16.30 | 96.17 | EE-8 |
| | Embankment | 6,000 | $m^3$ | 0.7 | 10.2 | 4.20 | 61.20 | EB-4 |
| | Removal of excess soil | 9,700 | $m^3$ | 0.2 | 1.1 | 1.94 | 10.67 | ET-1 |
| | Concrete works | | | | | | | |
| | Concrete | 2,700 | $m^3$ | 70 | 450 | 189.00 | 1,215.00 | CO-9 |
| | Form | 4,200 | $m^2$ | - | 110 | - | 462.00 | CO-12 |
| | Reinforcement bar | 190,000 | kg | 3.9 | 3.0 | 741.00 | 570.00 | CO-2 |
| | Foundation work | | | | | | | |
| | Pile 220 x 220$^{mm}$ | 669 | pile | 10 | 1,070 | 6.69 | 715.83 | CP-1 |
| | Pipe work | | | | | | | |
| | Pipe ϕ700 mm | 120 | m | - | 550 | - | 66.00 | Pr-11 |
| | Other | | | | | - | 415.00 | (F.C+L.C)x10% |
| | Sub-total | | | | | 959.13 | 3,611.87 | |
| | (b) Pumping Station | | | | | | | |
| | Building | 420 | $m^2$ | - | 3,000 | - | 1,260.00 | Pr-9 |
| | Sub-total | | | | | - | 1,260.00 | |

| No. | Description | Quantity | Unit | Rate F.C. (B) | Rate L.C. (B) | Amount F.C. (B1,000) | Amount L.C. (B1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| | (c) Gate Works | | | | | | | |
| | Roller-gate $5.0^m \times 5.0^m$ | 1 | gate | - | 186,000 | - | 186.00 | |
| | Roller-gate $5.0^m \times 2.0^m$ | 1 | gate | - | 93,600 | - | 93.60 | |
| | Slush-gate $3.0^m \times 1.6^m$ | 2 | gate | - | 57,200 | - | 114.40 | |
| | Slush-gate φ700 mm | 2 | gate | - | 4,400 | - | 8.80 | |
| | Screen | 120 | $m^2$ | - | 2,000 | - | 240.00 | |
| | Sub-total | | | | | - | 642.80 | |
| | Total | | | | | 959.13<br>= 960 | 5,514.67<br>5,510 | |

Road (On-farm)

| No. | Description | Quantity | Unit | Rate F.C. (B) | Rate L.C. (B) | Amount F.C. (B1,000) | Amount L.C. (B1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-4-1-1. | Block A | | | | | | | |
| | Main Road, Type MR-1 | 2,750 | m | 4 | 101 | 11 | 277.75 | |
| | Main Road, Type MR-2 | 10,450 | m | 2 | 83 | 20.9 | 867.35 | |
| | Main Road, Type MR-4 | 1,300 | m | 2 | 95 | 2.6 | 123.50 | |
| | Community Road, Type CR-1 | 25,050 | m | 2 | 19 | 50.1 | 475.95 | |
| | Community Road, Type CR-2 | 6,550 | m | - | 5 | - | 32.75 | |
| | Community Road, Type CR-3 | 1,000 | m | 1 | 7 | 1 | 7 | |
| | On Farm Road, Type OFR-1 | 19,500 | m | - | 2 | - | 39.00 | m/ha |
| | On Farm Road, Type On-3 | 94,590 | m | 1 | 10 | 94.59 | 945.90 | 31.25 x 3,027 |
| | Total | | | | | 180.19 | 2,769.2 | |
| 1-4-2-1. | Block B | | | | | | | |
| | Main Road, Type MR-1 | 2,400 | m | 4 | 101 | 9.6 | 242.40 | |
| | Main Road, Type MR-2 | 8,300 | m | 2 | 83 | 16.6 | 688.90 | |
| | Main Road, Type MR-3 | 5,600 | m | 2 | 90 | 11.2 | 504.00 | |
| | Community Road, Type CR-1 | 12,000 | m | 2 | 19 | 24.00 | 228.00 | |
| | On-Farm Road, Type OFR-1 | 24,700 | m | - | 2 | - | 49.40 | m/ha |
| | On-Farm Road, Type On-3 | 80,720 | m | 1 | 10 | 80.72 | 807.20 | 31.25 x 2,583 |
| | Total | | | | | 142.12 | 2,519.90 | |

| No. | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-4-3-1. | Block C | | | | | | | |
| | Main Road, Type MR-1 | 5,000 | m | 4 | 101 | 20 | 505 | |
| | Main Road, Tupe MR-2 | 16,900 | m | 2 | 83 | 33.80 | 1,402.70 | |
| | Main Road, Type MR-5 | 3,000 | m | 2 | 84 | 6.00 | 252.00 | |
| | Community Road, Type CR-1 | 28,200 | m | 2 | 19 | 56.40 | 535.80 | |
| | Community Road, Type CR-2 | 11,550 | m | - | 5 | - | 57.75 | |
| | Community Road, Type CR-3 | 11,550 | m | 1 | 7 | 11.55 | 80.85 | |
| | Community Road, Type CR-4 | 3,200 | m | 2 | 20 | 6.40 | 64.00 | |
| | On-Farm Road, Type OFR-1 | 30,400 | m | - | 2 | - | 60.80 | |
| | On-Farm Road, Type On-3 | 154,130 | m | 1 | 10 | 154.13 | 1,541,30 | $31.25^{m/ha}$ x 4,932 |
| | Total | | | | | 288.28 | 4,500.20 | |

Canal & Ditch (On-Farm)

| No. | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-4-1-2. | Block A | | | | | | | |
| | Main Irrigation Canal, Type MIC-2 | 7,500 | m | 10 | 100 | 75 | 750 | |
| | Lateral Irrigation Canal, Type LIC-1 | 2,750 | m | - | 15 | - | 41.25 | |
| | Lateral Irrigation Canal, Type LIC-2 | 25,050 | m | - | 15 | - | 375.75 | |
| | Lateral Irrigation Canal, Type LIC-3 | 1,300 | m | - | 15 | - | 19.50 | |
| | Lateral Irrigation Canal, Type LIC-4 | 1,000 | m | - | 15 | - | 15.00 | |
| | Lateral Irrigation Canal, Type LIC-5 | 4,150 | m | 1 | 24 | 4.15 | 99.60 | |
| | Leading Drainage, Canal Type LDC-1 | 9,750 | m | 4 | 41 | 39 | 399.75 | |
| | Leading Drainage, Type LDC-2 | 5,600 | m | 2 | 25 | 11.20 | 140.00 | |
| | Leading Drainage, Type LDC-3 | 1,300 | m | 3 | 29 | 3.90 | 37.70 | |
| | Leading Drainage, Type LDC-4 | 1,000 | m | 3 | 28 | 3 | 28.00 | |
| | Drainage Ditch, Type DD-1 | 20,900 | m | 1 | 10 | 20.90 | 209.00 | |
| | Drainage Ditch, Type DD-2 | 13,100 | m | 1 | 10 | 13.10 | 131.00 | |
| | Drainage Ditch, Type On-4 | 70,950 | m | 1 | 13 | 70.95 | 922.35 | $23.44^{m/ha}$ x 3,027 |
| | Total | | | | | 241.20 | 3,168.90 | |

| No. | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-4-2-2. | Block B | | | | | | | |
| | Main Irrigation Canal, Type MIC-2 | 9,450 | m | 10 | 100 | 94.50 | 945.00 | |
| | Main Irrigation Canal, Type MIC-3 | 2,650 | m | 1 | 27 | 2.65 | 71.55 | |
| | Lateral Irrigation Canal, Type LIC-1 | 2,400 | m | - | 15 | - | 36.00 | |
| | Lateral Irrigation Canal, Type LIC-2 | 12,000 | m | - | 15 | - | 180.00 | |
| | Lateral Irrigation Canal, Type LIC-5 | 5,450 | m | 1 | 24 | 5.45 | 130.80 | |
| | Leading Drainage canal, Type LDC-1 | 12,350 | m | 4 | 41 | 49.40 | 506.35 | |
| | Leading Drainage, Type LDC-2 | 5,600 | m | 2 | 25 | 11.20 | 140.00 | |
| | Leading Drainage, Type LDC-5 | 1,200 | m | 2 | 21 | 2.40 | 25.20 | |
| | Drainage Ditch, Type DD-1 | 16,600 | m | 1 | 10 | 16.60 | 166.00 | 23.44 m/ha x 2,583 |
| | Drainage Ditch, Type On-4 | 60,550 | m | 1 | 13 | 60.55 | 787.15 | |
| | Total | | | | | 242.75 | 2,988.05 | |
| 1-4-3-2. | Block C | | | | | | | |
| | Main Irrigation Canal, Type MIC-1 | 7,000 | m | 10 | 100 | 70 | 700 | |
| | Main Irrigation Canal, Type MIC-2 | 3,000 | m | 10 | 100 | 30 | 300 | |
| | Main Irrigation Canal, Type MIC-4 | 3,200 | m | - | 17 | - | 54.40 | |
| | Main Irrigation Canal, Type MIC-5 | 2,000 | m | 1 | 19 | 2 | 38.00 | |
| | Main Irrigation Canal, Type MIC-3 | 1,300 | m | 1 | 27 | 1.30 | 35.10 | |
| | Lateral Irrigation Canal, Type LIC-1 | 5,000 | m | - | 15 | - | 75.00 | |
| | Lateral Irrigation Canal, Type LIC-2 | 28,200 | m | - | 15 | - | 423.00 | |
| | Lateral Irrigation Canal, Type LIC-4 | 11,550 | m | - | 15 | - | 173.25 | |
| | Lateral Irrigation Canal, Type LIC-6 | 3,000 | m | - | 15 | - | 45.00 | |
| | Leading Drainage canal, Type LDC-1 | 15,200 | m | 4 | 41 | 60.8 | 623.20 | |
| | Leading Drainage, Type LDC-4 | 11.550 | m | 3 | 28 | 34.65 | 323.40 | |
| | Loading Drainage, Type LDC-5 | 4,600 | m | 2 | 21 | 9.20 | 96.60 | |
| | Main Drainage canal, Type MDC-1 | 2,000 | m | 6 | 58 | 12.00 | 116.00 | |
| | Main Drainage, Type MDC-2 | 500 | m | 8 | 82 | 4.00 | 41.00 | |
| | Drainage Ditch, Type DD-1 | 33,800 | m | 1 | 10 | 33.80 | 338.00 | |
| | Drainage Ditch, Type DD-2 | 23,100 | m | 1 | 10 | 23.10 | 231.00 | 23.44 m/ha x 4,932 |
| | Drainage Ditch, Type On-4 | 115,610 | m | 1 | 13 | 115.61 | 1,502.93 | |
| | Total | | | | | 396.46 | 5,115.88 | |

Terminal Facilities (On-farm)

| No. | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-4-1-3. | Block A | | | | | | | |
| | Diversion box | 18 | unit | 1,440 | 39,410 | 25.92 | 709.38 | |
| | Check, Type CH-2 | 2 | " | 3,130 | 41,850 | 6.26 | 83.70 | |
| | Check, Type CH-3 | - | " | 3,110 | 38,210 | - | - | |
| | Culvert, Type A-1 | 1 | " | 36,900 | 242,900 | 36.90 | 242.90 | |
| | Culvert, Type A-2 | 1 | " | 35,300 | 241,700 | 35.30 | 241.70 | |
| | Culvert, Type B-2 | - | " | 3,130 | 29,050 | - | - | |
| | Culvert, Type B-3 | 4 | " | 3,110 | 25,410 | 12.44 | 101.64 | |
| | Culvert, Type C-1 | - | " | 590 | 10,090 | - | - | |
| | Culvert, Type C-2 | 11 | " | 590 | 9,610 | 6.49 | 105.71 | |
| | Culvert, Type C-3 | 6 | " | 580 | 9,120 | 3.48 | 54.72 | |
| | Culvert, Type D-2 | 2 | " | 5,080 | 60,260 | 10.16 | 120.52 | |
| | Culvert, Type D-3 | 8 | " | 5,030 | 48,460 | 40.24 | 387.68 | |
| | Culvert, Type E-1 | 4 | " | 1,450 | 18,490 | 5.80 | 73.96 | |
| | Culvert, Type E-2 | 12 | " | 1,430 | 16,600 | 17.16 | 199.20 | |
| | Culvert, Type E-3 | 8 | " | 1,410 | 14,710 | 11.28 | 117.68 | |
| | Culvert, Type F-1 | 1 | " | 142,200 | 595,000 | 142.20 | 595.00 | |
| | Culvert, Type F-2 | 1 | " | 45,900 | 200,300 | 45.90 | 200.30 | |
| | Bridge, Type Br-3 | 2 | " | 70,200 | 278,700 | 140.40 | 557.40 | |
| | Turn out | 158 | " | 100 | 560 | 15.8 | 88.48 | 4 unit/76.8 ha x 3,027 ha |
| | Farm inlet ϕ200 m/m | 946 | " | - | 220 | - | 208.12 | 24 unit/76.8 ha x 3,027 ha |
| | Culvert (2) ϕ500 m/m Type-1 | 158 | " | - | 1,330 | - | 210.14 | 4 unit/76.8 ha x 3,027 ha |
| | Culvert (3) ϕ300 m/m Type-2 | 158 | " | - | 580 | - | 91.64 | 4 unit/76.8 ha x 3,027 ha |
| | Culvert (4) ϕ800 m/m Type-3 | 197 | " | 10 | 3,480 | 1.97 | 685.56 | 5 unit/76.8 ha x 3,027 ha |
| | Culvert (1) ϕ300 m/m Type-4 | 1,104 | " | - | 510 | - | 563.04 | 28 unit/76.8 ha x 3,027 ha |
| | Total | | | | | 557.70 | 5,638.47 | |

| No. | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-4-2-3. | Block B | | | | | | | |
| | Diversion box | 10 | unit | 1,440 | 39,410 | 14.40 | 394.10 | |
| | Check, Type CH-1 | - | " | 3,150 | 45,490 | - | - | |
| | Check, Type CH-2 | 2 | " | 3,130 | 41,850 | 6.26 | 83.70 | |
| | Check, Type CH-3 | - | " | 3,110 | 38,210 | - | - | |
| | Culvert, Type A-3 | 1 | " | 36,300 | 249,600 | 36.30 | 249.60 | |
| | Culvert, Type A-4 | 1 | " | 46,900 | 328,700 | 46.90 | 328.70 | |
| | Culvert, Type B-1 | 2 | " | 3,150 | 32,690 | 6.30 | 65.38 | |
| | Culvert, Type B-2 | - | " | 3,130 | 29,050 | - | - | |
| | Culvert, Tupe B-3 | 3 | " | 3,110 | 25,410 | 9.33 | 76.23 | |
| | Culvert, Type C-1 | 5 | " | 590 | 10,090 | 2.95 | 50.45 | |
| | Culvert, Type C-2 | 7 | " | 590 | 9,610 | 4.13 | 67.27 | |
| | Culvert, Type C-3 | 2 | " | 580 | 9,120 | 1.16 | 18.24 | |
| | Culvert, Type D-1 | 3 | " | 5,140 | 72,050 | 15.42 | 216.15 | |
| | Culvert, Type D-2 | 2 | " | 5,080 | 60,260 | 10.16 | 120.52 | |
| | Culvert, Type D-3 | 6 | " | 5,030 | 48,460 | 30.18 | 290.76 | |
| | Culvert, Type E-1 | 6 | " | 1,450 | 18,490 | 8.70 | 110.94 | |
| | Culvert, Type E-2 | 9 | " | 1,430 | 16,600 | 12.87 | 149.40 | |
| | Culvert, Type E-3 | 3 | " | 1,410 | 14,710 | 4.23 | 44.13 | |
| | Culvert, Type F-3 | 1 | " | 56,800 | 247,200 | 56.80 | 247.20 | |
| | Culvert, Type F-4 | 1 | " | 102,800 | 424,900 | 102.80 | 424.90 | |
| | Bridge, Type Br-3 | 2 | " | 70,200 | 278,700 | 140.40 | 557.40 | |
| | Turn out | 135 | " | 100 | 560 | 13.50 | 75.60 | 4 unit/76.8ha x 2,583 ha |
| | Farm inlet | 808 | " | - | 220 | - | 177.76 | 24 unit/75.8ha x 2,583 ha |
| | Culvert (2), Type-1 | 135 | " | - | 1,330 | - | 179.55 | 4 unit/76.8ha x 2,583 ha |
| | Culvert (3), Type-2 | 135 | " | - | 580 | - | 78.30 | 4 unit/76.8ha x 2,583 ha |
| | Culvert (4), Type-3 | 169 | " | 10 | 3,480 | 1.69 | 588.12 | 5 unit/76.8ha x 2,583 ha |
| | Culvert (1), Type-4 | 942 | " | - | 510 | - | 480.42 | 28 unit/76.8ha x 2,583 ha |
| | Total | | | | | 524.48 | 5,074.82 | |

