5.5. Sedimentation

There has been no sediment flow data collected in the Lebir River basin. Therefore, this is discussed herein on the basis of other references.

(1) Characteristics of the sediment load in the Kelantan Basin were studies in 1977, and presented in the Report entitled "Kelantan River Basin Study" by ENEX (Chapter 5 of Vol. I of the Report). It is mentioned in the Report that annual sediment transport is estimated at more or less 110 $m^3/km^2/year$.

(2) Until now, sediment deposits in the Ringlet Falls Reservoir located in the Cameron Highlands were measured 8 times during the period from 1963 to 1986 as shown in Appendix Figs. 5-36 and 37. The annual sediment volume is 167.7 $m^3/km^2/year$ on average. The range of these measurements, however, covers only the upstream portion of the reservoir, and so the values should not be regarded as indicating the sediment deposit volume in the whole of the reservoir. Generally speaking, sediment materials in the upstream area are mostly coarse in size, and normally the quantity of silt materials which are deposited all over the bottom of a reservoir is much greater than that of other size of materials.

Therefore, the actual sediment deposit should be judged to be far more than the above-mentioned measurement value. Average annual rainfall in this region during the period from 1975 to 1980 is 1,592 mm in Blue Valley, and 2,102 mm in the Cameron Highlands.

(3) Referred hereinafter are the results of studies by Dr. Kira on the relationship between unit sediment deposit (qs), annual average sediment inflow (I) and gross storage capacity of a dam after its completion, with respect to a

number of reservoirs in various countries (157 reservoirs in Japan, 58 in the U.S., 47 in India, and 14 in other countries). The relationship thus obtained is as depicted in Fig. 5-8, and expressed in the following equation:

$$qs = 473.55\ (C/I)^{0.366}$$

where, the unit sediment deposit qs is the value per unit area of the drainage basin from the annual total deposit volume.

The equations are:

$$C = 2.392 \times 10^9 m^3$$
$$I = 112.15\ m^3/s \times 365\ day \times 24\ hr/day \times 3{,}600\ sec/hr$$
$$= 3.537 \times 10^9 m^3$$

Hence, the mean unit sediment deposit is obtained as follows:

$$qs = 410.4\ m^3/km^2/year$$

From the above references, the largest value qs = 410.4 m^3/km^2/year was adopted for this study. The sediment deposit for 100-year period of the Lebir reservoir was then calculated;

$$Vs = 2{,}473\ km^2 \times 410.4\ m^2/km^2/year \times 100\ year$$
$$= 101 \times 10^6 m^3$$

Assuming that the total volume of sediment will accumulate evenly in the reservoir, the siltation level will reach EL. 47 m (Volume of 115 x $10^6 m^3$).
(Actually, only silt will deposit levelly. Sand or gravel materials will accumulate, and progress in the form of a terrace, starting from the upstream portion of the reservoir)

TABLE 5-1 STREAMFLOW RECORDS AT GUILLEMARD BRIDGE MONTHLY AVERAGE

(m^3/s/DAY)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1950	829.5	914.2	472.7	420.6	630.3	472.7	407.6	371.1	553.5	661.5	729.3	806.1	605.8
1951	1788.0	698.0	372.4	325.6	332.1	311.2	296.9	280.0	561.3	754.0	1005.3	988.4	642.8
1952	1122.5	642.0	586.0	395.9	616.0	401.1	323.0	307.3	360.7	730.6	823.0	567.8	573.0
1953	763.1	536.5	483.1	367.2	614.7	505.3	429.7	265.7	442.8	609.5	789.2	903.8	559.2
1954	1472.9	496.2	339.9	334.7	403.7	445.4	436.3	497.5	492.2	774.8	642.0	1782.8	676.5
1955	985.8	496.2	312.5	317.7	341.2	358.1	399.8	440.2	326.9	661.5	829.5	600.3	505.8
1956	437.6	428.4	356.8	480.5	427.1	509.2	395.9	431.0	765.7	1229.3	1492.4	1517.1	705.9
1957	1130.4	523.5	582.1	618.6	867.3	813.9	509.2	660.2	918.1	812.6	890.7	2152.6	873.3
1958	1027.5	759.2	487.0	243.5	394.6	388.1	171.9	471.4	341.2	632.9	863.4	449.3	519.2
1959	321.7	209.7	145.8	169.3	315.1	250.0	287.8	294.3	416.7	601.6	927.2	1013.2	412.7
1960	763.1	479.2	251.3	195.3	312.5	208.4	224.0	179.7	415.4	352.9	669.4	922.0	414.4
1961	1208.5	541.7	307.3	377.7	363.3	259.1	197.9	169.3	307.3	509.2	754.0	994.9	499.2
1962	1116.0	407.6	441.5	302.1	367.2	263.1	307.3	321.7	339.9	561.3	592.5	948.0	497.4
1963	946.7	376.3	283.9	147.2	160.2	170.6	173.2	253.9	282.6	513.1	914.2	1071.8	441.1
1964	493.6	552.2	420.6	239.6	411.5	381.6	406.3	323.0	461.0	398.5	458.4	690.2	436.4
1965	324.3	253.9	165.4	234.4	333.4	247.4	273.5	350.3	523.5	750.1	859.5	1754.1	505.8
1966	1315.3	593.8	496.2	359.4	358.1	381.6	393.3	418.0	441.5	1715.1	1472.9	1526.2	789.3
1967	3151.5	1026.2	1226.7	530.0	578.2	350.3	406.3	346.4	345.1	463.6	1362.2	1142.1	910.7
1968	464.9	225.3	182.3	140.6	269.6	339.9	339.9	199.2	424.5	655.0	411.5	640.7	357.8
1969	618.6	238.3	141.9	104.2	207.1	231.8	187.5	237.0	227.9	419.3	992.3	1554.9	430.1
1970	1087.4	451.9	306.6	364.6	302.1	304.7	370.0	410.0	570.0	850.0	810.0	1150.0	581.4
1971	2480.0	570.0	800.0	320.0	330.0	330.0	407.8	418.8	540.0	420.0	638.0	2909.0	847.0
1972	410.0	356.0	189.0	235.0	505.0	435.6	236.0	250.0	620.0	520.0	790.0	2160.0	558.9
1973	780.0	390.0	260.0	220.0	310.0	410.0	350.0	380.0	570.0	630.0	800.0	3970.0	755.8
1974	690.0	510.0	330.0	520.0	580.0	370.0	487.0	378.0	545.0	657.0	898.0	840.0	567.1
1975	1540.0	646.0	444.0	365.0	540.0	403.0	496.0	351.8	647.5	574.3	1429.2	1544.4	748.4
1976	592.6	302.9	231.4	248.1	395.7	407.9	328.6	441.0	457.2	675.3	1031.4	1139.2	520.9
1977	851.4	445.9	261.1	177.2	178.9	206.8	285.9	390.1	266.4	715.5	908.4	865.3	446.1
1978	699.0	297.6	182.6	181.9	314.2	327.8	390.1	245.2	472.2	484.6	759.1	1084.4	453.2
1979	463.0	339.8	240.5	272.2	305.5	348.3	287.4	229.2	431.4	383.2	2078.7	912.8	524.3
1980	363.1	287.9	157.4	245.2	288.5	280.7	212.4	468.6	583.5	928.2	1012.5	862.2	474.2
1981	410.8	263.0	157.4	254.7	402.3	213.6	226.5	130.2	285.8	446.2	547.2	646.5	332.0
1982	214.4	560.7	114.3	322.1	387.1	422.8	302.3	311.5	409.4	543.7	631.0	1345.2	463.7
1983	527.9	250.9	164.8	112.1	174.3	195.6	289.9	363.2	464.9	391.0	475.3	2690.8	508.4
1984	626.4	1808.8	755.3	538.7	634.5	518.0	458.7	359.5	460.5	533.3	438.1	1409.3	711.8
MEAN	914.78	510.86	361.44	305.17	398.61	356.10	334.17	341.27	464.90	644.54	877.88	1295.87	567.13

TABLE 5-2 STREAMFLOW ESTIMATE AT LEBIR DAM SITE MONTHLY AVERAGE

(m³/s/DAY)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1950	143.1	158.6	77.6	79.5	131.1	92.4	76.3	67.3	112.2	119.7	143.6	170.6	114.3
1951	318.9	119.0	59.2	56.1	57.7	52.6	49.1	44.9	114.2	152.3	240.8	234.8	125.0
1952	196.8	108.7	98.4	73.4	127.6	74.7	55.5	51.6	64.8	144.0	176.6	86.7	104.9
1953	130.9	89.3	79.6	66.4	127.3	100.4	81.8	41.4	85.0	101.4	164.7	205.0	106.1
1954	261.1	81.9	53.3	58.4	75.4	85.6	83.4	98.4	97.2	159.6	112.8	514.6	140.1
1955	171.8	81.9	48.3	54.2	60.0	64.1	74.4	84.3	56.4	119.7	178.9	98.2	91.0
1956	71.2	69.5	56.4	94.3	81.1	101.3	73.4	82.1	164.5	319.7	412.3	421.0	162.2
1957	198.3	87.0	97.7	128.3	189.5	176.4	101.3	138.5	202.0	172.9	200.4	644.8	194.8
1958	179.4	130.2	80.3	35.9	73.1	71.5	18.3	92.0	60.0	109.6	190.8	45.0	90.5
1959	49.9	29.4	17.7	17.6	53.6	37.5	46.8	48.4	78.6	98.6	213.3	243.5	77.9
1960	130.9	78.8	37.0	24.1	52.9	27.3	31.1	20.2	78.2	11.0	122.5	211.4	68.8
1961	212.6	90.3	47.3	68.9	65.4	39.8	24.7	17.6	51.6	66.1	152.3	237.1	89.5
1962	195.6	65.7	71.9	50.4	66.4	40.7	51.6	55.2	59.6	84.4	95.4	220.6	88.1
1963	164.6	60.0	43.0	12.2	15.4	18.0	18.6	38.5	45.5	67.4	208.7	264.2	79.7
1964	81.5	92.2	68.1	35.0	77.3	69.9	76.0	55.5	89.5	27.1	48.2	129.8	70.8
1965	50.4	37.5	21.3	33.7	58.0	36.9	43.3	62.2	104.9	150.9	189.4	504.5	107.7
1966	232.2	99.9	81.9	64.5	64.1	69.9	72.8	78.9	84.7	490.7	405.4	424.2	180.8
1967	569.0	179.2	216.0	106.5	118.3	62.2	76.0	61.3	60.9	50.0	366.5	288.9	179.6
1968	76.2	32.3	24.4	10.6	42.3	59.6	59.6	25.0	80.5	117.4	31.7	112.4	56.0
1969	104.4	34.6	17.0	1.6	26.9	33.0	22.1	34.3	32.1	34.4	236.2	434.3	84.3
1970	190.4	73.8	47.2	65.7	50.4	51.0	67.1	76.9	116.3	186.1	172.0	291.7	115.7
1971	445.8	95.5	137.7	54.8	57.2	57.2	76.4	79.1	108.9	34.6	111.4	911.2	180.8
1972	66.1	56.2	25.6	33.8	100.3	83.2	34.1	37.5	128.6	69.9	165.0	647.4	120.6
1973	134.0	62.5	38.6	30.1	52.3	76.9	62.1	69.5	116.3	108.6	168.5	1284.9	183.7
1974	117.5	84.5	51.5	104.0	118.8	67.1	95.9	69.0	110.1	118.1	203.0	182.6	110.2
1975	273.4	109.4	72.4	65.8	108.9	75.2	98.1	62.6	135.4	89.0	390.1	430.6	159.2
1976	99.6	46.5	33.4	37.1	73.4	76.4	56.9	84.5	88.5	124.6	250.0	287.9	104.9
1977	147.1	72.7	38.8	19.6	20.0	26.9	46.4	72.0	41.6	138.7	206.6	121.0	79.3
1978	119.1	45.5	24.4	20.8	53.3	56.7	72.0	36.3	92.2	57.4	154.1	268.6	83.4
1979	75.9	53.3	35.0	43.0	51.2	61.7	46.7	32.4	82.2	21.7	618.8	208.2	110.8
1980	57.5	43.7	19.8	36.3	47.0	45.1	28.3	91.3	119.6	213.6	243.3	190.4	94.7
1981	66.3	39.2	19.8	38.7	75.0	28.6	31.7	8.0	46.3	43.9	79.4	114.4	49.3
1982	30.3	93.8	11.9	55.3	71.3	80.1	50.4	52.7	76.8	78.2	109.0	360.5	89.2
1983	87.8	37.0	21.2	3.6	18.9	24.1	47.3	65.4	90.4	24.4	54.1	834.4	109.0
1984	105.8	322.7	129.5	108.6	132.2	103.5	88.9	64.5	89.3	74.5	41.0	383.1	137.0
MEAN	158.73	84.64	57.23	51.10	74.11	63.64	58.24	59.99	90.43	113.72	195.90	343.11	112.57

Table 5-3 Daily Rainfall by Thiessen Method
(based on a flood simulation of Dec.1983)

	Tualang Upstream	Bertam Upstream	Bertam to Dabong	Dabong , and Tualang to Guillemard
	mm	mm	mm	mm
1st day	342	103	133	181
	(31.7)	(9.6)	(12.3)	(16.7)
2nd day	145	43	56	81
	(25.0)	(7.5)	(9.6)	(13.9)
3rd day	172	53	66	99
	(16.8)	(5.1)	(6.4)	(9.7)
4th day	42	8	14	14
	(6.1)	(1.2)	(2.0)	(2.0)
5th day	39	5	13	10
	(8.9)	(0.8)	(2.0)	(1.5)
Total	740	212	282	385

Note: Figures in brackets indicate peak hourly rainfall.

Table 5-4 Daily Rainfall by Thiessen Method
(based on a flood simulation of Dec. 1984)

	Tualang Upstream	Bertam Upstream	Bertam to Dabong	Dabong and Tualang to Guillemard
	mm	mm	mm	mm
1st day	0	18	7	24
		(3.7)	(1.4)	(4.9)
2nd day	110	17	55	94
	(28.6)	(3.5)	(11.2)	(19.2)
3rd day	218	106	121	185
	(20.4)	(21.6)	(24.7)	(37.8)
4th day	18	13	29	34
	(7.4)	(2.7)	(5.9)	(6.9)
5th day	68	14	34	57
	(29.6)	(2.9)	(6.9)	(11.6)
Total	414	168	246	394

Note: Figures in brackets indicate peak hourly rainfall.