| No. | Description | Quantity | Unit | Rate F.C. (฿) | Rate L.C. (฿) | Amount F.C. (฿1,000) | Amount L.C. (฿1,000) | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1-4-3-3. | Block C | | | | | | | |
| | Diversion box | 19 | unit | 1,440 | 39,410 | 27.36 | 748.79 | |
| | Check, Type CH-1 | - | " | 3,150 | 45,490 | - | - | |
| | Check, Type CH-2 | 4 | " | 3,130 | 41,850 | 12.52 | 167.40 | |
| | Check, Type CH-3 | - | " | 3,110 | 38,210 | - | - | |
| | Culvert, Type A-5 | 1 | " | 65,000 | 385,500 | 65.00 | 385.50 | |
| | Culvert, Type B-1 | 1 | " | 3,150 | 32,690 | 3.15 | 32.69 | |
| | Culvert, Type B-2 | - | " | 3,130 | 29,050 | - | - | |
| | Culvert, Type B-3 | 10 | " | 3,110 | 25,410 | 31.10 | 254.10 | |
| | Culvert, Type C-1 | - | " | 590 | 10,090 | - | - | |
| | Culvert, Type C-2 | 11 | " | 590 | 9,610 | 6.49 | 105.71 | |
| | Culvert, Type C-3 | 13 | " | 580 | 9,120 | 7.54 | 118.56 | |
| | Culvert, Type D-1 | 1 | " | 5,140 | 72,050 | 5.14 | 72.05 | |
| | Culvert, Type D-2 | 5 | " | 5,080 | 60,260 | 25.40 | 301.30 | |
| | Culvert, Type D-3 | 8 | " | 5,030 | 48,460 | 40.24 | 387.68 | |
| | Culvert, Type E-1 | 4 | " | 1,450 | 18,490 | 5.80 | 73.96 | |
| | Culvert, Type E-2 | 14 | " | 1,430 | 16,600 | 20.02 | 232.40 | |
| | Culvert, Type E-3 | 15 | " | 1,410 | 14,710 | 21.15 | 220.65 | |
| | Culvert, Type F-5 | 1 | " | 109,600 | 449,500 | 109.60 | 449.50 | |
| | Bridge, Type Br-3 | 1 | " | 70,200 | 278,700 | 70.20 | 278.70 | |
| | Turn out | 257 | " | 100 | 560 | 25.70 | 143.92 | 4 unit/76.8 ha x 4,932 ha |
| | Farm inlet | 1,542 | " | - | 220 | - | 339.24 | 24 unit/76.8 ha x 4,932 ha |
| | Culvert (2), Type-1 | 257 | " | - | 1,330 | - | 341.81 | 4 unit/76.8 ha x 4,932 ha |
| | Culvert (3), Type-2 | 257 | " | - | 580 | - | 149.06 | 4 unit/76.8 ha x 4,932 ha |
| | Culvert (4), Type-3 | 321 | " | 10 | 3,480 | 3.21 | 1,117.08 | 5 unit/76.8 ha x 4,932 ha |
| | Culvert (1), Type-4 | 1,799 | " | - | 510 | - | 917.49 | 28 unit/76.8 ha x 4,932 ha |
| | Total | | | | | 479.62 | 6,837.59 | |

# Table A.4-69 Unit Cost

## 1. Unit Cost of Major Structures

| No. | Description | | Unit | Unit Cost F.C. (฿) | L.C. (฿) | Total (฿) | Remarks |
|---|---|---|---|---|---|---|---|
| 1. | Dike, | Type D-1 | m | 10 | 220 | 230 | B=8.00m |
| 2. | " | Type D-2 | " | 10 | 120 | 130 | B=4.00m |
| 3. | " | Type D-3 | m | 10 | 230 | 240 | B=8.00m |
| 4. | " | Type D-4 | m | 10 | 130 | 140 | B=4.00m |
| 5. | " | Type D-5 | m | 1 | 46 | 47 | |
| 6. | Provincial Road, | Type PR-1 | m | 4 | 102 | 106 | |
| 7. | " | Type PR-2 | m | 4 | 103 | 107 | |
| 8. | " | Type PR-3 | m | 3 | 94 | 97 | |
| 9. | " | Type PR-4 | m | 3 | 92 | 95 | |
| 10. | " | Type PR-5 | m | 4 | 103 | 107 | |
| 11. | " | Type PR-6 | m | 6 | 119 | 125 | |
| 12. | Main Road, | Type MR-1 | m | 4 | 101 | 105 | |
| 13. | " | Type MR-2 | m | 2 | 83 | 85 | |
| 14. | " | Type MR-3 | m | 2 | 90 | 92 | |
| 15. | " | Type MR-4 | m | 2 | 95 | 97 | |
| 16. | " | Type MR-5 | m | 2 | 84 | 86 | |
| 17. | Community Road. | Type CR-1 | m | 2 | 19 | 21 | |
| 18. | " | Type CR-2 | m | - | 5 | 5 | |
| 19. | " | Type CR-3 | m | 1 | 7 | 8 | |
| 20. | " | Type CR-4 | m | 2 | 20 | 22 | |
| 21. | On-Farm Road, | Type OFR-1 | m | - | 2 | 2 | |
| 22. | Main Irrigation Canal, | Type MIC-1 | m | 10 | 100 | 110 | |
| 23. | " | Type MIC-2 | m | 10 | 100 | 110 | |
| 24. | " | Type MIC-3 | m | 1 | 27 | 28 | |
| 25. | " | Type MIC-4 | m | - | 17 | 17 | |
| 26. | " | Type MIC-5 | m | 1 | 19 | 20 | |
| 27. | Lateral Irrigation Canal, | Type LIC-1 | m | - | 15 | 15 | |
| 28. | " | Type LIC-2 | m | - | 15 | 15 | |
| 29. | " | Type LIC-3 | m | - | 15 | 15 | |
| 30. | " | Type LIC-4 | m | - | 15 | 15 | |
| 31. | " | Type LIC-5 | m | 1 | 24 | 25 | |
| 32. | " | Type LIC-6 | m | - | 15 | 15 | |
| 33. | Leading Drainage Canal, " | Type LDC-1 | m | 4 | 41 | 45 | |
| 34. | " | Type LDC-2 | m | 2 | 25 | 27 | |
| 35. | " | Type LDC-3 | m | 3 | 29 | 32 | |
| 36. | " | Type LDC-4 | m | 3 | 28 | 31 | |
| 37. | " | Type LDC-5 | m | 2 | 21 | 23 | |
| 38. | Main Drainage, | Type MDC-1 | m | 6 | 58 | 64 | |
| 39. | " | Type MDC-2 | m | 8 | 82 | 90 | |

| No. | Description | Unit | F.C. (฿) | L.C. (฿) | Total (฿) | Remarks |
|---|---|---|---|---|---|---|
| 40. | Drainage Ditch, Type DD-1 | m | 1 | 10 | 11 | |
| 41. | " Type DD-2 | m | 1 | 10 | 11 | |
| 42. | Bridge, Type Br-1 | L.S. | 164,800 | 633,600 | 798,400 | B=8.00m |
| 43. | " Type Br-2 | " | 93,600 | 386,300 | 479,900 | B=8.00m |
| 44. | " Type Br-3 | " | 70,200 | 278,700 | 348,900 | B=6.00m |
| 45. | " Type Br-4 | " | 50,200 | 204,500 | 254,700 | B=4.00m |
| 46. | Diversion box | L.S. | 1,440 | 39,410 | 40,850 | |
| 47. | Check, Type CH-1 | L.S. | 3,150 | 45,490 | 48,640 | |
| 48. | " Type CH-2 | " | 3,130 | 41,850 | 44,980 | |
| 49. | " Type CH-3 | " | 3,110 | 38,210 | 41,320 | |
| 50. | Culvert, Type A-1 | L.S. | 36,900 | 242,900 | 279,800 | |
| 51. | " Type A-2 | " | 35,300 | 241,700 | 277,000 | |
| 52. | " Type A-3 | " | 36,300 | 249,600 | 285,900 | |
| 53. | " Type A-4 | " | 46,900 | 328,700 | 375,600 | |
| 54. | " Type A-5 | " | 65,000 | 385,500 | 450,500 | |
| 55. | " Type B-1 | " | 3,150 | 32,690 | 35,840 | |
| 56. | " Type B-2 | " | 3,130 | 29,050 | 32,180 | |
| 57. | " Type B-3 | " | 3,110 | 25,410 | 28,520 | |
| 58. | " Type C-1 | " | 590 | 10,090 | 10,680 | |
| 59. | " Type C-2 | " | 590 | 9,610 | 10,200 | |
| 60. | " Type C-3 | " | 580 | 9,120 | 9,700 | |
| 61. | " Type D-1 | " | 5,140 | 72,050 | 77,190 | |
| 62. | " Type D-2 | " | 5,080 | 60,260 | 65,340 | |
| 63. | " Type D-3 | " | 5,030 | 48,460 | 53,490 | |
| 64. | " Type E-1 | " | 1,450 | 18,490 | 19,940 | |
| 65. | " Type E-2 | " | 1,430 | 16,600 | 18,030 | |
| 66. | " Type E-3 | " | 1,410 | 14,710 | 16,120 | |
| 67. | " Type F-1 | " | 142,200 | 595,000 | 737,200 | |
| 68. | " Type F-2 | " | 45,900 | 200,300 | 246,200 | |
| 69. | " Type F-3 | " | 56,800 | 247,200 | 304,000 | |
| 70. | " Type F-4 | " | 102,800 | 424,900 | 527,700 | |
| 71. | " Type F-5 | " | 109,600 | 449,500 | 559,000 | |
| 72. | Turn out | L.S. | 100 | 560 | 660 | |
| 73. | Inlet ϕ200 mm | " | - | 220 | 220 | |
| 74. | Culvert (2), Type-1 | " | - | 1,330 | 1,330 | ϕ500 mm |
| 75. | Culvert (3), Type-2 | " | - | 580 | 580 | ϕ300 mm |
| 76. | Culvert (4), Type-3 | " | 10 | 3,480 | 3,490 | ϕ800 mm |
| 77. | Culvert (1), Type-4 | " | - | 510 | 510 | ϕ300 mm |

| No. | Description | Unit | Unit Cost F.C. (฿) | Unit Cost L.C. (฿) | Unit Cost Total (฿) | Remarks |
|---|---|---|---|---|---|---|
| On-1 | Land Clearing | ha | 20 | 240 | 260 | |
| On-2 | Land Leveling | ha | 480 | 3,740 | 4,220 | |
| On-3 | Farm Road & Ditch | m | 1 | 10 | 11 | |
| On-4 | Drainage Ditch | " | 1 | 13 | 14 | |
| ES-1 | Stripping | $m^3$ | 0.6 | 3.8 | 4.4 | D=50m |
| ES-2 | " | " | 0.5 | 3.3 | 3.8 | D=40m |
| EE-1 | Excavation | " | 0.3 | 2.8 | 3.1 | |
| EE-2 | " | " | 0.3 | 2.5 | 2.8 | |
| EE-3 | " | " | 0.5 | 5.0 | 5.5 | |
| EE-4 | " | " | 0.3 | 3.4 | 3.7 | |
| EE-5 | " | " | 0.5 | 4.7 | 5.2 | |
| EE-6 | " | " | 0.3 | 2.6 | 2.9 | |
| EE-7 | " | " | - | 12.0 | 12.0 | |
| EE-8 | " | " | 1.0 | 5.9 | 6.9 | |
| EB-1 | Embankment | " | 0.2 | 1.9 | 2.1 | |
| EB-2 | " | " | 0.2 | 2.7 | 2.9 | |
| EB-3 | " | " | - | 12.0 | 12.0 | |
| EB-4 | " | " | 0.7 | 10.2 | 10.7 | |
| EP-1 | Pavement | " | 1.0 | 83.0 | 84.0 | |
| ET-1 | Removal of excess soil | " | 0.2 | 1.1 | 1.3 | |
| CO-1 | Reinforcement bar | kg | 3.9 | 3.1 | 7.0 | |
| CO-2 | " | " | 3.9 | 3.0 | 6.9 | |
| CO-3 | Concrete material | $m^3$ | 58.0 | 374.0 | 432.0 | $\sigma_{28}$=210kg/m$^2$ |
| CO-4 | " | " | 45.0 | 335.0 | 380.0 | $\sigma_{28}$=160kg/m$^2$ |
| CO-5 | Concrete mixing | " | 1.2 | 28.0 | 29.2 | 0.5m$^3$Mixer |
| CO-6 | " | " | 1.3 | 29.8 | 31.1 | 0.3m$^3$Mixer |
| CO-7 | Placing concrete | " | 0.6 | 24.2 | 24.8 | 0.3m$^3$Mixer |
| CO-8 | " | " | 0.5 | 20.9 | 21.4 | 0.5m$^3$Mixer |
| CO-9 | Concrete | " | 70 | 450 | 520 | 0.5m$^3$Mixer $\sigma_{28}$=210kg/m$^2$ |
| CO-10 | " | " | 70 | 450 | 520 | 0.3m$^2$Mixer $\sigma_{28}$=210kg/m$^2$ |
| CO-11 | Form | $m^2$ | - | 60 | 60 | |
| CO-12 | " | " | - | 110 | 110 | |
| CP-1 | Concrete pile | pile | 10 | 1,070 | 1,080 | □200x200mm |
| CP-2 | " | " | 10 | 2,810 | 2,820 | □350x350mm ℓ=12m |
| CP-3 | " | " | 10 | 3,470 | 3,480 | □350x350mm ℓ=15m |
| CP-4 | " | " | 10 | 4,570 | 4,580 | □350x350mm ℓ=20m |
| Pr-1 | Drying works | day | 20 | 80 | 100 | φ4"pump |
| Pr-2 | Setting & Withdrawing of a concrete plant | L.S. | 2,000 | 23,000 | 25,000 | 0.5m$^3$ Mixer |
| Pr-3 | Retaining wall | m | 200 | 290 | 490 | |
| Pr-4 | Foothold | $m^3$ | - | 40 | 40 | |
| Pr-5 | Curing concrete | $m^2$ | - | 10 | 10 | |
| Pr-6 | Temprary pier | m | - | 6,000 | 6,000 | |

| No. | Description | Unit | Unit Cost F.C. (฿) | L.C. (฿) | Total (฿) | Remarks |
|---|---|---|---|---|---|---|
| Pr-7 | Backfill of canal | km | 1,880 | 18,750 | 20,630 | |
| Pr-8 | Sheet-piling cofferdam | m | - | 600 | 600 | |
| Pr-9 | Field Office | $m^2$ | - | 3,000 | 3,000 | |
| Pr-10 | Motor pool | " | - | 20 | 20 | |
| Pr-11 | Concrete pipe | m | - | 550 | 550 | ϕ700 mm |

2. Labor Cost

| Personnel | Unit | Cost ฿ |
|---|---|---|
| Worker | day | 40 |
| Skilled worker | " | 50 |
| Foreman | " | 65 |
| Chief worker | " | 100 |
| Operator of vehicle | " | 65 |
| Asst. operator of vehicle | " | 60 |
| Operator of heavy equipment | " | 90 |
| Asst. operator of heavy equipment | " | 60 |
| Mason | " | 40 |
| Carpenter | " | 40 |
| Smith | " | 50 |
| Painter | " | 80 |
| Asphalt worker | " | 80 |
| Watchep | " | 50 |
| Head carpenter | " | 100 |
| Head smith | " | 100 |
| Head welder | " | 100 |

Source: Land Reform Office, Royal Irrigation Department

3. Material Cost

| Description | Unit | Cost (฿) F.C. | L.C. | Total | Remarks |
|---|---|---|---|---|---|
| Portland cement | ton | 160.00 | 640.00 | 800.00 | one bag 50 kgs |
| Sand (for concrete) | $m^3$ | - | 70.00 | 70.00 | |
| Gravel (for concrete) | " | - | 130.00 | 130.00 | |
| Unscreened gravel | " | - | 120.00 | 120.00 | |
| Deformed bar | t | 4,314.00 | 2,876.00 | 7,190.00 | SD30 $\phi$16mm |
| Round bar | " | 3,756.00 | 2,504.00 | 6,260.00 | SR24 $\phi$15mm |
| Miscellaneous steel | " | 6,000.00 | 4,000.00 | 10,000.00 | |
| Wood (for reform) | $m^2$ | - | 150.00 | 150.00 | |
| Gasolin | lit | 1.80 | 1.80 | 3.60 | |
| Lubricating oil | " | 9.00 | 9.00 | 18.00 | |
| Diesel fuel (for truck) | " | 1.30 | 1.30 | 2.60 | |
| Diesel fuel (for generator engine) | " | 1.30 | 1.30 | 2.60 | |
| Light gasolin | " | 1.30 | 1.30 | 2.60 | |
| Timeber (soft) | $m^3$ | - | 2,200.00 | 2,200.00 | |
| " (hard) | " | - | 4,000.00 | 4,000.00 | |
| Brick | $m^2$ | - | 40.00 | 40.00 | |
| Masonary | $m^3$ | - | 700.00 | 700.00 | |
| Crushed stone | " | - | 120.00 | 120.00 | |
| Asphalt | t | | | 3,000.00 | |
| Laterite (pavement of road) | $m^3$ | - | 80.00 | 80.00 | from salaburi |
| Water stop | m | 300.00 | - | 300.00 | |