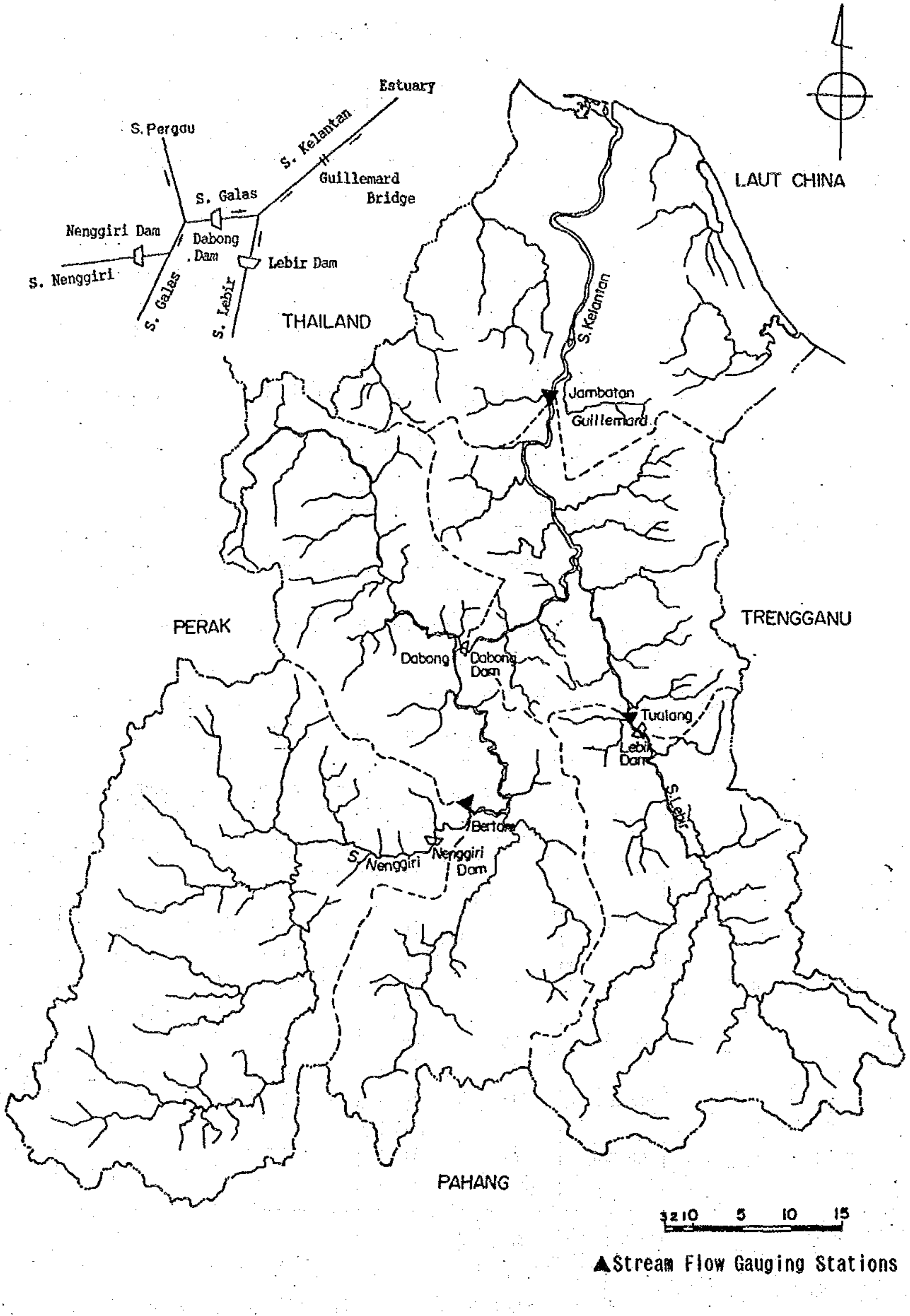


Fig. 5-1 Map of Kelantan River Basin

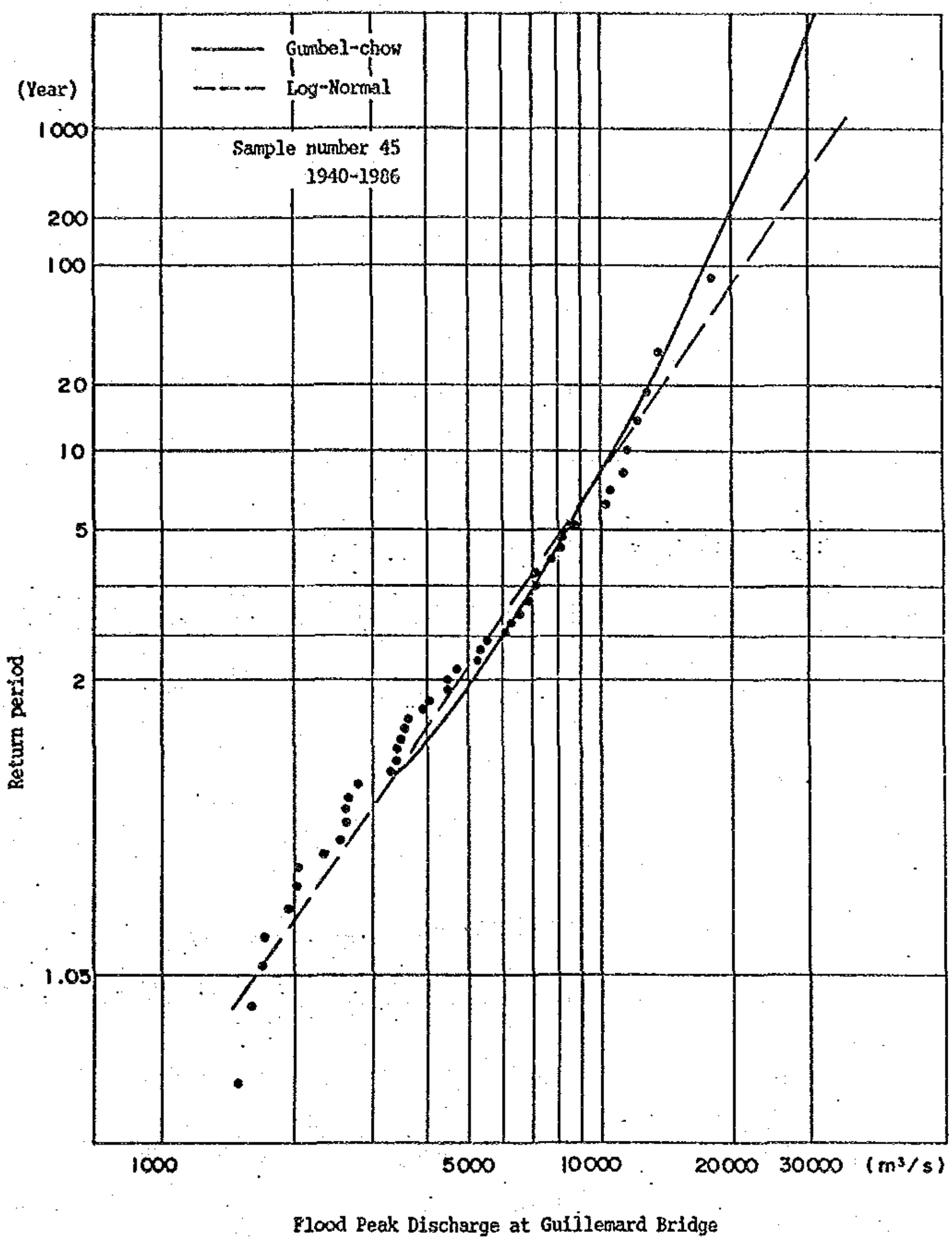


Fig.5-2 Relationship between Flood Peak Dischage at Guillemard Bridge and Its Return Period