## 4. Operation Cost of Heavy Equipment

| Description | Purchase Price a/ (1) | Life time (2) | Depreciation Cost $(3)=\frac{(1-0.1)\times(1)}{(2)}$ | Repair Cost: Rate (4) | Repair Cost: Parts Cost $(5)=\frac{(1)\times(4)}{(2)}\times 0.7$ | Repair Cost: Labor Cost $(6)=\frac{(1)\times(4)}{(2)}\times 0.3$ | Fuel & Lubricant b/: ℓ/h | Fuel & Lubricant Cost (7): F.C. | Fuel & Lubricant Cost (7): L.C. | Labor c/ (Operator) (8) | Administration & Other d/ (9) | Foreign (7) | Local (6)+(7)+(8)+(9) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ฿ | hr | ฿ | | ฿ | ฿ | ℓ/hr | ฿/hr | ฿/hr | ฿/hr | ฿/hr | ฿/hr | ฿/hr | ฿/hr |
| Bulldozer $15^t$ $140^{ps}$ | 1,000,000 | 6,500 | 138.5 | 1.10 | 118.5 | 50.8 | 11.0 | 18.6 | 18.6 | 26.3 | 15.4 | 18.6 | 111.1 | |
| " $16^t$ $140^{ps}$ | 1,050,000 | 6,500 | 145.4 | 1.20 | 136.7 | 58.2 | 11.0 | 18.6 | 18.6 | 26.3 | 16.2 | 18.6 | 119.3 | Swampy type |
| " $21^t$ $200^{ps}$ | 1,600,000 | 7,800 | 184.6 | 1.15 | 165.1 | 70.8 | 20.0 | 33.8 | 33.8 | 26.3 | 20.5 | 33.8 | 151.4 | |
| Backhoe $0.6^{m^3}$ $100^{ps}$ | 1,450,000 | 7,200 | 181.3 | 0.95 | 133.9 | 57.4 | 8.0 | 13.5 | 13.5 | 26.3 | 20.1 | 13.5 | 117.3 | |
| " $0.3^{m^3}$ | 730,000 | 6,000 | 109.5 | 0.75 | 63.9 | 27.4 | 5.0 | 8.5 | 8.5 | 26.3 | 12.2 | 8.5 | 74.4 | |
| Dragline $0.6^{m^3}$ $125^{ps}$ | 90,000 | 7,200 | 11.3 | 0.95 | 8.3 | 3.7 | - | - | - | - | - | - | 3.7 | Backhoe attachment |
| Frontend loader $1.6^{m^3}$ | 770,000 | 6,500 | 106.6 | 1.05 | 87.1 | 37.3 | 11.0 | 18.6 | 18.6 | 26.3 | 11.8 | 18.6 | 94.0 | |
| Scrape-dozer $6.4^{m^3}$ $183^{ps}$ | 1,850,000 | 6,500 | 256.2 | 1.00 | 199.2 | 85.4 | 19.0 | 32.1 | 32.1 | 26.3 | 28.5 | 32.1 | 172.3 | |
| Motor-grader $3.7^{m^3}$ $125^{ps}$ | 1,150,000 | 6,600 | 156.8 | 0.85 | 103.7 | 44.4 | 12.0 | 20.3 | 20.3 | 26.3 | 17.4 | 20.3 | 108.4 | |
| Tire rollor $10^t$ $40^{ps}$ | 350,000 | 7,000 | 45.0 | 0.85 | 29.8 | 12.8 | 4.0 | 6.8 | 6.8 | 26.3 | 5.0 | 6.8 | 50.9 | |
| Water tank truck $6^t$ | 230,000 | 6,000 | 34.5 | 0.90 | 24.2 | 10.4 | 5.0 | 8.5 | 8.5 | 11.4 | 3.8 | 8.5 | 34.1 | |
| Dupm truck $8^t$ $196^{ps}$ | 310,000 | 6,000 | 46.5 | 0.80 | 28.9 | 12.4 | 7.0 | 11.8 | 11.8 | 11.4 | 5.2 | 11.8 | 40.8 | |
| Agitator truck $3.0^{m^3}$ $195^{ps}$ | 420,000 | 5,500 | 68.7 | 0.60 | 32.1 | 13.7 | 7.0 | 11.8 | 11.8 | 11.4 | 7.6 | 11.8 | 44.5 | |
| " $1.6^{m^3}$ $135^{ps}$ | 250,000 | 5,000 | 45.0 | 0.60 | 21.0 | 9.0 | 5.0 | 8.5 | 8.5 | 11.4 | 5.0 | 8.5 | 33.9 | |
| Diesel hammer $2.2^t$ | 690,000 | 6,000 | 103.5 | 0.95 | 76.5 | 32.8 | - | - | - | - | - | - | 32.8 | Backhoe attachment |
| Diesel hammer $1.25^t$ (95ps) | 410,000 | 6,000 | 61.5 | 0.95 | 45.4 | 19.5 | - | - | - | - | - | - | 19.5 | Backhoe attachment |

Note: a/ Heavy equipment purchase cost
C.I.F Bangkok in Oct. 1976

b/ Fuel & Lubricant Cost
Fuel consumption (ℓ/hr) x 1.30 ฿/ℓ x 1.3 (Light gasolin)
Fuel consumption (ℓ/hr) x 1.80 ฿/ℓ x 1.15 (Gasolin)

c/ Labor
Heavy equipment (Bulldozer, Backhoe, etc.)

$$\text{Operator: } (90^{฿}+60^{฿}) \times \frac{\left(\frac{8H}{8H} + \frac{4H}{8H} \times 1.5\right)}{10\ \text{hr}} = 26.3\ ฿/H$$

Dump truck

$$\text{Operator: } 65฿ \times \frac{\left(\frac{8H}{8H} + \frac{4H}{8H} \times 1.5\right)}{10\ \text{hr}} = 11.4\ ฿/H$$

d/ Administration & other
[(1)/(2)] x 0.1

## Decision of Required Number of Construction Equipments

The required number of construction equipments can be calculated based on the work volume, operation hours of equipment during the construction period.

Sample explanation for the estimation of the required number of equipments is given hereinafter in case of scrape dozer 6.4 cu.m;

Construction stage of max. work volume: 4th year

Required total operation hours in 4th year 1/ ;

for dike and provincial road works: 2,191.9 hr

for on-farm works: 25,895.7 hr

Operation hours during construction period per unit:

for dike and provincial road works:

7 months x 25 days/mon. x 10 hr/day = 1,750 hr/unit

for on-farm works:

5 months x 25 days/mon. x 10 hr/day = 1,250 hr/unit

Required number of equipments;

for dike and provincial road works;

2,191.9/1,750 = 1.25

for on-farm works:

25,895.7/1,250 = 20.72

Total 21.97 ≒ 22 units

1/ : See Appendix 4-65.

Following figure shows the yearly required number of main construction equipments, which was estimated through same procedure mentioned above.

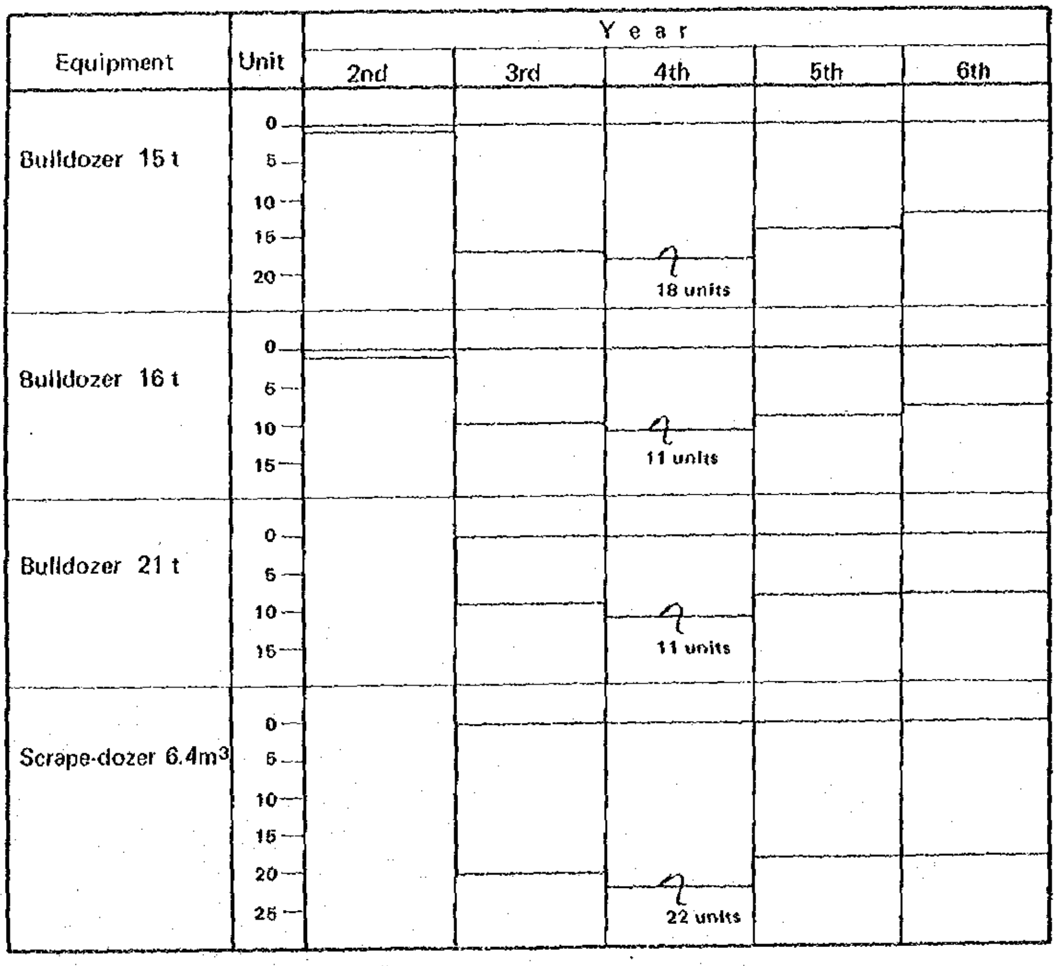


Table A.4-70 Estimation of Total Operation Hours of Scrape Dozer 6.4 $m^3$

| Description | Works | Work Volume ($m^3$) | Hourly Production ($m^3$/hr) | Required Operation Hours (hour) |
|---|---|---|---|---|
| 1. Dike | | | | |
| Block A | Type D-2 Excavation | 48,976.0 | 95.0 | 515.5 |
| | Type D-4 Excavation | 195,151.3 (62,657.3) | 101.8 | 1,917.0 (615.5)a/ |
| Block B | Type D-2 Excavation | 61,702.5 (43,093.8) | 95.0 | 649.0 (453.6) |
| | Type D-4 Excavation | 146,195.0 (79,624.1) | 101.8 | 1,436.1 (782.2) |
| Block C | Type D-1 Excavation | 57,389.2 | 95.0 | 604.1 |
| | Type D-2 Excavation | 19,589.0 | 95.0 | 206.2 |
| | Type D-3 Excavation | 54,505.4 | 101.8 | 535.4 |
| | Type D-4 Excavation | 148,811.2 | 101.8 | 1,461.8 |
| Sub-total | | | | 7,325.6 (1,851.3) |
| 2. On-Farm | | | | |
| Block A | | | | |
| Land leveling | Excavation | 732,534.0 (102,850.0) | 57.0 | 12,851.5 (1,804.4) |
| | Excavation | 1,059,450.0 (148,750.0) | 86.4 | 12,262.2 (1,721.6) |
| Road | Type R-1 Excavation | 5,619.4 (789.0) | 101.8 | 55.2 (7.8) |
| | Type R-2 Excavation | 2,504.3 (351.6) | 101.8 | 24.6 (3.4) |
| | Type R-6 Excavation | 37,452.2 (5,258.4) | 101.8 | 367.9 (51.7) |
| Canal & ditch | Type MC-2 Excavation | 33,915.0 (4,761.8) | 95.0 | 357.0 (50.1) |
| | Type LI-1 Excavation | 1,018.0 (142.9) | 101.8 | 10.0 (1.4) |
| | Type LI-2 Excavation | 9,263.8 (1,300.7) | 101.8 | 91.0 (12.8) |
| | Type LI-5 Excavation | 2,433.0 (341.6) | 101.8 | 23.9 (3.4) |

Note: a/ shows the required operation hours in 4th year

| Description | Works | Work Volume ($m^3$) | Hourly Production ($m^3/hr$) | Required Operation Hours hour |
|---|---|---|---|---|
| | Type DD-1 Excavation | 1,349.7 (195.8) | 101.8 | 13.7 (1.9) |
| | Type DD-2 Excavation | 875.5 (122.9) | 101.8 | 8.6 (1.2) |
| Block B | | | | |
| Land leveling | Excavation | (625,084.8) | 57.0 | (10,966.4) |
| | Excavation | (904,055.0) | 86.4 | (10,463.6) |
| Road | Type R-1 Excavation | (4,906.8) | 101.8 | (48.2) |
| | Type R-2 Excavation | (1,985.1) | 101.8 | (19.5) |
| | Type R-6 Excavation | (17,937.2) | 101.8 | (176.2) |
| Canal & ditch | Type MC-2 Excavation | (42,731.0) | 95.0 | (449.8) |
| | Type MC-3 Excavation | (1,801.9) | 101.8 | (17.7) |
| | Type LI-1 Excavation | (885.7) | 101.8 | (8.7) |
| | Type LI-2 Excavation | (4,438.5) | 101.8 | (43.6) |
| | Type LI-5 Excavation | (3,196.5) | 101.8 | (31.4) |
| | Type DD-1 Excavation | (1,109.6) | 101.8 | (10.9) |
| Block C | | | | |
| Land leveling | Excavation | 1,193,545.8 | 57.0 | 20,939.4 |
| | Excavation | 1,726,211.5 | 86.4 | 19,979.3 |
| Road | Type R-1 Excavation | 10,220.7 | 101.8 | 100.4 |
| | Type R-2 Excavation | 4,051.6 | 101.8 | 39.8 |
| | Type R-5 Excavation | 2,107.3 | 101.8 | 20.7 |
| | Type R-6 Excavation | 42,165.6 | 101.8 | 414.2 |
| | Type R-9 Excavation | 4,947.5 | 101.8 | 48.6 |

| Description | Works | Work Volume (m³) | Hourly Production (m³/hr) | Required Operation Hours hour |
|---|---|---|---|---|
| Canal & ditch | Type MC-1 Excavation | 31,654.0 | 95.0 | 333.2 |
| | Type MC-2 Excavation | 13,566.0 | 95.0 | 142.8 |
| | Type MC-4 Excavation | 1,353.9 | 101.8 | 13.3 |
| | Type MC-3 Excavation | 885.7 | 101.8 | 8.7 |
| | Type LI-1 Excavation | 1,852.8 | 101.8 | 18.2 |
| | Type LI-2 Excavation | 10,424.3 | 101.8 | 102.4 |
| | Type LI-6 Excavation | 1,109.6 | 101.8 | 10.9 |
| | Type DD-1 Excavation | 2,260.0 | 101.8 | 22.2 |
| | Type DD-2 Excavation | 1,537.2 | 101.8 | 15.1 |
| Sub-total | | | | 90,510.8 (25,895.7) |
| 3. Provincial Road | | | | |
| Block A | Type PR-1 Excavation | (7,502.7) | 101.8 | (73.7) |
| Block B | Type PR-1 Excavation | (9,854.2) | 101.8 | (96.8) |
| | Type PR-2 Excavation | (4,957.7) | 101.8 | (48.7) |
| | Type PR-5 Excavation | (12,358.5) | 101.8 | (121.4) |
| Block C | Type PR-6 Excavation | 4,519.9 | 101.8 | 44.4 |
| Sub-total | | | | 385.0 (340.6) |
| Total | | | | 98,221.4 (28,087.6) |

## Residual Values of Construction Equipments

Residual values of the construction equipments can be calculated by the following equation;

Residual values = Purchase Price - {Depreciation cost + Repair Cost}

Sample explanation for the residual values in case of scrape dozer 6.4 $m^3$ is given hereinafter.

Purchase price = ฿1,850,000 x 22 unit x 1.2 [1/]
= ฿48,840,000

Depreciation cost = Operation hours x Depreciation cost/hours
= 98.221.4 [2/] hr x 256.2 [3/] ฿/hr = ฿25,164,000

Repair cost = Operation hours x Repair cost/hour x (1.0 - 0.1) [4/]
= 98,221.4 hr x 199.2 [5/] x 0.9
= ฿17,609,000

so that,

Residual values = ฿48,840,000 - ( ฿25,164,000 + ฿17,609,000 )
= ฿6,067,000

Note:
1/ : 20% of spare parts are included (see Appendix 4-62, page 8)
2/ : See Appendix 4-65
3/ : See Appendix 4-64, page 7
4/ : 10% of residual values for spare parts are considered
5/ : See Appenidx 4-64, page 7

Based on the above procedure for the estimation of the residual values of construction equipments, total residual values of the construction equipment required for the project are evaluated to be ฿25,460,000 as shown in Table A.4-71.

Table A.4-71 Residual Values of Construction Equipments and Provisional Facilities

| Equipments | | | Purchase Cost (A) | Operation Hour (hr) | Depreciation Cost | | Repair Cost | | Total (B)+(C) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cost/hr | Cost (B) | Cost/hr | Cost (C) | |
| | | | 1,000B | hour | B | 1,000B | B | 1,000B | 1,000B |
| Bulldozer | 15 | t | 21,600 | 82,569.3 | 138.5 | 11,436 | 106.7 | 8,810 | 20,246 |
| " | 16 | t | 13,860 | 49,864.7 | 145.4 | 7,250 | 123.0 | 6,133 | 13,383 |
| " | 21 | t | 21,120 | 43,564.6 | 184.6 | 8,042 | 148.6 | 6,474 | 14,516 |
| Scrapedozer | 6.4 | $m^3$ | 48,840 | 98,221.4 | 256.2 | 25,164 | 179.3 | 17,611 | 42,775 |
| Tire Roller | 10 | t | 2,520 | 32,273.6 | 45.0 | 1,452 | 26.8 | 865 | 2,317 |
| Motor-grader | 3.7 | m | 1,380 | 485.2 | 156.8 | 76 | 93.3 | 45 | 121 |
| Watertruck | 6 | t | 276 | 485.2 | 34.5 | 17 | 21.8 | 11 | 28 |
| Backhoe | 0.6 | $m^3$ | 8,700 | 13,784.0 | 181.3 | 2,499 | 120.5 | 1,611 | 4,160 |
| " | 0.3 | $m^2$ | 6,132 | 29,491.5 | 109.5 | 3,229 | 57.5 | 1,696 | 4,925 |
| Fronted Loader | 1.6 | $m^3$ | 924 | 578.0 | 106.6 | 62 | 78.4 | 45 | 107 |
| Dump Truck | 8 | t | 1,116 | 1,503.5 | 46.5 | 70 | 26.0 | 39 | 109 |
| Disel Hammer | 1.25 | t | 492 | 1,885.4 | 61.5 | 116 | 40.9 | 77 | 193 |
| " | 2.2 | t | 828 | 253.4 | 103.5 | 26 | 68.8 | 17 | 43 |
| Mixser | 0.5 | $m^3$ | 696 | 1,420.0 | 130.5 | 185 | 54.8 | 78 | 263 |
| " | 0.3 | $m^3$ | 216 | 390.9(day) | 90.0 | 35 | 44.1 | 17 | 52 |
| Total | | | 128,700 | | | 59,659 | | 43,579 | 103,238 |

Residual values of equipments = (A) - {(B) + (C)}
= B128,700,000 - B103,238,000
= B25,462,000 ≒ B25,460,000

Residual values of provisional facility = B1,800,000 x 0.3
= B540,000

Total residual value = B25,460,000 + B540,000
= B26,000,000

Table A.4-72 Disbursement Schedule

(Unit: ¥'000)

| Discription | Total | | | 1st Year(Oct.'77-Sep.'78) | | | 2nd year(Oct.'78-Sep.'79) | | | 3rd year(Oct.'79-Sep.'80) | | | 4th year(Oct.'80-Sep.'81) | | | 5th year(Oct.'81-Sep.'82) | | | 6th year(Oct.'82-Sep.'83) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F.C. | L.C. | T | F.C. | L.C. | T | F.C. | L.C. | T | F.C. | L.C. | T | F.C. | L.C. | T | F.C. | L.C. | T | F.C. | L.C. | T |
| 1. Civil Works | 94,020 | 177,080 | 271,100 | | | | 26,850 | 16,118 | 42,968 | 25,086 | 44,611 | 69,697 | 37,778 | 56,745 | 94,523 | 2,126 | 30,468 | 32,594 | 2,180 | 29,138 | 31,138 |
| 1-1. Preparation | 330 | 18,580 | 18,910 | - | - | - | 20 | 4,628 | 4,648 | 87 | 3,385 | 3,472 | 97 | 5,981 | 5,988 | 63 | 1,949 | 2,012 | 63 | 2,727 | 2,790 |
| 1-2. Pumping Station | 83,590 | 31,760 | 115,350 | | | | 26,830 | 11,490 | 38,320 | 22,400 | 8,880 | 31,280 | 34,360 | 11,390 | 45,750 | | | | | | |
| 1-3. Dike | 1,340 | 20,600 | 21,940 | | | | | | | 459 | 6,764 | 7,223 | 341 | 4,856 | 5,197 | 249 | 5,442 | 5,691 | 291 | 3,538 | 3,829 |
| 1-4. On-Farm | 8,320 | 101,500 | 109,820 | | | | | | | 2,140 | 25,582 | 27,722 | 2,550 | 30,448 | 32,998 | 1,804 | 22,597 | 24,401 | 1,826 | 22,873 | 24,699 |
| 1-5. Provincial Road | 440 | 4,640 | 5,080 | | | | | | | | | | 430 | 4,160 | 4,590 | 10 | 480 | 490 | | | |
| 2. Construction Equipment | 133,100 | 1,300 | 134,400 | | | | 9,276 | 100 | 9,376 | 101,669 | 1,000 | 102,669 | 7,385 | 67 | 7,452 | 7,385 | 67 | 7,452 | 7,385 | 66 | 7,451 |
| 3. Agricultural Development | - | 14,860 | 14,860 | | 2,200 | 2,200 | | 3,640 | 3,640 | | 3,290 | 3,290 | | 980 | 980 | | 980 | 980 | | 3,770 | 3,770 |
| 4. Project Administration & Facility | 1,280 | 21,460 | 22,740 | 1,280 | 9,530 | 10,810 | | 2,386 | 2,386 | | 2,386 | 2,386 | | 2,386 | 2,386 | | 2,386 | 2,386 | | 2,386 | 2,386 |
| 5. Consulting Services | 22,700 | 8,620 | 31,320 | 7,690 | 1,440 | 9,130 | 3,002 | 1,436 | 4,438 | 3,002 | 1,436 | 4,438 | 3,002 | 1,436 | 4,438 | 3,002 | 1,436 | 4,438 | 3,002 | 1,436 | 4,438 |
| 6. Land Acquisition | - | 3,640 | 3,640 | - | 910 | 910 | | 910 | 910 | | 910 | 910 | | 910 | 910 | | | | | | |
| Sub-total | 251,100 | 226,960 | 478,060 | 8,970 | 1,4080 | 23,050 | 39,128 | 24,590 | 63,718 | 129,757 | 53,633 | 183,390 | 48,165 | 62,524 | 110,689 | 12,513 | 35,337 | 47,850 | 12,567 | 36,796 | 49,363 |
| 7. Contingency | 37,665 | 34,045 | 71,710 | 1,346 | 2,113 | 3,459 | 5,869 | 3,689 | 9,558 | 19,464 | 8,045 | 27,509 | 7,224 | 9,379 | 16,603 | 1,877 | 5,300 | 7,177 | 1,885 | 5,519 | 7,404 |
| Total | 288,765 | 261,005 | 549,770 | 10,316 | 16,193 | 26,509 | 44,997 | 28,279 | 73,276 | 149,221 | 61,678 | 210,899 | 55,389 | 71,903 | 127,292 | 14,390 | 40,637 | 55,027 | 14,452 | 42,315 | 56,767 |
| 8. Price Escalation | 82,269 | 91,846 | 174,115 | 825 | 1,295 | 2,120 | 7,487 | 4,706 | 12,193 | 38,754 | 16,019 | 54,773 | 19,967 | 25,920 | 45,887 | 6,754 | 19,072 | 25,826 | 8,482 | 24,834 | 33,316 |
| Grand Total | 371,034 | 352,851 | 723,885 | 11,141 | 17,488 | 28,629 | 52,484 | 32,985 | 85,469 | 187,975 | 77,697 | 265,672 | 75,356 | 97,823 | 173,179 | 21,144 | 59,709 | 80,853 | 22,934 | 67,149 | 90,083 |

## Construction Method of the Works

### 1. Outline

Construction works in the Project Area consist of the following works:

1. Pumping station
2. Dike
3. Land consolidation
4. Provincial road

Project Area is located in the low-lying area with an elevation of averaged two meters above mean sea level and it is submerged in the wet season. The construction of dike and pumping station will be proceeded prior to the construction of land consolidation taking account the flooding irrigation in the wet season. Construction period will be five years, of which Block A will be started first, then Block B and lastly Block C. It will be possible to use the existing canals and provincial road in order that the construction materials will be transported to Project Area. And, in order to transport the heavy equipments, it would be effective to use the ship which comes from Bangkok passing through Chao Phya river and goes through the existing canals, Khlóng Phraya Banlu, in the Project Area. As regards the soil texture, silty clay (or CH) covers the ground surface in the Project Area, therefore crawlar type construction equipments are more effective for these works and swampy-type heavy equipment would also be partly required. It is assumed in this planning that daily operation hours of heavy equipments would be ten (10) hours which is generally adopted in Thailand. Outline of construction method for principal works are as follows.

### 2. Workable days and Bulk factor of soil

Workable days

Workable days for civil works are influenced by climate, especially rainfall. And in order to calculate the workable days, the daily rainfall data for the last ten years (1966 - 1975, observation station. Sing Ha Nat Office of RID) were analyzed based on the standards below.

a) Concrete works

Below 10 mm/day -------------------- Possible to work

Over 10.1 mm/day ------------------- Impossible to work

b) Other works (Excavation, Embankment, and Others)

Below 5 mm/day --------------------- Possible to work

5.1 mm/day - 20.0 mm/day ----------- One restday

20.1 mm/day - 50.0 mm/day ---------- Two restdays

Over 50.1 mm/day ------------------- Three restdays

Monthly Workable Days

| Works | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total | Annual mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Concrete | 30 | 27 | 29 | 28 | 26 | 25 | 25 | 24 | 20 | 24 | 28 | 30 | 316 | 26days |
| Others | 30 | 27 | 28 | 26 | 23 | 21 | 22 | 19 | 15 | 20 | 27 | 29 | 287 | 24days |

The above-mentioned table indicates the annual workable days after analyzing the rainfall data, but flooding irrigation method has been adopted in the Project Area, therefore, annual workable days will be decided taking into account the water level in the Project Area and the growing period of paddy. Figure A.5-1 indicates the relationships.

After these analyses, workable periods for civil works are as follows:

Pumping station works ------------ From the beginning of January to the end of August (Eight months/year)

Dike and provincial road works -- From the beginning of January to the end of July (Seven months/year)

On-farm works ------------------- Twentieth of January - Twentieth of June (Five months/year)

And also, monthly mean workable days are as follows:

Concrete works ------------- Twenty seven (27) days/month

Other works ----------------- Twenty five (25) days/month

## Bulk factor of soil

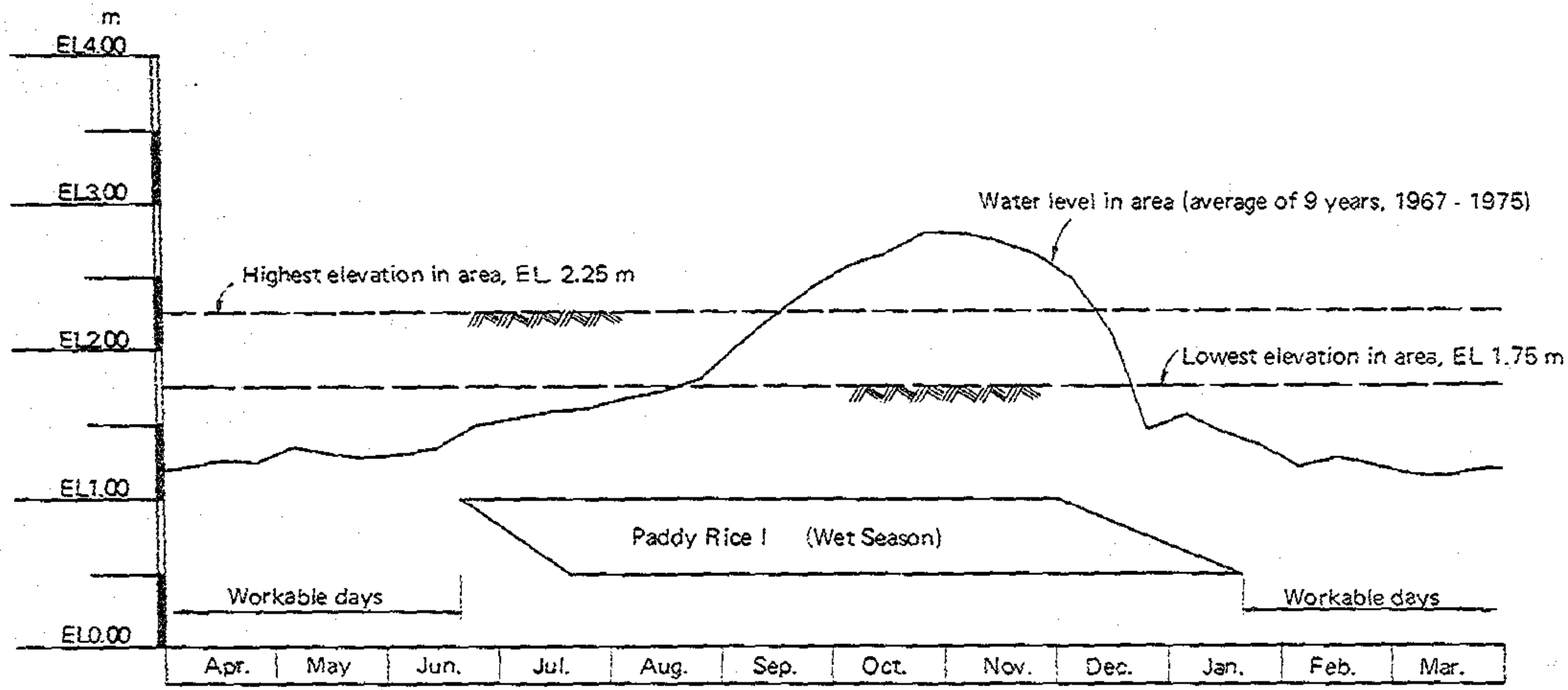
Bulk factor of soil for construction of civil works were decided follows:

Bulk Factor of Soil

| Classification of Soil texture | Original condition of soil | Bulk factor of soil P | L | B |
|---|---|---|---|---|
| Clayey soil | P | 1.00 | 1.43 | 0.90 |
| | L | 0.70 | 1.00 | 0.63 |
| | B | 1.11 | 1.59 | 1.00 |
| Sandy soil | P | 1.00 | 1.25 | 0.90 |
| | L | 0.80 | 1.00 | 0.72 |
| | B | 1.11 | 1.39 | 1.00 |
| Gravel & Sand | P | 1.00 | 1.18 | 1.08 |
| | L | 0.85 | 1.00 | 0.91 |
| | B | 0.93 | 1.09 | 1.00 |

Note: P: in place condition
L: in bank condition
B: in loose condition

FIGURE A. 5–1 WORKABLE PERIOD OF THE PROJECT UNDER PRESENT CONDITIONS



3. Construction method of works

(a) Pumping station works

Pumping station are to be constructed in each blocks. Pumping station works must be started earlier than the other works, with Block A at first, then Block B and finally Block C.

Excavation works

The following equipments are required for excavation works.

Bulldozer with capacities of 15 ton

Fronted loader with capacities of 1.6 cu.m

Backhoe with capacities of 0.6 cu.m

Dump truck with capacities of 8 ton

Materials excavated by the above mentioned equipments are deposited at nearby and, which would used for backfill or embankment materials. And also excess soil are leveled in field for the land consolidation works.

Works of concrete pile

The foundation at construction site is weak of N-values 1-2 to the depth of ten meters, therefore concrete piles are required in order to bear the pumping stations. Concrete pile are drived by 1.25 ton diesel pile hammer attached to the universal excavator from which the backhoe is taken off. Daily (10 hours/day) production of piling is about 13 pieces.

Concrete works

Concrete mixing works are accomplished by 0.5 cu.m portable batching plant which is set at job site, then, mixed concrete is transferred and placed by agitator truck and concrete conveyer. Daily mixing capacity is about 3.0 cu.m by using the 0.5 cu.m portable batching plant .

(b) Dike works

Stripping of surface soil

The work belongs to embankment works of dike and is composed of stripping the vegitations and the organic soil lying on the depth of 20 cm. This work is required in order that the connection of embankment portion and foundation will be in good condition, and in order to prevent from water seepage from the abutment portion. The surface soil is stripped by 15 ton bulldozer or swampy type 16 ton bulldozer, and it is hauled and embanked at nearby place. Then, the soil is leveled in land consolidated area.