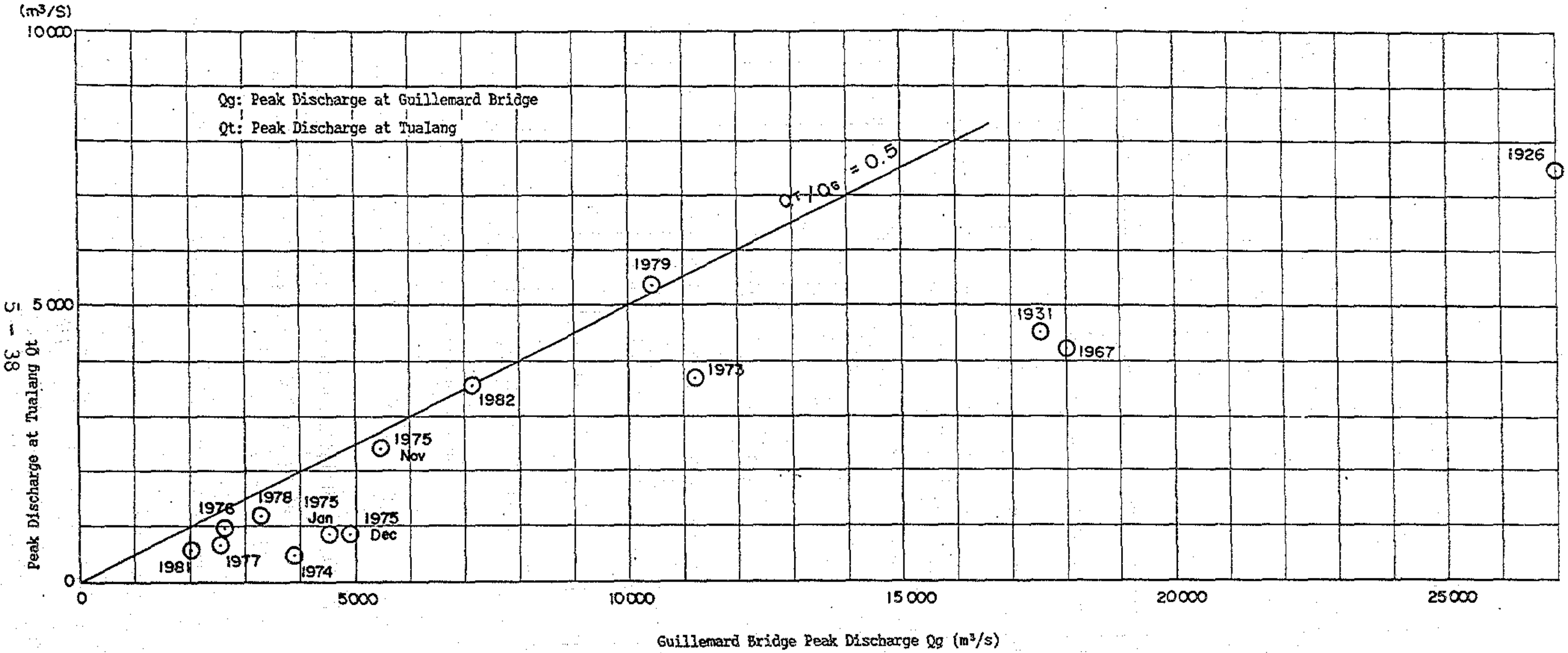


Fig.5-3 Relationship of Flood Peak Dischage at Guillemard Bridge and Tualang

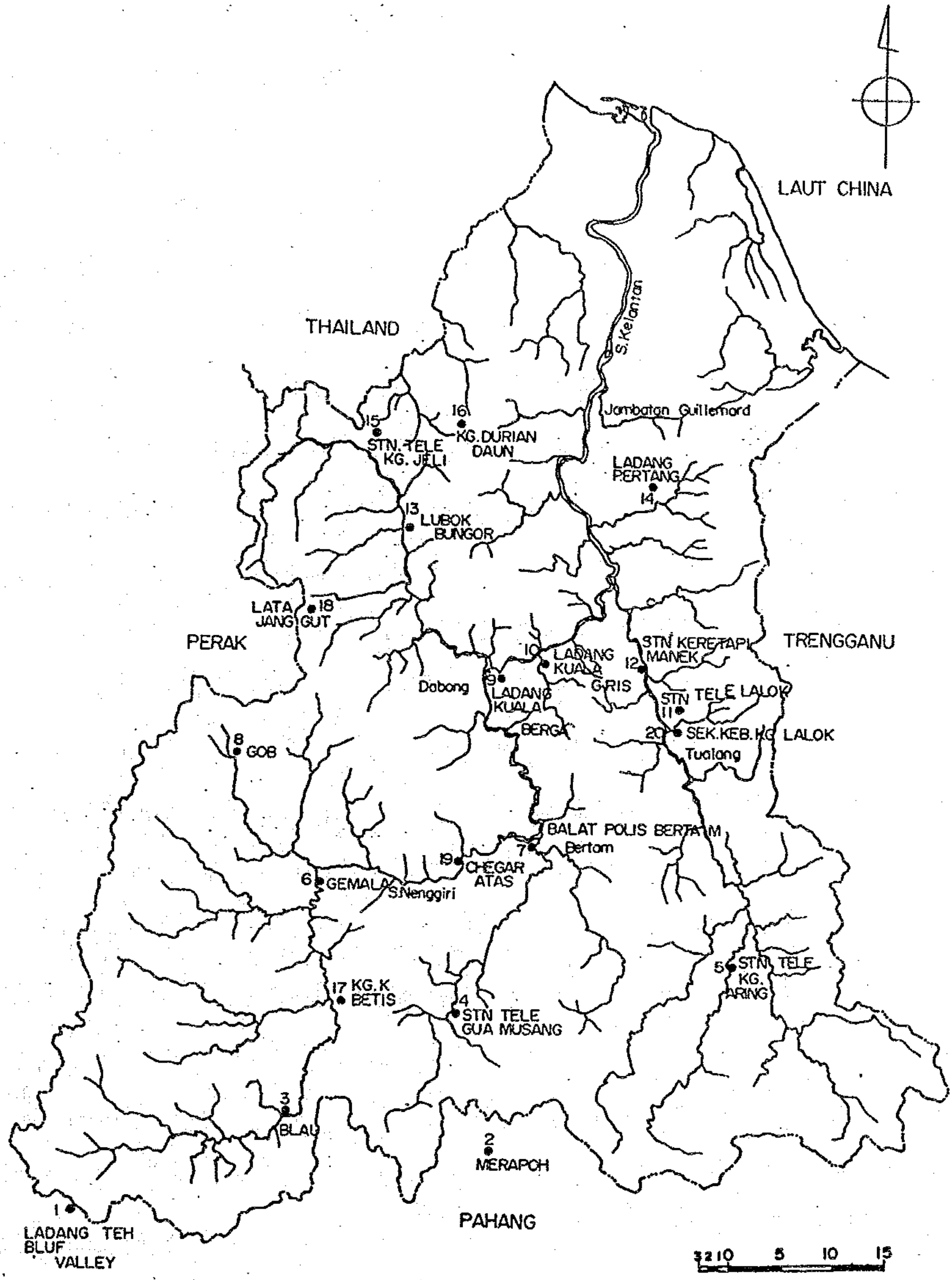


Fig.5-4 Location Map of Rainfall Gauging Station used in the study