Excavation works

Planning of excavation works is indicated in Type A of Figure A.5-2. Excavated materials from the borrow pit portion are transferred to the embankment portion. The upper layer is excavated by 15 ton bulldozer and the lower layer is excavated by 6.4 cu.m scrape dozer, and afterward excavated materials are hauled and transferred to the embankment portion.

Embankment works

Non-pavement embankment portion:

Transferred embankment materials are spread by 15 ton bulldozer or swampy type 16 ton bulldozer and afterwards compacted by tire roller with capacities of 8-20 ton

Pavement embankment portion:

Principal main roads are paved at depth of 15 cm on the surface by the good materials contained with many gravel and sand, so called a laterite, which is transferred from the mountainous area. In this planning, the laterite is transported from Salaburi located in the northern part of about 100 km from the Project Area. Transported laterite is spread by 15 ton bulldozer and afterward compacted by tire roller with capacities of 8-20 ton.

(c) On-farm works

On-farm works will be divided into following works.

(i) Road and canal works

(ii) Land leveling works

(iii) Related structure works

Road and canal works

Planning of road and canal works are indicated in Type B and Type C of Figure A.5-2.

Type B:

Excavated materials from the canal portion are transferred to the embankment portion. Methods of excavation works are as follows: the excavated materials by 0.6 cu.m backhoe are houled to the embankment portion and embanked by 15 ton bulldozer or swampy type 16 ton bulldozer

Type C:

Embankment materials, which are equally excavated from surrounding paddy fields, are transferred to the embankment portion. Excavation works are conducted as follows, embankment materials are excavated by 15 ton bulldozer or swampy-type 16 ton bulldozer and afterward hauled or transferred to embankment portion.

Construction methods of embankment works are same as methods adopted to dike works.

Land levelling works

(1) Land clearing works

There are many small hills in which trees and shrubs grow in the Project Area, therefore, before the execution of land consolidation works, stripping the obstructions (land clearing works) are required in the Project. And also it is considered that these obstructions will be cleared by bulldozer. Therefore, in this planning, 15 ton and/or 21 ton bulldozer are used for this purpose.

(2) Land leveling works

As regards soil texture in the Project Area, which was previously described, silty clay reaches to the depth from 10 m to 15 m. Namely, clear classifications between surface soil and sub-surface soil can not be observed. Averaged volumes of land levelling works are calculated in sample areas as follows:

Land adjustment: 242 cu.m/ha (hauling distance 197 m)
Land leveling: 520 cu.m/ha (hauling distance 65 m)

Method of land adjustment and land leveling works are: two third of these works are accomplished by 6.4 cu.m scrape dozer and one third of these works are accomplished by 21 ton bulldozer and 15 ton bulldozer or swampy type 16 ton bulldozer. After hauling the soil, in order to remove fluctuation and level the field surface, bulldozer are used along the width of plot throughout the field, and also along the length of run throughout the field.

(3) Farm Road and Ditch works

Road works:

Embankment materials are gathered from vicinity of proposed farm roads, and embanked by 15 ton bulldozer and/or swampy type 16 ton bulldozer. And afterward, these are spready by the bulldozer and compacted by tire roller having 8 - 20 ton capacities.

Ditch works:

Ditchs are excavated by backhoe with capacities of 0.3 cu.m

Related structure works

In this planning, concrete required for related structures are mixed by the potable concrete mixer set at jobe site, and mixed concrete are transferred and placed by man power using wheelbarrows or by belt conveyer.

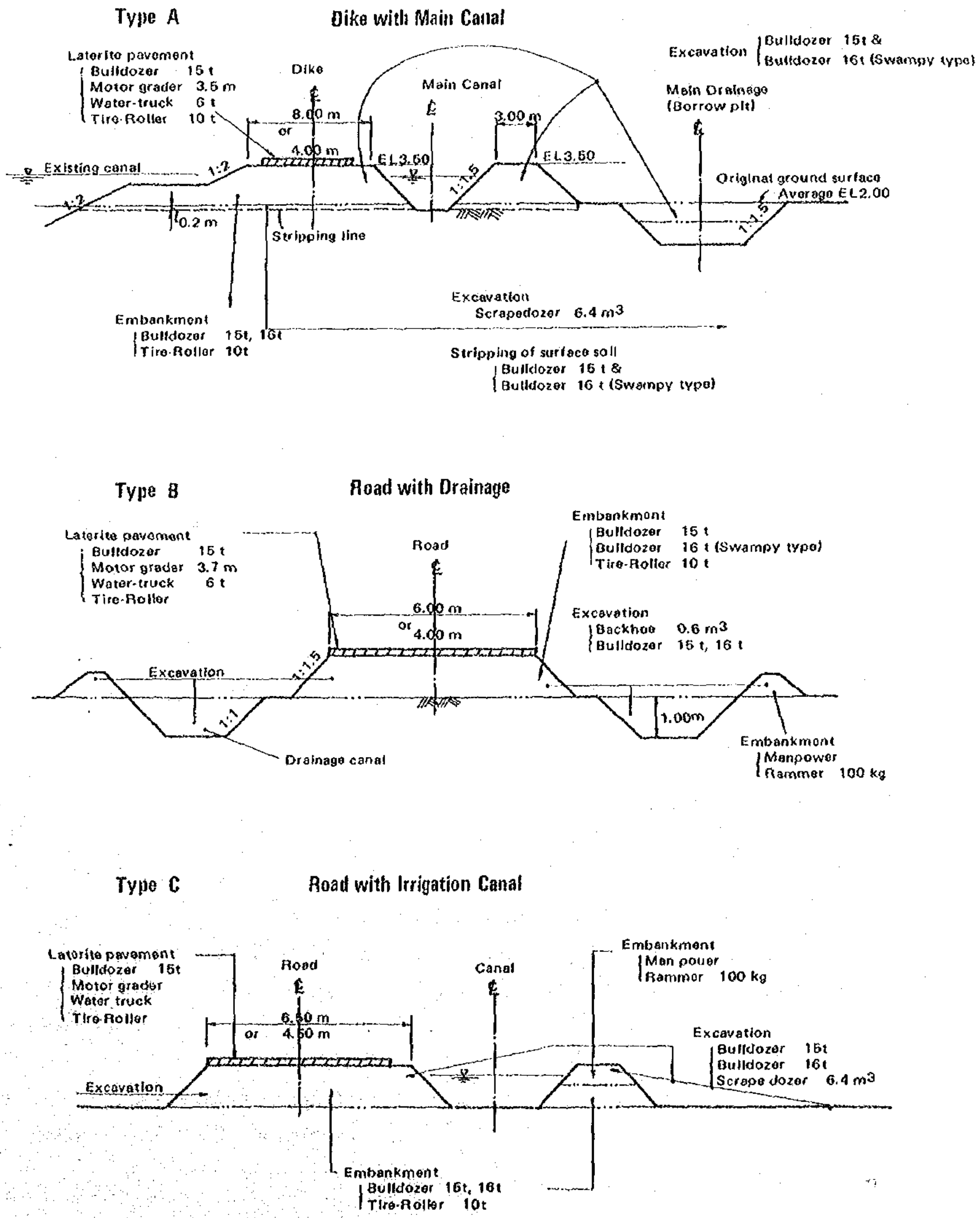
Daily mixing capacities of 0.3 cu.m potable concrete mixer will be considered to 20 cu.m/day.

(d) Provincial road works

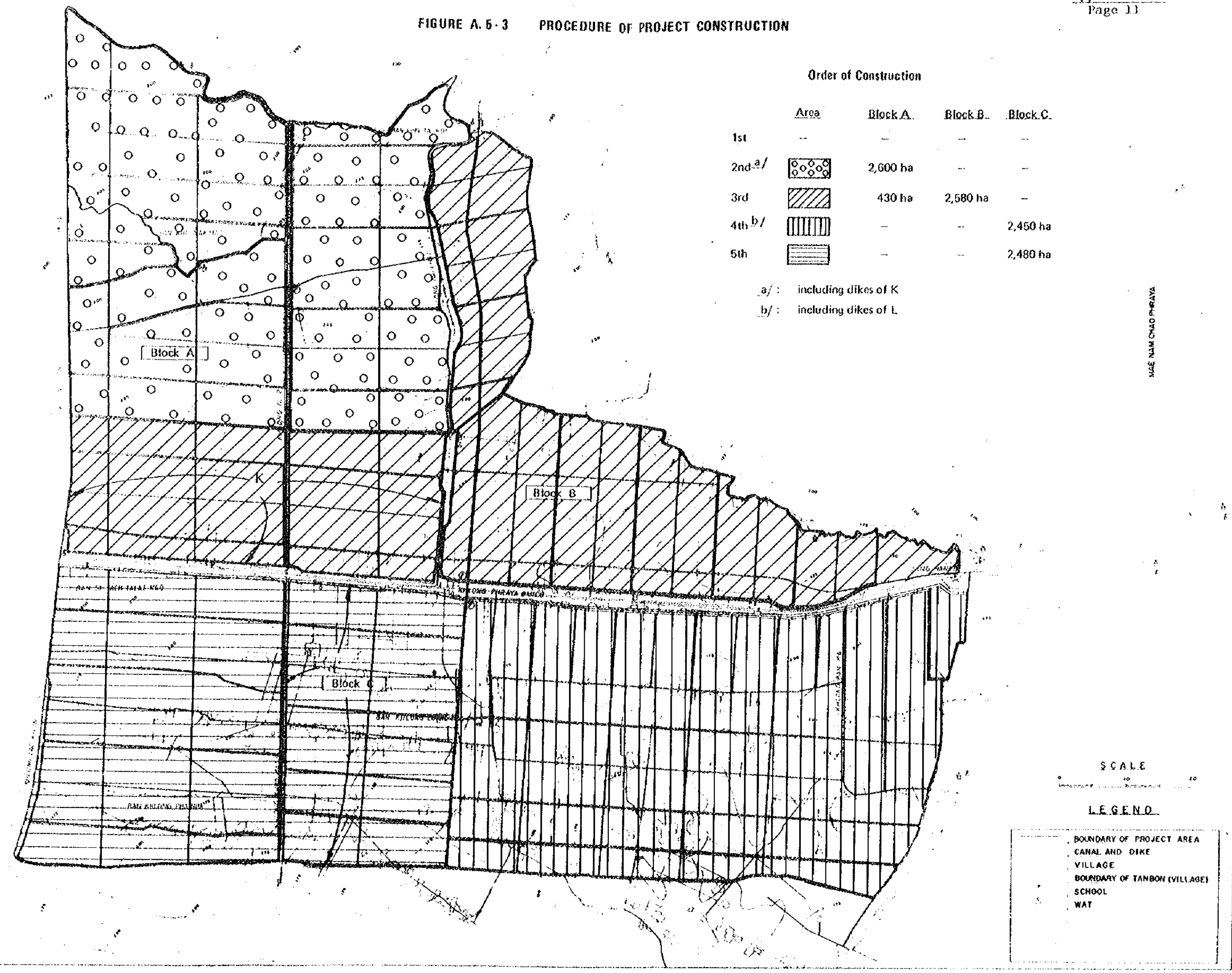
Construction methods for provincial roads conform to Type B of Figure A.5-2.

FIGURE A. 5-2

CONSTRUCTION METHOD OF DIKES, ROADS AND CANALS



## FIGURE A.5-3 PROCEDURE OF PROJECT CONSTRUCTION




**Order of Construction**

| | Area | Block A | Block B | Block C |
|---|---|---|---|---|
| 1st | – | – | – | – |
| 2nd [a]/ | (circles pattern) | 2,600 ha | – | – |
| 3rd | (diagonal hatching) | 430 ha | 2,580 ha | – |
| 4th [b]/ | (vertical hatching) | – | – | 2,450 ha |
| 5th | (horizontal hatching) | – | – | 2,480 ha |

a/ : including dikes of K

b/ : including dikes of L

## Operation and Maintenance Costs

1. Maintenance costs (฿'000)

1-1. Irrigation, drainage and road systems

Laterite pavement of main road and dike

$0.18m^3/m \times 78.3km \times 84฿/m^3 =$ 1,184

$0.18m^3/m \times 13.6km \times 84฿/m^3$ 206

Excavation

$0.15m \times 4.0m \times 343km \times 13฿m^3 =$ 2,675

1-2. Building facilities

$10,425,000 \times 4\% =$ 417

1-3. Others 900

Total 5,382

2. Personnel Cost

| Personnel | Yearly Expenses (฿ '000) | Number | Amount (฿ '000) |
|---|---|---|---|
| 2-1. Director | | | |
| General Director | 12 | 1 | 12 |
| Vice General Director | 6 | 1 | 6 |
| Director | 3 | 8 | 24 |
| Deputy Director | 3 | 2 | 6 |
| 2-2. Man Staff | | | |
| General Manager | 72 | 1 | * 72 |
| Division Chief | 50 | 7 | *350 |
| Clerk - 1st Class | 30 | 10 | 300 |
| - 2nd Class | 25 | 12 | 300 |
| - 3rd Class | 15 | 9 | 135 |
| Expert | 45 | 11 | *495 |
| 2-3. Woman Staff | | | |
| Woman Clerk - 1st Class | 10 | 10 | 100 |
| - 2nd Class | 96 | 15 | 144 |
| 2-4. Others | | | |
| Common Irrigator | 3 | 29 | 97 |
| Leader of Management Group | 3 | 29 | 97 |
| Leader of Farming Group | 1 | 136 | 136 |
| Hired Labor | (1,917man x ฿30 x 12mos) | | 690 |
| Total | | 281 | 2,964 |

3. Running cost (1,000 ฿)

3-1. Operation cost of pumps

| | |
|---|---|
| 0.5 ฿/kwh x 170kw x 1,842hr x 3units = | 470 |
| 0.5 ฿/kwh x 140kw x 1,802hr x 3units = | 378 |
| 0.5 ฿/kwh x 300kw x 1,817hr x 3units = | 818 |
| 3-2. Others | 1,917 |
| Total | 3,583 |

4. Depreciation cost of vehicles and equipments

4-1. Vehicles

| | | |
|---|---|---|
| Truck | 2 x ฿260,000 x 20% depn. = | 104 |
| Pickup Truck | 2 x ฿100,000 x 20% " = | 40 |
| Motor Bicycle | 24 x ฿ 12,000 x 20% " = | 58 |

4-2. Wireless phone

| | | |
|---|---|---|
| Main station (ALRC) | 1x2x฿2,000x10% depn.= | 1 |
| Sub-station (Production unit) | 4x2x฿2,000x10% " = | 2 |
| Sub-station (Management group) | 29x2x฿2,000x10% " = | 12 |

4-3. Office equipment

| | | |
|---|---|---|
| Typewriter | 7 x ฿10,000 x 20% depn. = | 14 |
| Calculation machine | 11 x ฿ 1,500 x 20% " = | 3 |
| Copying machine | 5 x ฿20,000 x 20% " = | 20 |
| | Total | 254 |

Grand Total (1 to 4) 12,200
(12,183)

Terms of Reference for the Consultant's Services

1. Objectives

The purpose of the consultant's services is to assist the Government in the effective implementation of the Irrigated Agricultural Development Project in the West Bank Tract of Greater Chao Phya.

2. Specific Terms of Reference

The consultants will provide a team to undertake the followings of the consultant's services.

(a) To prepare detailed design, cost estimates, specifications and tender documents for civil works and for procurement of operation and maintenance equipments, construction machineries, construction materials and other goods and instruments necessary for the project;

(b) To assist ALRO in the supervision of construction works under the project.

(c) To assist and advise the Project Manager in preparing monthly construction schedule and work records;

(d) To assist the relevant Government agencies to prepare agri-institutional establishment program which will include provision for:

(i) effective education of farmers in the project area through intensive demonstration and other means to enable them to adopt new cropping systems, diversify crops, use improved varieties of crops and improve cultivation practices;

(ii) strengthening of existing farmer's organizations and establishment of new organizations, of local farmers for the effective channelling of agricultural services;

(iii) adequate supply of agricultural credit and production requisites to these farmers as required for the recommended system of intensive cropping; and

(e) To train local counterpart personnel in all phases of project activities.

3. Expertise

(a) Senior Irrigation Engineer with sufficient experience in the planning, design, and operation and maintenance of irrigation and drainage system and with sufficient seniority to function as team leader

(b) Design Engineer with sufficient experience in the planning, design and construction of the pumps, road and dike, canal systems and on-farm facilities

(c) Equipment Engineer with experience in management and organization of operation and maintenance of construction equipments;

(d) Engineering Geologist with sufficient experience in the geological and soil mechanical investigation for the major structures such as canal structures, pumping station, bridge and etc.

(e) Agronomist with sufficient experience in the crop and soil management under paddy irrigation and upland crops at the farm level as well as in agricultural supporting services for irrigated agriculture.