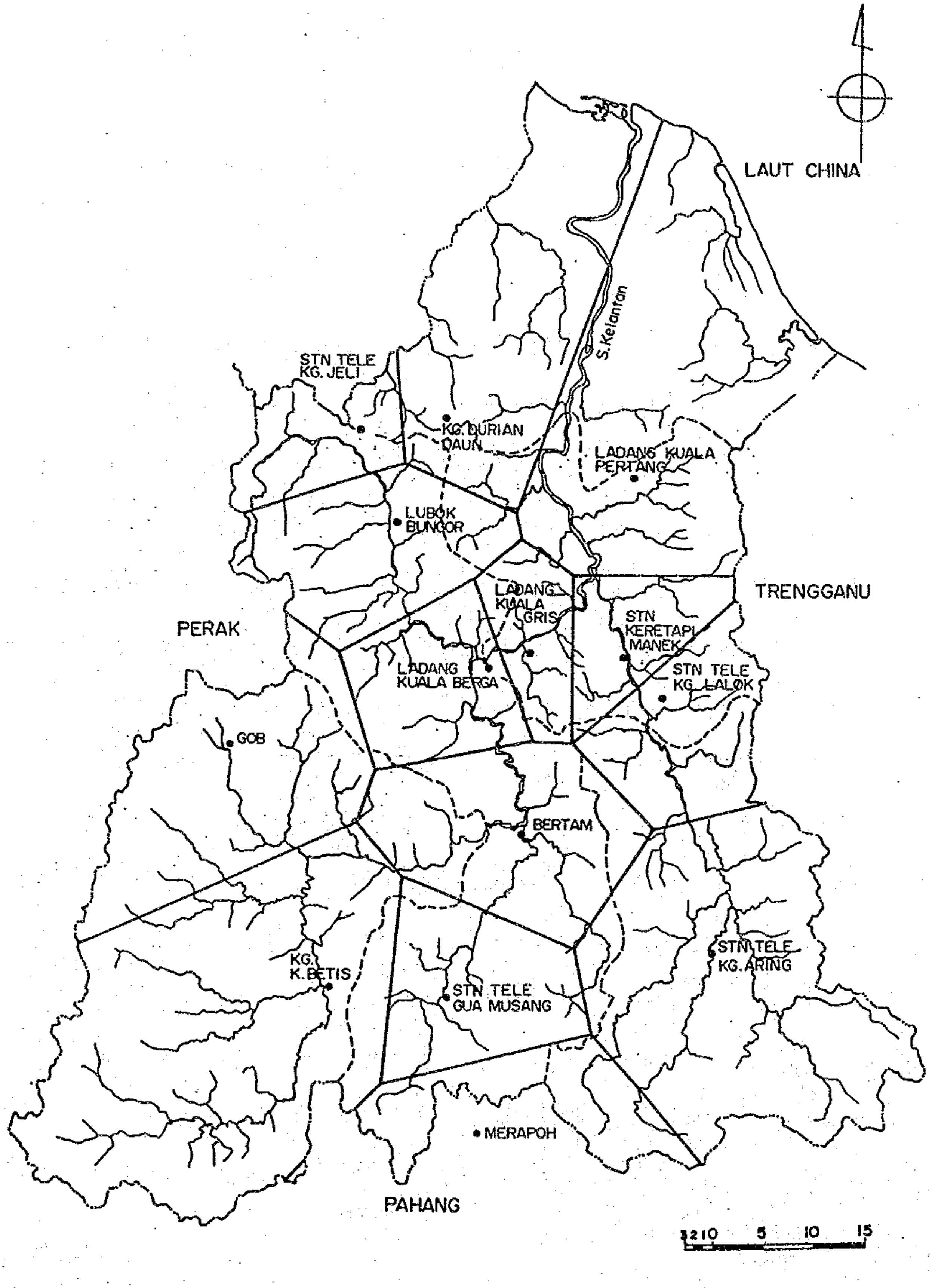


Fig. 5-5 Diagram of Area Division in Thiessen Method

Fig. 5-6 Simulation of Flood on December, 1983

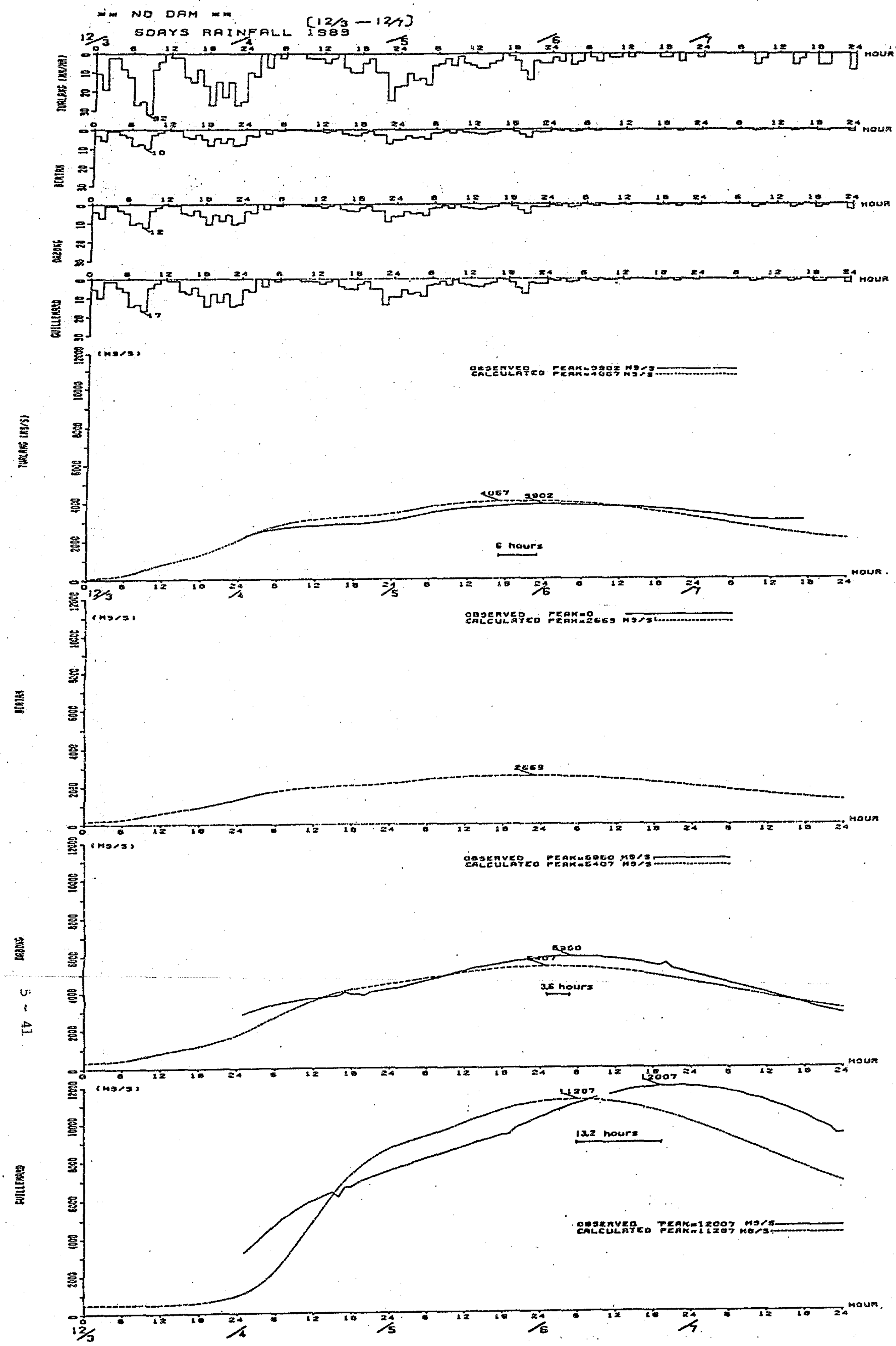
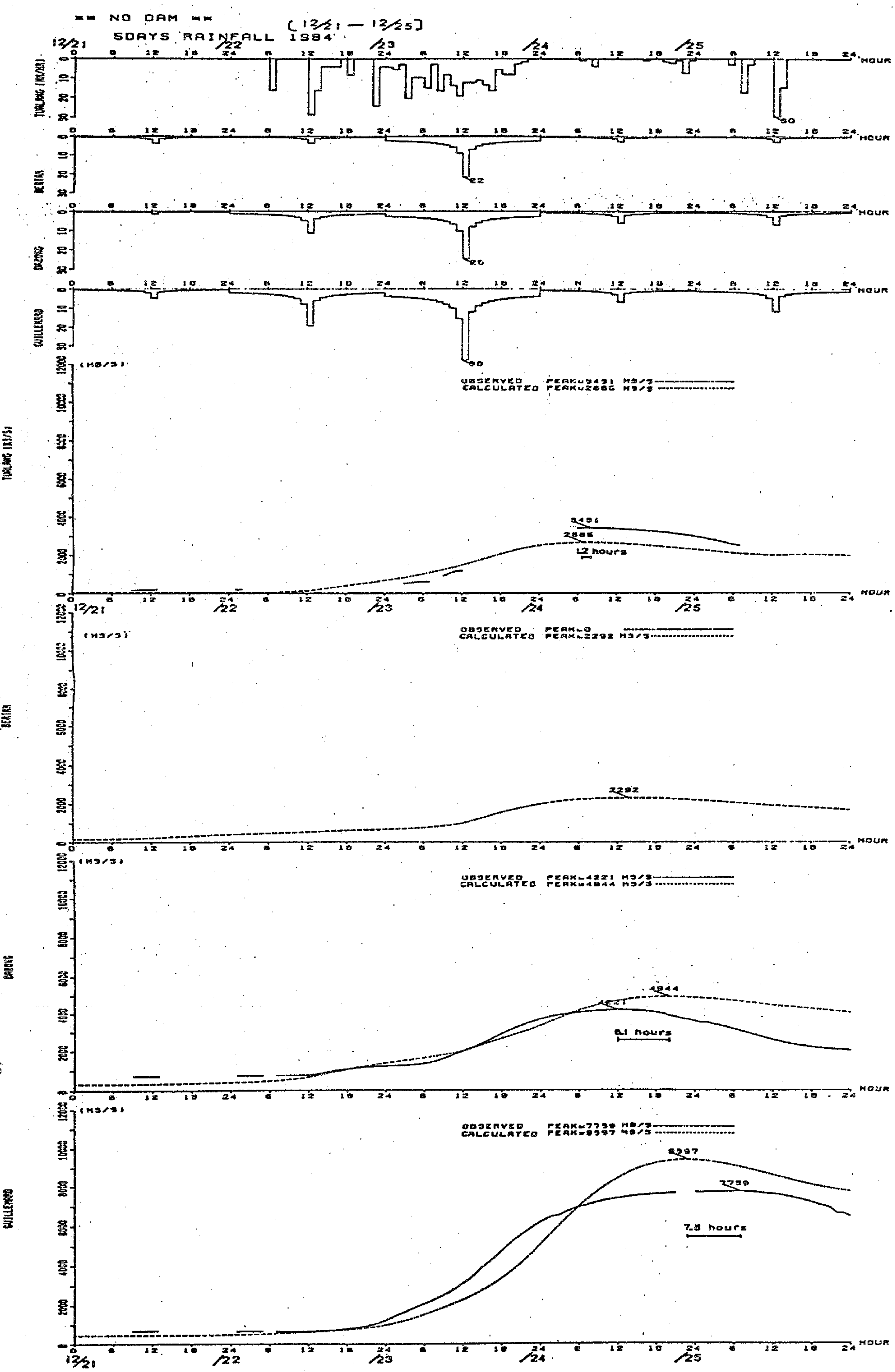


Fig. 5-7 Simulation of Flood on December, 1984



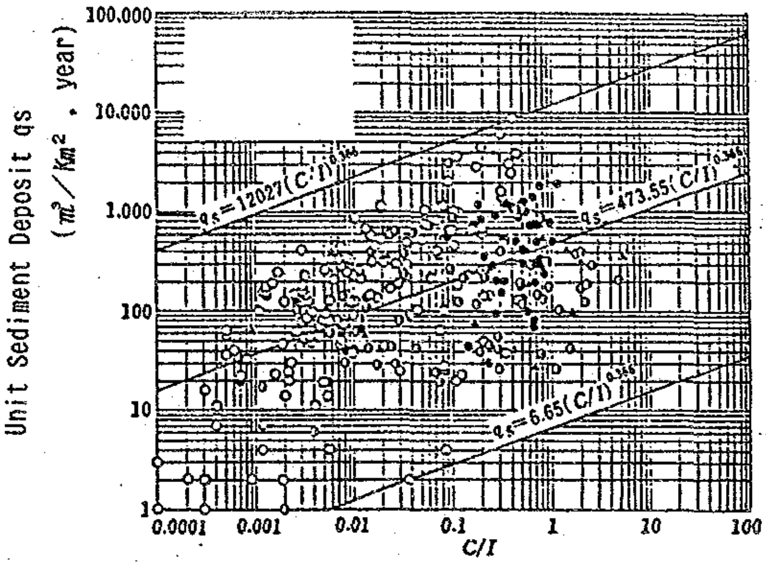


Fig.5-8 Relation between C/I and qs

6. Power Planning

(Refer to Volume 1)

7. Flood Control

(Refer to Volume 1)

8. Agricultural Irrigation

(Refer to Volume 1)

9. Feasibility Grade Design of Structures

(Refer to Volume 1)

10. Electrical Equipment

(Refer to Volume 1)

11. Environmental Problems

11. Environmental Problems

11.1. General

The objective of this project is to construct a hydroelectric power station with a reservoir high water level ranging from EL. 70 m to EL. 90 m. By the implementation of the project, the reservoir surface will cover a maximum area of approx. 23,000 ha, and the reservoir is anticipated to have considerable impact on the natural and a socio-economic environment.

This area has a rich natural environment owing to human activity which has been carried out since ancient times. This area is not of a primitive nature, but is inhabited by various kinds of wild animals, since Taman Negara National Park is located at the southern end of the area.

The inhabitants consist of settlers who transmigrated into this area a long time ago, and therefore small riverine villages can be observed along the Lebir River. In addition to these people, since land settlement schemes operated by KESEDAR, FELDA, FELCRA, etc. have been developing, transmigrations into these land schemes have already taken place. The forest in this area has been logged continuously for over 30 years and is a significant forest resource in Kelantan. Furthermore, four parties of Orang Asli who are inhabiting the two Orang Asli reservations developed by JOA (Jabatan Orang Asli) and two other locations, are within the area.

In Malaysia, the "Environmental Quality Act" was enforced in 1974, and since then, various regulations against the environmental impact of industrial development have been established. This Act was once amended in 1987 and its requirements became compulsory for large scale development projects. Prior to the amendment of the Act and related regulations, in consideration of the significant losses and damage to the surrounding environment which are caused by hydroelectric power station construction, NEB has been preparing Environmental Impact Statements (EIS) for various projects, which were the subject of discussion with government authorities concerned.

The following study teams were appointed by NEB to prepare an EIS for the Lebir Dam Project, and these teams have carried out the following:

(1) USM (Universiti Sains Malaysia) carried out ecological and socioeconomic baseline studies including terrestrial, aquatic and archaeological surveys.

    As a result, USM prepared the "Final Report - Ecological/ Socioeconomic Baseline Studies on The Proposed Lebir Dam Project" (hereinafter referred to as "USM Sub-study Report") in December, 1987.

(2) GSD (Geological Survey Department) carried out the mineral potential study and prepared a report, "A Preliminary Assessment on the Mineral Potential in the Area of the Proposed Lebir Hydroelectric Dam Reservoir, Kelantan" (hereinafter referred to as "GSD Mineral Potential Report") in November, 1987.