(f) Agri-institutional Expert with broad experience in the agricultural supporting services for irrigated agriculture

(g) Economist with sufficient experience in the establishment of farm budgets, marketing and credit services and in the evaluation of economic and financial viability of the irrigated agricultural development project.

(h) Topographical Surveyor with sufficient experience in the planning execution and supervision of the topographical surveying works.

4. Services to be provided by the Government

The Government will provide the following for carrying out the Consultant's services.

(a) All available documents, drawing, maps, statistics, data and other information related to the Irrigated Agricultural Development Project in the West Bank Tract.

(b) Suitable full-time counterparts personnel, including engineers, technicians and professionals, as required for the project; and

(c) To exempt the Consultants from (or bear the cost of) any taxes, duties, fees, levies and other impositions imposed under its laws and regulations in the respect of;

(i) any payment made to the onsultants in connection with the carrying out their services;

(ii) any equipment and materials and supplies brought into the territories of the Government for the purpose of carrying out the services; and

(iii) any property brought by the members of the Consultants for their personnel use and consumption.

Figure A.5-4 shows the proposed schedule for the Consultant's services.

**FIGURE A.5 – 4. PROPOSED SCHEDULE FOR CONSULTANT'S SERVICES**

Phasing Year: 1976 (7–8, 9–10, 11–12), 1977, 1978, 1979, 1980, 1981, 1982, 1983 (1–2, 3–4, 5–6, 7–8, 9–10, 11–12)

| Description | Remarks | months |
|---|---|---|
| **I. Final Design** | | |
| 1. Senior Irrigation Engineer | I – 1 | 10 |
| 2. Equipment Engineer | I – 2 | 4 |
| 3. Engineering Geologist | I – 3 | 2 |
| 4. Design Engineer (Pump) | I – 4 | 6 |
| 5. Design Engineer (Road & Dike) | I – 5 | 10 |
| 6. Design Engineer (On-farm) | I – 6 | 10 |
| 7. Design Engineer (On-farm) | I – 7 | 7 |
| 8. Design Engineer (Building) | I – 8 | 5 |
| 9. Topographic Surveyor | I – 9 | 2 |
| | | 56 |
| **II. Construction Supervision** | | |
| 1. Project Engineer | II – 1 | 15 |
| 2. Construction Engineer | II – 2 | 60 |
| | | 75 |
| **III. Supporting Services** | | |
| 1. Agronomist | III – 1 | 34 |
| 2. Agri-institutional Expert | III – 2 | 15 |
| 3. Economist | III – 3 | 2 |
| | | 51 |
| | | 182 |

Table A. 6-1 Structure of Paddy Price per Ton

| | | |
|---|---|---|
| 1. World market price of milled rice in 1985 in constant end-1974 prices, Bangkok fob. | US$222 | IBRD forecast in constant end-1974 prices<br>5% broken US$ 285/MT<br>25% broken US$ 206/MT<br>Assumption: 20% of 5% broken and 80% of 25% broken<br>Weighted average price: US$221.8<br>Weighted price index of "Total food"<br>1973 : 100 64<br>1974 : 157 or 100<br>1976 : 147 94<br>Source: "Price forecast for main primary commodities" July 1975. IBRD |
| 2. World market price of milled rice in 1985 in constant 1976 prices | US$209 | |
| 3. Price of milled rice in Baht | ฿4,174 | |
| 4. Commission for middleman and exportor | ฿ -417 | |
| 5. Transport & handling | ฿ -295 | Transport and handling<br>Mill to boat 40<br>Freight by boat 35<br>Handling 20<br>Ware house 200<br>10/sack/month 2 month |
| 6. Rice price at rice mill | ฿3,462 | |
| 7. Transport from farm to mill | ฿ -40 | |
| 8. Milling charge | ฿ -150 | ฿100/ton Paddy, ฿100÷0.66 = ฿150/ton milled rice |
| 9. Farm gate price of milled rice | ฿3,272 | |
| 10. Farm gate price of paddy excluding by-products | ฿2,160 | Recovery rate: 0.66 |
| 11. By-products | ฿ 196 | $\overset{1/}{0.7} \times (1 - \overset{2/}{0.94}) \div 0.66 = 0.06$<br>3,272 x 0.06 = 196<br>1/: Recovery rate of hulled rice from paddy in weight<br>2/: Recovery rate of milled rice from hulled rice in weight |
| 12. Farm gate price of paddy | ฿2,356<br>≒2,360 | |

# Farm Labor Analysis

1. Labor Supply

Because almost all of the farm lands have been planted to rice, seasonal fluctuation of farm labor requirement has been high, namely, during the seasons of transplanting and harvesting of rice, relatively large sized farmers have suffered from scarcity of hired labor, resulting in introducing them from outside the Project Area.

On the other hand, in the slack seasons, even large sized farmers have little opportunity of employment.

In future, however, when the double cropping of rice and horticulture, animal husbandry and inland fishery are introduced through the provion of facilities for flood control and irrigation, and on-farm facilities, the said fluctuation of farm labor requirement is expected to be diminished.

But a substantial increase in absolute labor requirement will cause severe scarcity of labor forces in near future if the growth rate of population will remain at low of 1.9% as it is.

To meet the increase in farm labor requirement, workable population should be increased by preventing emigration and by U-turn of ones who have deserted the villages of the Project Area.

Furthermore, according to the proposed cropping pattern, the peak month of labor demand will be shifted from June at present to February, March, August and November in future.

Present conditions of labor requirement in the neighboring area are similar to those in the Project Area and are not expected to change simultaneously with the Project Area, therefore, many of the workers of these areas would be expected to commute to the Project Area on a daily basis.

In this context, the available labor force for the farming in the Project Area including casual migration was estimated, as shown in the Tables A.6-2, on the assumption that the workable heads per family are three, workable days per month are 25 and available labor force which commutes to the Project Area is 40 per cent of those inside.

A part of this potential labor force, for instance, of well-off farmers, in fact, does not participate in manual farm work, but it can be compensated by a part of non-farmers' labor force which is estimated at 20 per cent of total labor force in the Project Area.

2. Existing Wage Rate

It is difficult to obtain reliable data on the existing wage rates for farm labor, because of the following reasons;

- Most of the farm labor is provided by the farm family.
- An exchange of labor among neighbors and relatives is common.
- Land preparation, transplanting, weeding, harvesting etc. are paid by the job.
- Therefore, an employment on a daily basis is limited.

So far as the information obtained by field survey, the current wage rates are likely to be 15 to 18 Baht for male and 10 to 12 Baht for female on transplanting of rice, and about 20 Baht for male and 10 to 12 Baht for female on harvesting of rice.

In the case of permanent labor in orchards, employees are paid 15 Baht for male and 12 Baht for female per day.

3. Economic Costs of Farm Labor

It is postulated that the marginal opportunity cost of farm labor in the Project Area can be approximated by an S-shaped curve (Figure A. 6-2). The marginal opportunity costs are positive at all levels of labor demand and increase as more labor is employed in farm work.

The increase is slow initially, reflecting the scarcity of alternative productive employment, but becomes more rapid as the labor supply becomes fully used.

At the employment level corresponding to full employment of abailable family labor in the Project Area and surrounding areas (Table A. 6-2), the marginal opportunity costs are assumed equal to the market wage rates. If the demand for farm labor were to increase beyond this level, as would generally happen under the with project conditions the opportunity cost would continued to rise, though at a slower pace. At a level of about 30 per cent about full employment it is postulated that the opportunity cost curve would flatten out, at that cost the available labor pool would be drastically enlarged, as laborers from many other areas could be diverted to farm work in the Project Area.

It is, therefore, reasonable to approximate the S-shaped curve by three straight line segments. (Figure A.6-1)

Three points determine the position of the curve. Point A represents the minimum opportunity cost of farm labor which is judged to be four Baht per man-day, equal to economic values of alternative employment (casual non-farm labor, fishing, house repairs, etc.) plus the cost to supply the additional food requirements of strenuous farm work with the Project. Point B indicates that at full employment of available labor in the Project Area and in neighboring areas, the opportunity cost would equal the market wage rate of 15 Baht per man-day. The horizontal segment to the right of Point C indicates that at 20 Baht per man-day as many hired laborers as needed would be available for farm labor in the Project Area.

The curve in Figure A.6-2 was drawn by idealizing figure. The monthly opportunity cost may be read directly from the curve at the corresponding level of labor demand.

4. Labor Demand

Based on the results of field survey and information from extension workers, labor requirement per hectare and per production unit were estimated as shown in the tables A.6-3 and A.6-4.

Total farm labor requirements at present and in future with Project were computed on the basis of the above tables and the present and projected cropping patterns, and the results were shown in Tables A.6-5 and A.6-6.

5. Yearly Change in Labor Demand

Labor demand in future was assumed that the demand level would remain as it was with the situations of without Project, while with the with-Project-situations, the demand would increase corresponding to the intensification and divercification of farming through the implementation of the Project in the Area.

Estimated labor demand are tabulated in Tables A.6-7 and A.6-8.

6. Ratios of Labor Demand to Available Labor Force

Monthly farm labor demand as percentage of available labor force was derived from Tables A.6-2, A.6-7 and A.6-8, as shown in Table A.6-9 and A.6-10.

7. Wage Rate (Opportunity Cost of Labor per Man-day)

The monthly marginal opportunity costs of labor per man-day were read from the curve in Figure A.6-2 at the corresponding level of labor demand and shown in Tables A.6-11 and A.6-12.

8. Total Labor Costs

The total labor costs were computed by multiplying labor demand by wage rates and the results were tabulated in Tables A.6-13 and A.6-14. The differences between total labor costs without project and the ones with project were applied to Table A.6-16.

Table A.6-2 Available Farm Labor Force in Future

Available Farm Labor Force inside the Project Area

| Year | Without Project: Population Growth Rate % | Without Project: Population No. | Without Project: Family Size 1/ | Without Project: No. of Farm Families | Without Project: Mandays per Month 1,000 man-days | With Project: Population Growth Rate % | With Project: Population No. | With Project: Family Size 1/ | With Project: No. of Farm Families | With Project: Mandays per Month 1,000 man-days |
|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 1.9 | 10,200 | 6.34 | 1,610 | 120 | 1.9 | 10,200 | 6.34 | 1,610 | 120 |
| 1977 | 1.9 | 10,390 | 6.25 | 1,660 | 125 | 2.1 | 10,410 | 6.25 | 1,670 | 125 |
| 1978 | 1.9 | 10,590 | 6.16 | 1,720 | 129 | 2.3 | 10,650 | 6.16 | 1,730 | 130 |
| 1979 | 1.9 | 10,790 | 6.08 | 1,770 | 133 | 2.5 | 10,920 | 6.08 | 1,800 | 135 |
| 1980 | 1.9 | 11,000 | 5.99 | 1,840 | 138 | 2.8 | 11,220 | 5.99 | 1,870 | 140 |
| 1981 | 1.9 | 11,210 | 5.90 | 1,900 | 143 | 3.0 | 11,560 | 5.90 | 1,970 | 148 |
| 1982 | 1.9 | 11,420 | 5.83 | 1,960 | 147 | 3.0 | 11,910 | 5.83 | 2,040 | 153 |
| 1983 | 1.9 | 11,640 | 5.74 | 2,030 | 152 | 3.0 | 12,260 | 5.74 | 2,140 | 161 |
| 1984 | 1.9 | 11,860 | 5.66 | 2,100 | 158 | 3.0 | 12,630 | 5.66 | 2,230 | 167 |
| 1985 | 1.9 | 12,090 | 5.58 | 2,170 | 163 | 2.8 | 12,980 | 5.58 | 2,330 | 175 |
| 1986 | 1.9 | 12,310 | 5.50 | 2,240 | 168 | 2.6 | 13,320 | 5.50 | 2,420 | 182 |
| 1987 | 1.9 | 12,550 | 5.50 | 2,280 | 171 | 2.5 | 13,650 | 5.50 | 2,480 | 186 |
| 1988 | 1.9 | 12,790 | 5.50 | 2,330 | 174 | 2.5 | 14,000 | 5.50 | 2,550 | 191 |

Note: 1/ Average size of families 1970
Changwat Ayutthaya: 5.4 persons
Project area : 6.34 persons

Available Farm Labor Force per Month including Surrounding Areas

(Unit: 1,000 man-days)

| Year | Without Project: Inside | Without Project: Outside | Without Project: Total | With Project: Inside | With Project: Outside | With Project: Total |
|---|---|---|---|---|---|---|
| 1980 | 138 | 14 | 152 | 140 | 21 | 161 |
| 1981 | 143 | 14 | 157 | 148 | 25 | 173 |
| 1982 | 147 | 13 | 160 | 153 | 31 | 184 |
| 1983 | 152 | 13 | 163 | 161 | 34 | 195 |
| 1984 | 158 | 12 | 170 | 167 | 45 | 212 |
| 1985 | 163 | 12 | 175 | 175 | 56 | 231 |
| 1986 | 168 | 11 | 179 | 182 | 66 | 248 |
| 1987 | 171 | 11 | 182 | 186 | 73 | 259 |
| 1988 | 174 | 10 | 184 | 191 | 76 | 267 |

Table A.6-3 Monthly Labor Requirement per Hectare by Crop at Present

(Unit: Man-day)

| | Per | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice | | | | | | | | | | | | | | |
| Wet, BC | Ha | 31.6 | 8.1 | 0 | 1.3 | 4.8 | 5.9 | 5.8 | 1.0 | 0 | 0 | 0 | 19.9 | 78.4 |
| Wet, TP | Ha | 0 | 0 | 0 | 8.7 | 28.8 | 17.6 | 8.0 | 37.0 | 23.9 | 0 | 0 | 0 | 124.0 |
| Dry, TP | Ha | 0 | 9.7 | 20.6 | 22.2 | 6.0 | 33.4 | 28.7 | 3.4 | 0 | 0 | 0 | 0 | 124.0 |
| Upland Crops | Ha | 0 | 0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 0 | 0 | 0 | 0 | 36.0 |
| Citrus | Ha | 28.0 | 28.0 | 28.0 | 12.0 | 12.0 | 28.0 | 28.0 | 28.0 | 12.0 | 12.0 | 12.0 | 12.0 | 240.0 |

Table A.6-4 Monthly Labor Requirement per Hectare or Production Unit by Crop in Future with Project

(Unit: Man-day)

| | Per | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice (Total) | | 9.0 | 23.5 | 20.4 | 7.0 | 16.3 | 19.6 | 16.8 | 25.0 | 15.1 | 7.5 | 19.8 | 18.2 | 198.2 |
| Wet, BC | Ha | - | - | - | - | - | 0.6 | 12.9 | 25.0 | 15.1 | 7.5 | 19.8 | 18.2 | 99.1 |
| Wet, TP | Ha | 9.0 | 23.5 | 20.4 | 7.0 | 16.3 | 19.0 | 3.9 | - | - | - | - | - | 99.1 |
| Vegetables | Ha | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 360 |
| Citrus | Ha | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 360 |
| Animal | PU | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 180 |
| Fish | PU | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 180 |

Note: PU; Production Unit

Table A.6- 5 Monthly Labor Requirement by Crop at Present

(Unit: 1,000 Man-days)

| | Area (ha) | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice (Total) | | 69 | 41 | 49 | 71 | 76 | 124 | 96 | 76 | 42 | 0 | 0 | 44 | 688 |
| Wet, BC | 2,190 | 69 | 18 | 0 | 3 | 11 | 13 | 13 | 2 | 0 | 0 | 0 | 44 | 172 |
| Wet, TP | 1,773 | 0 | 0 | 0 | 15 | 51 | 31 | 14 | 66 | 42 | 0 | 0 | 0 | 220 |
| Dry, TP | 2,390 | 0 | 23 | 49 | 53 | 14 | 80 | 69 | 8 | 0 | 0 | 0 | 0 | 296 |
| Upland Crops | 106 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | 6 |
| Citrus | 240 | 7 | 7 | 7 | 3 | 3 | 7 | 7 | 7 | 3 | 3 | 3 | 3 | 60 |
| Total | 6,699 | 76 | 48 | 57 | 75 | 80 | 132 | 104 | 84 | 45 | 3 | 3 | 47 | 754 |

Table A.6-6 Monthly Labor Requirement by Crop in Future with Project

(Unit: 1,000 Man-days)

| | Area & PU | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice (Total) | | 86 | 224 | 195 | 67 | 156 | 187 | 160 | 239 | 144 | 72 | 189 | 174 | 1,893 |
| Wet, TP | 9,542 | 0 | 0 | 0 | 0 | 0 | 6 | 123 | 239 | 144 | 72 | 189 | 174 | 947 |
| Dry, TP | 9,542 | 86 | 224 | 195 | 67 | 156 | 181 | 37 | 0 | 0 | 0 | 0 | 0 | 947 |
| Vegetables | 500 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 180 |
| Citrus | 500 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 180 |
| Animal | 250 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 48 |
| Fish | 250 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 48 |
| Total | | 124 | 262 | 233 | 105 | 194 | 225 | 198 | 277 | 182 | 110 | 227 | 212 | 2,349 |