(3) IMR (Institute for Medical Research) was appointed to study the medico-ecology, and the field surveys were carried out, but the report is not yet available as of January 1989, though a briefing on the interim results was made to JICA Study Team in March, 1988. The interim results obtained are as shown in Appendix Attachment 11-0-2.

(4) Based on the results obtained from the above-mentioned baseline studies, JICA Study Team presented in EIS, "Environmental Impact Statement on Lebir Dam Project,

Malaysia" (hereinafter referred to as "JICA EIS") in February, 1988 in a separate volume.

Sections 11.1. to 10. in this report are a summary of JICA EIS, and Sections 11.11. to 12. state the prospects of the development of aquaculture industries and the impact of water level fluctuation in the downstream area respectively. In Sections 11.13. to 14. JICA Study Team outlines the study results regarding the costs of resettlement and compensation, and the costs of environmental measures.

11.2. Water Environment

The Lebir River is a major tributary of the Kelantan River System with its origin in the Taman Negara National Park at the southern end of Kelantan.

The river flows to the north through the hilly area to Kuala Kerai, then joins the Galas River. Below the confluence it is called the Kelantan River.

Water quality in the upstream of the Lebir River shows undeveloped characteristics of a tropical river with little artificial effects. But, the increased electrical conductivity of water (EC) observed along the Lebir River just after the confluence of the Aring River shows the characteristics of artificial development. As the flow of the river downstream is slower with little turbulence, a high density of organic burdens and pollutions can be observed. It is also considered that the high level of organic burdens and pollution may be due in the main to the extensive agricultural schemes now under development in the upstream basin, as shown by the water quality data for Aring River.

The Kelantan River system is very rich in freshwater fishes and water related industries. Many rivers within the Kelantan River system are well known for their game fish especially Tor tambroides (Ikan Kelah) and Scleropages formosus (Ikan Kelisa).

Fisheries within the Lebir River basin involve many people in various ways including the foodstuffs of riverine inhabitants. Most of the fishermen use small artificial gear and they operate independently of major landings. Further, the majority of the fishermen fish for their own consumption, but they do market the more expensive components of their catch. The existing fisheries within the Lebir River consist mainly of small scale fisheries. The majority are part-time fishermen who catch fish for their own consumption and there is only a small group of fishermen who actively participate in fisheries on a full time basis. The problems that have recently hit the area arise from the use of specific insecticides which have been used by a limited number of fishermen, and not through the use of gear such as cast nets, etc. which have traditionally been used by the majority of fishermen.

The fish species of the Lebir River are of various kinds and are very similar to those in other large rivers within the Malay Peninsula. In the upstream area, a great abundance of fish were found by means of experimental fishing, and many interesting specimens of large riverine carp such as Scleropages formosus (Ikan Kelisa), Tor tambroides (Ikan Kelah), Tor duronensis (Ikan Kelah Puteh), P. daruphani (Ikan Kerai), P. bulu (Ikan Tenggalan) and A. hexagonolepis were observed.

In the middle and downstream area, the result of an experimental catch was very poor because of the high sediment load in the river.

Impoundment results in aquatic changes and transforms the existing natural riverine ecosystem into a new man-made lacustrine ecosystem. These changes are brought about over a period of time, and the transformation results in drastic changes to the aquatic ecosystem.

Changes in water quality in the proposed reservoir formed by the impoundment depend on how the inundated pondage would remain. In this study, it is tentatively conceived that they will clear only the valuable timber within the proposed reservoir area prior to impoundment.

As the water rises after commencement of impounding, large quantities of nutrients will be released into the river from both soil and vegetation. It is anticipated that the submerged vegetation, depending on the quantities left behind, will reduce the dissolved oxygen caused by the release of nutritious and organic matter, and this will lead to extremely high-levels of BOD and COD. The excessive release of nutritious and organic matter will lead to eutrophication of the impoundment and the associated deterioration of water quality.

The level and amount of such anoxic water will gradually develop following the impounding. The existence of anoxic water in the bottom layer will promote the development of anaerobic bacteria which readily convert sulphates to sulphides and ferric to ferrous ions for their energy requirements leading to extensive liberation of hydrogen sulphide. Hydrogen sulphide is very toxic to fish and other aquatic life, and will seriously affect the production of fish within the new impoundment. Furthermore, the inundated terrestrial vegetation will result in substantial amounts of leaching of phenols from dead trees. These phenols and other breakdown products of the decaying vegetation will lead to a significant deterioration of the water quality with respect to colour, taste and odour.

Also, as large scale land schemes are developed in the proposed impoundment area and its surroundings, considerable organic matter will flow into the reservoir, such as fertilizers, etc. which are used in the land schemes (among those that remain after impoundment), and will accelerate the above-mentioned deterioration of the overall water quality.

The de-oxygenated layer of water within the reservoir will not be able to support aquatic life, and with the wind blowing into the reservoir, the de-oxygenated layer will be concentrated at the windward end of the reservoir. In the event this effect is remarkably large, a de-oxygenated layer will be created on the surface of the reservoir to quite a large extent.

With the drastic change in the water quality, only those fish species which can adapt to the new lacustrine environment will be able to survive. It is considered that 60% to 70% of the existing fish species found in the Lebir River would be able to adapt to the new environment. Soon after impoundment, productivity and production of fish will increase. In considering the production of fish, the carnivorous fish population will become dominant. Dominant carnivorous fish species will include Channa micropeltes (Ikan Toman) or Mystus nemurus (Ikan Baung). Although the ability of new fish species to adapt to the new environment will depend on the ecosystem of the new reservoir, the new lacustrine environment will provide a suitable fishery for a water related industry. However, as the construction of a dam creates a new artificial obstacle in the path of a river, the obstruction will affect fishes and other riverine fauna of the migratory kind, such as M. rosenbergii. The migration of Udang Galah (M. rosenbergii) for breeding purposes would be affected.

Man-made lakes in the tropics are prone to the growth and spread of aquatic weeds which cause many problems in the management of water resources. Although there are no aquatic macrophytes within the Lebir River system, these aquatic macrophytes can easily establish themselves within tropical reservoirs. The problem gradually worsens with increasing enrichment of the reservoirs.

The downstream impact of changes in the water quality are limited to the area near the proposed dam site, but this also depends on its scale of changes. The impact will decrease if the river flow is gradually increased after the confluence of tributaries downstream. It is considered that the temporary drying up of the river downstream will have a large impact, since continuous discharge of water will not be made. In addition, the impact of sedimentation downstream is also anticipated.

The large number of trees left behind in the inundated area is also a major factor regarding the impact on the water environment. The following measures are required to cope with such environmental impact:

(1) Trees in the proposed inundation area should be logged and cleared prior to impounding to prevent eutrophication of the reservoir. However as a rule, the cleared trees should also be removed outside the reservoir area.

(2) It is advisable to stop land development temporarily and to carry out continuous limnological monitoring of the water quality, ecosystem, etc. Based on the results of limnological monitoring, a land development plan should be established.

(3) For the prevention of the impact of sedimentation on the river basin, re-forestation is recommended to guard against erosion.

(4) The results from the above item (2) will be used for the ichthyological study, and this will be the basis of assessing the economic feasibility of employing the water surface. The new lacustrine environment has the possibility of being a fishery, and in addition to the above item (2), it is required to establish fishery plans, including plans for recreational utilization.

(5) In order to cope with the decrease of water volume downstream, a re-regulating pondage should be designed to be constructed downstream of the dam.