Note: BC; Broadcast TP; Transplanted PU; Production Unit

Table A.6-7 Total Labor Demand by Month without Project

(Unit: 1,000 Man-days)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 to 1988 | 76 | 48 | 57 | 75 | 80 | 132 | 104 | 84 | 45 | 3 | 3 | 47 | 754 |

Note: It is assumed that the labor demand for farming in the Project area is constant in the conditions of without-Project

Table A.6-8 Total Labor Demand by Month with Project

(Unit: 1,000 Man-days)

| Year | AL | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (41) | (41) | (41) | (41) | | | | | | | | | |
| 1980 | 161 | 76 | 48 | 57 | 75 | 80 | 132 | 104 | 84 | 45 | 3 | 3 | 47 | 754 |
| | | (49) | (49) | (49) | (49) | | | | | | | | | |
| 1981 | 173 | 79 | 61 | 69 | 77 | 88 | 138 | 111 | 96 | 55 | 12 | 16 | 57 | 859 |
| | | (29) | (29) | (29) | (29) | | | | | | | | | |
| 1982 | 184 | 84 | 84 | 85 | 80 | 99 | 148 | 120 | 117 | 68 | 21 | 41 | 73 | 940 |
| | | (28) | (28) | (28) | (28) | | | | | | | | | |
| 1983 | 195 | 91 | 116 | 113 | 85 | 118 | 163 | 135 | 148 | 89 | 38 | 77 | 95 | 1,268 |
| 1984 | 212 | 101 | 160 | 150 | 91 | 140 | 181 | 154 | 186 | 116 | 61 | 122 | 125 | 1,587 |
| 1985 | 231 | 111 | 203 | 184 | 97 | 163 | 201 | 173 | 225 | 144 | 83 | 169 | 156 | 1,909 |
| 1986 | 248 | 118 | 237 | 212 | 101 | 180 | 214 | 187 | 254 | 164 | 99 | 202 | 179 | 2,147 |
| 1987 | 259 | 122 | 254 | 227 | 104 | 189 | 221 | 195 | 267 | 175 | 108 | 218 | 205 | 2,285 |
| 1988 | 267 | 124 | 262 | 233 | 105 | 194 | 225 | 198 | 227 | 182 | 110 | 227 | 212 | 2,349 |

AL : Available Labor Forces

Note: The figures in parentheses indicate the labor required for construction works of the Project, and are excluded from ones outside

Table A.6-9 Monthly Farm Labor Demand as Percentage of Potential Full Employment
Without Project

(Unit: %)

| Year | AL | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 152 | 50 | 32 | 38 | 49 | 53 | 87 | 68 | 55 | 30 | 2 | 2 | 31 |
| 1981 | 157 | 48 | 31 | 36 | 48 | 51 | 84 | 66 | 54 | 29 | 2 | 2 | 30 |
| 1982 | 160 | 48 | 30 | 36 | 47 | 50 | 83 | 65 | 53 | 28 | 2 | 2 | 29 |
| 1983 | 163 | 47 | 29 | 35 | 46 | 49 | 81 | 64 | 51 | 28 | 2 | 2 | 29 |
| 1984 | 170 | 45 | 28 | 34 | 44 | 47 | 78 | 61 | 49 | 26 | 2 | 2 | 28 |
| 1985 | 175 | 43 | 27 | 33 | 43 | 46 | 75 | 59 | 48 | 26 | 2 | 2 | 27 |
| 1986 | 179 | 42 | 27 | 32 | 42 | 45 | 74 | 58 | 47 | 25 | 2 | 2 | 26 |
| 1987 | 182 | 42 | 26 | 31 | 41 | 44 | 73 | 57 | 46 | 25 | 2 | 2 | 26 |
| 1988 | 184 | 41 | 26 | 31 | 41 | 43 | 72 | 57 | 46 | 24 | 2 | 2 | 26 |

Table A.6-10 Monthly Farm Labor Demand as Percentage of Potential Full Employment
With Project

(Unit: %)

| Year | Al | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 161 | 73 | 56 | 61 | 73 | 50 | 82 | 65 | 52 | 28 | 2 | 2 | 29 |
| 1981 | 173 | 74 | 64 | 68 | 73 | 51 | 80 | 64 | 56 | 32 | 7 | 9 | 33 |
| 1982 | 184 | 61 | 61 | 61 | 59 | 54 | 80 | 65 | 64 | 37 | 11 | 22 | 40 |
| 1983 | 195 | 61 | 74 | 72 | 58 | 61 | 84 | 69 | 76 | 46 | 19 | 39 | 49 |
| 1984 | 212 | 48 | 75 | 71 | 43 | 66 | 85 | 73 | 88 | 55 | 29 | 58 | 59 |
| 1985 | 231 | 48 | 88 | 80 | 42 | 71 | 87 | 75 | 97 | 62 | 36 | 73 | 68 |
| 1986 | 248 | 48 | 96 | 85 | 41 | 73 | 86 | 75 | 102 | 66 | 40 | 81 | 72 |
| 1987 | 259 | 47 | 98 | 88 | 40 | 73 | 85 | 75 | 103 | 68 | 42 | 84 | 79 |
| 1988 | 267 | 46 | 98 | 87 | 39 | 73 | 84 | 74 | 104 | 68 | 41 | 85 | 79 |

FIGURE A.6 – 1. TYPICAL OPPORTUNITY COST CURVES FOR FARM LABOR

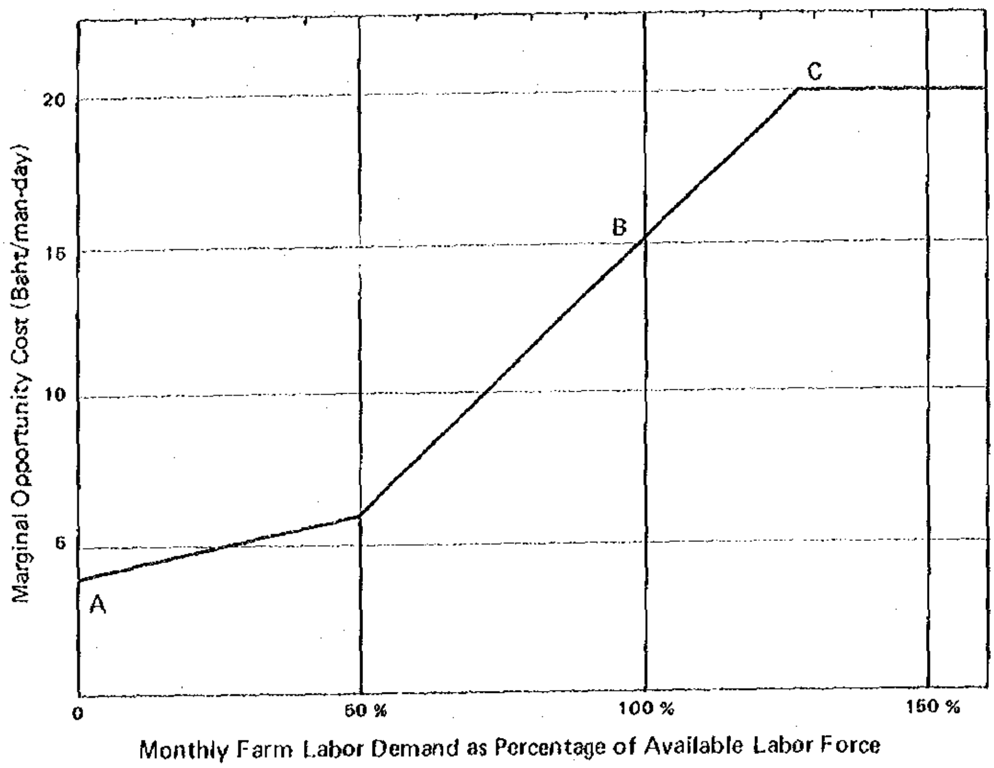



FIGURE A.6 – 2. OPPORTUNITY COST CURVES FOR FARM LABOR

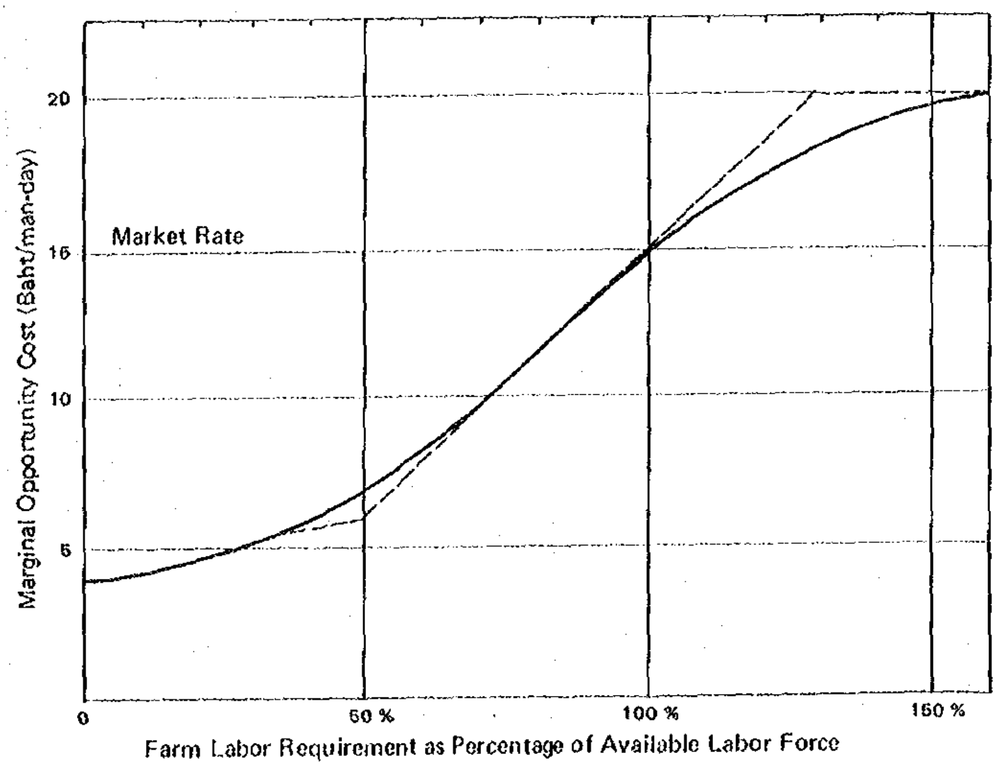


Table A.6-11 Wage Rate by Month without Project

(Unit: Baht/Man-day)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 7 | 5 | 6 | 7 | 8 | 13 | 10 | 8 | 5 | 4 | 4 | 5 |
| 1981 | 7 | 5 | 6 | 7 | 7 | 12 | 9 | 8 | 5 | 4 | 4 | 5 |
| 1982 | 7 | 5 | 6 | 7 | 7 | 12 | 9 | 8 | 5 | 4 | 4 | 5 |
| 1983 | 7 | 5 | 6 | 7 | 7 | 12 | 9 | 7 | 5 | 4 | 4 | 5 |
| 1984 | 7 | 5 | 6 | 7 | 7 | 11 | 9 | 7 | 5 | 4 | 4 | 5 |
| 1985 | 6 | 5 | 6 | 6 | 7 | 11 | 8 | 7 | 5 | 4 | 4 | 5 |
| 1986 | 6 | 5 | 5 | 6 | 7 | 11 | 8 | 7 | 5 | 4 | 4 | 5 |
| 1987 | 6 | 5 | 5 | 6 | 7 | 10 | 8 | 7 | 5 | 4 | 4 | 5 |
| 1988 | 6 | 5 | 5 | 6 | 6 | 10 | 8 | 7 | 5 | 4 | 4 | 5 |

Table A.6-12 Wage Rate by Month with Project

(Unit: 1,000 Man-day)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 10 | 8 | 9 | 10 | 7 | 12 | 9 | 7 | 5 | 4 | 4 | 5 |
| 1981 | 10 | 9 | 10 | 10 | 7 | 12 | 9 | 8 | 5 | 4 | 4 | 6 |
| 1982 | 9 | 9 | 9 | 8 | 8 | 12 | 9 | 9 | 6 | 4 | 5 | 6 |
| 1983 | 9 | 10 | 10 | 8 | 9 | 12 | 10 | 11 | 7 | 5 | 6 | 7 |
| 1984 | 7 | 11 | 10 | 6 | 9 | 12 | 10 | 13 | 8 | 5 | 8 | 8 |
| 1985 | 7 | 13 | 12 | 6 | 10 | 13 | 11 | 15 | 9 | 6 | 10 | 10 |
| 1986 | 7 | 14 | 12 | 6 | 10 | 13 | 11 | 15 | 9 | 6 | 12 | 10 |
| 1987 | 7 | 15 | 13 | 6 | 10 | 12 | 11 | 15 | 10 | 6 | 12 | 11 |
| 1988 | 7 | 15 | 13 | 6 | 10 | 12 | 11 | 15 | 10 | 6 | 12 | 11 |

Table A.6-13 Total Labor Costs by Month without Project

(Unit: 1,000 Baht)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 532 | 240 | 342 | 525 | 640 | 1,716 | 1,040 | 672 | 225 | 12 | 12 | 235 | 6,191 |
| 1981 | 532 | 240 | 342 | 525 | 560 | 1,584 | 936 | 672 | 225 | 12 | 12 | 235 | 5,875 |
| 1982 | 532 | 240 | 342 | 525 | 560 | 1,584 | 936 | 672 | 225 | 12 | 12 | 235 | 5,875 |
| 1983 | 532 | 240 | 342 | 525 | 560 | 1,584 | 936 | 588 | 225 | 12 | 12 | 235 | 5,791 |
| 1984 | 532 | 240 | 342 | 525 | 560 | 1,452 | 936 | 588 | 225 | 12 | 12 | 235 | 5,659 |
| 1985 | 456 | 240 | 342 | 450 | 560 | 1,452 | 832 | 588 | 225 | 12 | 12 | 235 | 5,404 |
| 1986 | 456 | 240 | 285 | 450 | 560 | 1,452 | 832 | 588 | 225 | 12 | 12 | 235 | 5,347 |
| 1987 | 456 | 240 | 285 | 450 | 560 | 1,320 | 832 | 588 | 225 | 12 | 12 | 235 | 5,215 |
| 1988 | 456 | 240 | 285 | 450 | 480 | 1,320 | 832 | 588 | 225 | 12 | 12 | 235 | 5,135 |

Table A.6-14 Total Labor Costs by Month with Project

(Unit: 1,000 Baht)

| Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 760 | 384 | 513 | 750 | 560 | 1,584 | 936 | 588 | 225 | 12 | 12 | 188 | 6,512 |
| 1981 | 790 | 549 | 690 | 770 | 616 | 1,656 | 999 | 768 | 275 | 48 | 64 | 342 | 7,567 |
| 1982 | 756 | 756 | 765 | 640 | 792 | 1,776 | 1,080 | 1,053 | 408 | 84 | 205 | 438 | 8,753 |
| 1983 | 819 | 1,160 | 1,130 | 680 | 1,062 | 1,956 | 1,350 | 1,628 | 623 | 190 | 462 | 665 | 11,725 |
| 1984 | 707 | 1,760 | 1,500 | 546 | 1,260 | 2,172 | 1,540 | 2,418 | 928 | 305 | 976 | 1,000 | 15,212 |
| 1985 | 777 | 2,639 | 2,208 | 582 | 1,630 | 2,613 | 1,903 | 3,375 | 1,296 | 516 | 1,690 | 1,560 | 20,789 |
| 1986 | 826 | 3,318 | 2,544 | 606 | 1,800 | 2,782 | 2,057 | 3,810 | 1,476 | 594 | 2,424 | 1,790 | 24,027 |
| 1987 | 854 | 3,810 | 2,951 | 624 | 1,890 | 2,652 | 2,145 | 4,005 | 1,750 | 648 | 2,616 | 2,255 | 26,200 |
| 1988 | 868 | 3,930 | 3,029 | 630 | 1,940 | 2,700 | 2,178 | 4,155 | 1,820 | 660 | 2,724 | 2,332 | 26,966 |

Table A.6-15 Net Production Value before Labor by Crop at Present and at Full Development

| | | Rice | | | | | | | Vegetables | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Without Project | | | | With Project | | | Without Project | With Project | | | | |
| | | Wet Season | | Dry Season | Total | Wet Season | Dry Season | Total | | Chinese | | Cauli- | | |
| Item | Unit | BC | TP | TP | (Avg.) | TP | TP | (Avg.) | Coconut 2/ | Cabbage | Cabbage | flower | Total | Average |
| Yield | ton/ha | 1.6 | 2.2 | 3.0 | (2.294) | (4.2) | 4.7 | (4.45) | | 14.6 | 15.2 | 9.0 | 38.8 | 12.93 |
| Price | Baht/ton | 2,360 | 2,360 | 2,360 | (2,360) | 2,360 | 2,360 | (2,360) | | 1,200 | 1,600 | 2,500 | - | 1,658 |
| Value | Baht/ha | 3,776 | 5,192 | 7,080 | (5,414) | 9,912 | 11,092 | (10,502) | 10,000 | 17,520 | 24,320 | 22,500 | 64,340 | 21,447 |
| Cash Cost 1/ | Baht/ha | 1,689 | 2,510 | 2,510 | (2,227) | 3,042 | 3,210 | (3,126) | 0 | 6,572 | 9,183 | 7,995 | 23,750 | 7,917 |
| NPV | Baht/ha | 2,087 | 2,682 | 4,570 | (3,187) | 6,870 | 7,882 | (7,376) | 10,000 | 10,948 | 15,137 | 14,505 | 40,590 | 13,530 |
| Area | Ha | 2,190 | 1,773 | 2,390 | 6,353 | 9,542 | 9,542 | 19,084 | 106 | 500 | 500 | 500 | 1,500 | 500 |
| Total NPV | (฿ '000) | 4,571 | 4,755 | 10,922 | 20,248 | 65,554 | 75,210 | 140,764 | 1,060 | 5,474 | 7,569 | 7,253 | 20,295 | 6,765 |
| Incremental NPV | (฿ '000) | 140,764 - 20,248 = 120,516 | | | | | | | 20,295 - 1,060 = 19,235 | | | | | |

1/: Labor costs are not incuded in the cash cost.

2/: It is assumed that other crop than rice is coconut, yield: 5 tons, price: 2 Baht/kg

BC: Broadcast

TP: Transplanted

Net Production Value before Labor by Crop at Present and at Full Development (cont.)

| Item | Unit | Citrus: Without Project | Citrus: With Project: Existing | Citrus: With Project: Expanding | Citrus: With Project: Total (Avg.) |
|---|---|---|---|---|---|
| Yield | Ton/ha | 15 | 30 | 30 | (30) |
| Price | Baht/ton | 3,000 | 3,000 | 3,000 | (3,000) |
| Value | Baht/ha | 45,000 | 90,000 | 90,000 | (90,000) |
| Cash Cost | Baht/ha | 18,930 | 27,040 | 27,040 | (27,040) |
| NPV | Baht/ha | 26,070 | 62,960 | 62,960 | (62,960) |
| Area | Ha | 240 | 240 | 260 | 500 |
| Total NPV | 1,000Baht | 6,257 | 15,110 | 16,370 | 31,480 |
| Incremental NPV | 1,000Baht | 31,480 - 6,257 = 25,223 | | | |

| Item | Unit | Animal: With Project: Swine | Chicken | Ducks | Total | Average |
|---|---|---|---|---|---|---|
| Products | | 8,080 | 900kg(Meat)<br>108,000eggs | 675kg(Meat)<br>67,500eggs | - | - |
| Price | Baht/egg | 13 | 12<br>0.95/egg | 10<br>1.0/egg | - | - |
| Value | Baht/PU | 105,040 | 113,400 | 74,250 | 292,690 | 97,560 |
| Cash Cost | Baht/PU | 87,600 | 90,615 | 43,900 | 222,115 | 74,040 |
| NPV | Baht/PU | 17,440 | 22,785 | 30,350 | 70,575 | 23,530 |
| Number of PU | | 83 | 84 | 83 | 250 | 83.3 |
| Total NPV | 1,000Baht | 1,448 | 1,914 | 2,519 | 5,881 | 1,960 |
| Incremental NPV | 1,000Baht | 5,881 | | | | |

| Item | Unit | Fish: With Project: Carp | Ciclid | Catfish | Total | Average |
|---|---|---|---|---|---|---|
| Products | | 3.0 | 3.0 | 7.5 | 13.5 | 4.5 |
| Price | Baht/egg | 8 | 8 | 12 | - | 10.2 |
| Value | Baht/PU | 24,000 | 24,000 | 90,000 | 138,000 | 46,000 |
| Cash Cost | Baht/PU | 14,076 | 13,060 | 80,719 | 107,850 | 35,950 |
| NPV | Baht/PU | 9,930 | 10,940 | 9,281 | 30,150 | 10,050 |
| Number of PU | | 83 | 83 | 84 | 250 | 83.3 |
| Total NPV | 1,000Baht | 824 | 908 | 780 | 2,512 | 837 |
| Incremental NPV | 1,000Baht | | | 2,512 | | |

Note: PU - Production unit

Table A.6-16 Economic Cost and Benefit Stream

(unit: million Baht)

| Year | Cost | | | Incremental Production Benefit | | | |
|---|---|---|---|---|---|---|---|
| | Construction Costs | Operation & Maintenance Costs 1/ | Sub-total | Net Production Value before Labor 2/ | Labor Costs | Net Production Value after Labor | Project Benefits |
| 1978 | 25.5 | 0 | 25.5 | 0 | 0 | 0 | -25.5 |
| 1979 | 70.6 | 0 | 70.6 | 0 | 0 | 0 | -70.6 |
| 1980 | 190.0 | 1.8 | 191.8 | -8.4 | 0.3 | -8.7 | -200.5 |
| 1981 | 118.5 | 6.6 | 125.1 | 0.2 | 1.7 | -1.5 | -126.6 |
| 1982 | 49.9 | 9.0 | 58.9 | 14.8 | 2.9 | 11.9 | -47.0 |
| 1983 | 50.3 | 10.9 | 61.2 | 40.9 | 5.9 | 35.0 | -26.2 |
| 1984 | -12.5 3/ | 12.2 | -0.3 | 84.5 | 9.6 | 74.9 | 75.2 |
| 1985 | 0 | 12.2 | 12.2 | 129.3 | 15.4 | 113.9 | 101.7 |
| 1986 | 0 | 12.2 | 12.2 | 148.8 | 18.7 | 130.1 | 117.9 |
| 1987 | 0 | 12.2 | 12.2 | 165.2 | 21.0 | 144.2 | 132.0 |
| 1988 | 0 | 12.2 | 12.2 | 173.2 | 21.8 | 151.4 | 139.2 |

Notes: 1/ Operation and maintenance costs indicate all the costs for the Land Reform Cooperative who is proposed to conduct the operation and maintenance of irrigation and drainage facilities and also the supporting services.

2/ Costs for construction of orchards and fish-ponds, and net value of production which will be lost during construction works (dry season) are counted in the farm management costs.

3/ Residual values of equipment and provisional facilities for the project construction.

Table A.6-17 Crop Budgets per Hectare without Project

(unit: Baht)

| Item | Rice: Wet Season BC | Rice: Wet Season TP | Rice: Dry Season TP | Citrus |
|---|---|---|---|---|
| 1. Gross Income (Baht) | 3,520 | 4,840 | 6,600 | 45,000 |
| Yield (ton) | 1.6 | 2.2 | 3.0 | 15.0 |
| Price (฿/kg) | 2.2 | 2.2 | 2.2 | 3.0 |
| 2. Production Costs excld. Labor Cost | 1,899 | 2,677 | 2,677 | 24,543 |
| Seeds | 312 | 108 | 108 | 240 1/ |
| Fertilizers | 0 | 658 | 658 | 5,684 |
| Agro-chemicals | 385 | 581 | 581 | 10,364 |
| Draft Animals | 90 | 90 | 90 | 700 2/ |
| Equipment | 787 | 845 | 845 | 170 |
| Others | 79 | 114 | 114 | 858 |
| Interest | 169 | 240 | 240 | 6,486 |
| Land Tax | 41 | 41 | 41 | 41 |
| 3. NPV before Labor | 1,621 | 2,163 | 3,923 | 20,457 |
| 4. Hired Labor | | | | |
| 5. Net Crop Income | | | | |

1/: Costs for recruiting trees

2/: Costs for fuel

Table A. 6-18 Crop Budgets per Hectare (Field Crops)

| Item | Rice | | | Vegetables | | | | Citrus |
|---|---|---|---|---|---|---|---|---|
| | Wet Season | Dry Season | Total | Chinese Cabbage | Cabbage | Cauli-flower | Total | |
| 1. Gross Income (Baht) | 9,240 | 10,340 | 19,580 | 17,520 | 24,320 | 22,500 | 64,340 | 90,000 |
| Yield (ton) | 4.2 | 4.7 | - | 14.6 | 15.2 | 9.0 | (12.14) | 30 |
| Price (฿/kg) | 2.2 | 2.2 | - | 1.2 | 1.6 | 2.5 | 5.3 | 3 |
| 2. Production Costs excld. Labor Cost | 3,214 | 3,387 | 6,601 | 6,769 | 9,610 | 8,126 | 24,505 | 33,531 |
| Seeds | 104 | 104 | 208 | 315 | 898 | 776 | 1,989 | 340 |
| Fertilizers | 878 | 1,020 | 1,898 | 3,028 | 3,918 | 3,523 | 10,469 | 8,120 |
| Agro-chemicals | 763 | 763 | 1,526 | 1,966 | 2,638 | 2,051 | 66,550 | 14,805 |
| Equipment | 1,063 | 1,063 | 2,126 | 637 | 996 | 791 | 2,424 | 1,240 |
| Others | 140 | 148 | 288 | 297 | 423 | 357 | 1,077 | 1,225 |
| Interest | 225 | 248 | 473 | 499 | 710 | 600 | 1,809 | 7,719 |
| Land Tax | 41 | 41 | 82 | 27 | 27 | 28 | 82 | 82 |
| 3. NPV before Labor | 6,026 | 6,953 | 12,979 | 10,751 | 14,710 | 14,374 | 39,835 | 62,130 |

Table A.6-18 (Cont.) Crop Budgets per Production Unit (Animal and Fish)

(Unit: Baht)

| Item | Animals: Swine | Chicken | Ducks | Average | Fish: Carp | Tilapia | Catfish | Average |
|---|---|---|---|---|---|---|---|---|
| 1. Gross Income (Baht) | 105,040 | 113,400 | 74,250 | 97,560 | 24,000 | 24,000 | 90,000 | 46,000 |
| Yield | 8,080 | 108,000eggs 900head | 67,500eggs 675heads | | 3.0tons | 3.0 | 7.5 | |
| Price | 13 | ฿0.95/egg ฿ 12/head | ฿1/egg ฿10/head | | 8 ฿/kg | 8 | 12 | |
| 2. Production Costs excld. Labor Costs | 96,405 | 101,236 | 49,187 | 82,260 | 14,755 | 13,729 | 84,598 | 37,690 |
| Feed | 84,000 | 73,000 | 36,500 | 64,500 | 9,200 | 9,200 | 63,870 | 27,420 |
| Recruiting | - | 12,940 | 5,190 | 6,040 | Fingerlings 3,200 | -"- 2,240 | -"- 12,000 | 5,810 |
| Vaccination | 1,800 | 2,050 | 1,500 | 1,780 | - | - | - | - |
| Facilities | 1,800 | 4,000 | 1,500 | 2,430 | 1,000 | 1,000 | 1,000 | 1,000 |
| Others | 4,380 | 4,600 | 2,235 | 3,730 | 670 | 622 | 3,844 | 1,715 |
| Interest | 4,415 | 4,636 | 2,252 | 3,770 | 675 | 657 | 3,874 | 1,735 |
| Land Tax | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 3. NPV before Labor | 8,635 | 12,164 | 25,063 | 15,300 | 9,245 | 9,644 | 5,402 | 8,310 |

Table A.6-19 Farm Budgets (Without Project)

(unit: Baht)

| Item | 3 ha | | | 4 ha | | | 6 ha | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rice | | | | | | Rice | | |
| | Wet Season | | Dry Season | Wet Season | | Dry Season | Wet Season | | Dry Season |
| | BC | TP | TP | BC | TP | TP | BC | TP | TP |
| Gross Income | 10,560 | 14,520 | 19,800 | 14,080 | 19,360 | 26,400 | 21,120 | 29,040 | 39,600 |
| Production Costs | 6,000 | 9,140 | 8,750 | 8,440 | 13,185 | 12,690 | 13,775 | 21,760 | 21,175 |
| Costs excl. Labor Costs | 5,700 | 8,030 | 8,030 | 7,600 | 10,710 | 10,710 | 11,390 | 16,060 | 16,060 |
| Hired Labor | 300 | 1,110 | 720 | 840 | 2,475 | 1,980 | 2,385 | 5,700 | 5,115 |
| Net Income | 4,560 | 5,380 | 11,050 | 5,640 | 6,175 | 13,710 | 7,345 | 7,280 | 18,425 |

Table A.6-20 Farm Budgets (With Project)

(unit: Baht)

| Item | 3 ha | | | | 4 ha | | | 6 ha |
|---|---|---|---|---|---|---|---|---|
| | Rice | 2 ha Rice 1 ha Vegetables | 2 ha Rice 1 ha Citrus | 3 ha Rice 1 PU Animals 1 PU Fish | Rice | 3 ha Rice 1 ha Vegetables | 3 ha Rice 1 ha Citrus | Rice |
| Gross Income | 58,740 | 103,500 | 129,160 | 202,300 | 78,320 | 123,080 | 148,740 | 117,480 |
| Production Costs | 19,943 | 38,027 | 85,080 | 142,173 | 27,534 | 46,728 | 55,754 | 45,846 |
| Costs excld.Labor Costs | 19,803 | 37,707 | 84,760 | 139,753 | 26,404 | 44,308 | 53,334 | 39,606 |
| Hired Labor | 140 | 320 | 320 | 2,420 | 1,130 | 2,420 | 2,420 | 6,240 |
| Net Income | 38,797 | 65,473 | 44,080 | 60,127 | 50,786 | 76,352 | 92,986 | 71,634 |

Table A.6-21 Farmers' Ability to Pay Water Charge and Investment Costs

(unit: Baht)

| Item | 3 ha | | | | 4 ha | | | 6 ha |
|---|---|---|---|---|---|---|---|---|
| | Rice | 2 ha Rice 1 ha Vegetables | 2 ha Rice 1 ha Citrus | 3 ha Rice 1 PU Animals 1 PU Fish | Rice | 3 ha Rice 1 ha Vegetables | 3 ha Rice 1 ha Citrus | Rice |
| Net income | 38,797 | 65,473 | 44,080 | 60,127 | 50,786 | 76,352 | 92,352 | 71,634 |
| Amount for tax exemption | 38,797 | 25,865 | 25,865 | 38,797 | 50,786 | 38,797 | 38,797 | 71,634 |
| Taxable amount | 0 | 39,608 | 18,215 | 21,330 | 0 | 37,555 | 53,555 | 0 |
| Tax rate | - | 0.08 | 0.07 | 0.07 | - | 0.08 | 0.10 | - |
| Individual income tax | - | 3,169 | 1,275 | 1,493 | - | 3,004 | 5,356 | - |
| Amount after deduction of income tax (a) | 38,797 | 62,304 | 42,805 | 58,634 | 50,786 | 73,348 | 86,996 | 71,634 |
| Water Charge (OM costs) (b) | 3,450 | 3,450 | 3,450 | 3,634 | 4,600 | 4,600 | 4,600 | 6,900 |
| (b)/(a) x 100 | 9 | 6 | 8 | 6 | 9 | 6 | 5 | 10 |
| Disposable Income(c)=(a)-(b) | 35,347 | 58,854 | 39,355 | 55,000 | 46,186 | 68,748 | 82,396 | 64,734 |
| FC Amortisation (d) | 8,448 | 8,448 | 8,448 | 8,899 | 11,264 | 11,264 | 11,264 | 16,896 |
| Amount left to individual farmer after deduction of FC repayment | 26,899 | 50,406 | 30,907 | 46,101 | 34,922 | 57,484 | 71,132 | 47,838 |
| (d)/(c) x 100 | 24 | 14 | 21 | 16 | 24 | 16 | 14 | 25 |

Table A.6-22 Contribution to Rice Export by Project

1. Incremental Paddy Production by Project

(a) Present Production

1.6ton/ha x 2,190ha = 3,504ton (Wet season broadcasting)

2.2ton/ha x 1,773ha = 3,900ton (Wet season transplanting)

3.0ton/ha x 2,390ha = 7,170ton (Dry season transplanting)

Total 14,574ton

(b) Production with Project

4.2ton/ha x 9,542ha = 40,076ton (Wet season transplanting)

4.7ton/ha x 9,542ha = 44,847ton (Dry season transplanting)

Total 84,923ton

(c) Increment = (b) - (a) = 70,349 ton

2. Increasing Rice Consumption in Project Area

(a) Present Consumption

10,200 (Population at present) x 197kg1/ = 2,009 ton

(b) Future Consumption

14,000 (Population in future) x 197kg1/ = 2,758 ton

(c) Increasing Paddy Consumption = (b) - (a) = 749 ton

1/ 130kg ÷ 0.66 (Milling rate)

3. Contribution Amount to Export in Paddy = 1 - 2

= 69,600

4. Contribution Ammount to Export of Milled Rice = 45,936 ton/year

5. Saving of Foreign Currency

45,936ton x 6,152฿/ton = ฿282.6 million : US$14.1 million