(6) A warning system should be installed to let the downstream inhabitants know when flood discharge from the dam or powerhouse is to be made, since a sudden increase in water flow will occur.

(7) In order to maintain free communication of the riverine ecosystem, a fish ladder should be provided to permit the migration of fish such as Udang Galah.

11.3. Fauna

Most of the wildlife in Malaysia is protected by the Wildlife Laws of Malaysia. Within the project area concerned, a large amount of wildlife has been identified, and the present status was investigated in order to establish the impact on such wildlife which the construction of a dam will have.

Small mammals such as the Stump-tailed Macaque (Macaca arctoides), which are quite rare in Northern Malaysia, were observed in the Lebir area.

Many totally protected and endangered large mammals such as the Red Dog, Panther, Tiger, Banteng, Elephant, Tapir, Primates, Giant Squirrels, etc. were also within the area of the proposed project site.

Concerning the bird survey, the Hornbill, Argus pheasant, etc. which are of great interest were also observed.

The following eight mammals are protected and endangered:

(1) Macaca arctoides (Stump-tailed Macaque)
(2) Tapiros indicus (Malayan Tapir)
(3) Panthera tigris (Malayan Tiger)
(4) Dicerorhinoceros sumatrana (Sumatran Rhinoceros)
(5) Elephas maximus (Elephant)
(6) Panthera pardes (Black Panther)
(7) Cuon alpinus (Red Dog/Dhole)
(8) Bos javanicus (Banteng/Wild Cattle)

and the following three bird species are protected and endangered.

(1) Pheasants
(2) Hornbills
(3) Birds of prey

Approximately 15,400 ha. will be inundated following the construction of the dam with the spillway crest elevation of 80 m. The following impact is considered to affect wildlife inhabiting the proposed inundation area;

(1) All wildlife (excluding migrants) resident in various parts of the impoundment area, without the power of rapid flight or speed will drown in the rising water.

(2) Large ground birds, e.g. Argus pheasant and other pheasants will generally be trapped in the water. Some may be able to escape to higher ground.

(3) All small mammals, except those resident on "Island Areas" will drown.

(4) Depending on the speed of impounding, and the location of the animal at the time of flooding, even large herbivores will drown.

(5) Herbivores that may be marooned on an island are Elephants, Sambhur, Barking Deer and perhaps the Banteng, and Rhino.

(6) Carnivores (e.g. Tiger, Panther, Red Dog) have a greater chance of escape from the impoundment, to the "island" and catchment areas. If trapped on islands, they should be rescued.

(7) Most of the islands will not be large enough to support a breeding population of herbivores and some carnivores. The herbivores would eventually overeat their food supplies and starve.

Since the areas to be impounded and "islands" created by the impoundment have important protected/endangered species of wildlife, the obvious measure to take is to avoid building the dam. However, since the Lebir Dam Project has a considerable number of economic and social benefits, the following mitigating measures are recommended if the project is implemented;

Two methods may be envisaged: clear felling and translocation.

(1) The first method is to clear and log the forest within the proposed reservoir prior to the impoundment. Since all the forests in the impoundment area have been badly logged, these forests can be clear-felled, i.e. clear the whole forest or whatever is left of it. This will totally disrupt the habitats of the wildlife resident there. The wildlife that manages to survive the clear-felling especially the big game (Tigers, Panthers, Deer, Wild Cattle, Elephants, etc.) will be forced onto higher ground above the level of the dam. This method which may help in the movement of big game, can be quite destructive to all other less mobile communities of animals and plants.

(2) The second method is the compulsory translocation of animals. This method was employed by Jabatan Perhilitan when elephants "marooned" on "islands" in the Kenyir Dam were rescued, with the assistance of the Army. Translocation of wildlife, can basically be done before the impoundment takes place. This needs a great deal of organization and effort, and to prevent the animals from returning to the previous home ranges, sites of release should be deep in the catchment area. Of course, there are practical difficulties, but these are in noway insurmountable. The time lag between translocation and flooding should be brief, so that if the animals manage to return, they will be unable to reach their previous home ranges.

Eleven types of animals should be considered as a target to be rescued e.g. Elephant, Panther, Tiger, Banteng, Sambur, Barking Deer, Red Dog, Mabled Cat, Agile Gibbon and Teh Tapir. One large mammal that is endangered and present in the catchment area, (not recorded in the Aring transect) and which could most probably, be present on "Aring-Lebir island", is the Sumatran Rhinoceros. This animal should be included in the translocation list, to make it up to 11 species.

The total cost for the translocation of the estimated 99 animals, including the Sumatoran Rhinos, is estimated to be M$ 1.52 million as reported in the USM Sub-study Report (Page 83).

However, a suitable habitat after translocation should be selected for the rescued and escaped animals, because translocated animals sometimes can not adapt to a new environment. Therefore, a preliminary survey of the proposed location of new habitats should be made prior to the implementation of translocation plans. Based on the result, the conclusion for the protection of animals should be made.

11.4. Flora

A field survey was carried out in two zones, namely Plot-1 and Plot-2.

There was a total of 452 samples in Plot-1, comprising 122 plant species from 79 Genera and 35 Families. In Plot-2, only 311 specimens were recorded and these were made up of 95 species, 65 Genera and 27 Families. When the two plots were combined, 185 species were recorded consisting of 102 Genera and 40 Families.

The study area has been the major logging area in Kelantan for more than 30 years. Most timber of high commercial value has already been logged, leaving behind mostly the non-commercial species. However, our survey indicated that in the two sampling areas, very few sizeable commercial value plants were growing there. It can be said that the Lebir area has potential timber resources. Several plants within the two plots were identified and known to be of traditional medical value. Rafflesia arnoldii, a parasitic plant which bears the largest flower in the world was also found on the jungle floor in the vicinity of the study area.

In this field survey, 38 unidentified species were observed and a high possibility of discovery of new species exists. The standing biomasses for Plot-1 and Plot-2 were calculated to be 439.67 tonnes/ha and 359.39 tonnes/ha respectively. The average of the two plots was 399.53 tonnes/ha and this is said to be an average value within tropical forests.

The proposed area consists of a tropical rain forest which has an affluent characteristic. Due to the impoundment the flora growing there will be submerged. The area to be affected corresponds to the reservoir area. However from the global point of view, the very large scale of plantation lands now developing in the proposed submerged area, will suffer an environmental impact corresponding to the forest zone, excluding plantation lands and water surface. The total area affected will be as follows:

1) HWL at 70 m — 3,428 ha which corresponds to 1.4 % of the catchment area.

2) HWL at 90 m — 8,321 ha which corresponds to 3.4 % of the catchment area.

The impact on flora is an unavoidable factor of the implementation of this type of dam project. The following measures may be considered to preserve the existing flora:

(1) Preservation of species by carrying out a scientific detailed survey

Flora in the proposed project area is composed of various species of plants as specified in the field survey. (Details are reported in the JICA EIS.) It is possible that discovery of more unidentified species will be made by a further detailed survey. Therefore, from the botanical point of view, it is necessary to carry out a scientific survey prior to any impoundment.

(2) Protection of shoreline erosion

There are very many impacts arising out of the creation of a large reservoir. One of the main factors is nutritive salt and sediment inflows through the catchment area. Unstable inflows of these sediments will cause delay in the stabilization of the ecological environment of the reservoir, and will shorten the life span of the dam by sedimentation. To cope with the above impact, flora around the reservoir should be preserved and the shoreline should be protected from further erosion.

11.5. Agro-Forestry Resource

Within that part of the Lebir River basin related to the proposed dam scheme, forestry has been conducted for over 30 years, and recently agricultural farms have been developed to a great extent, especially for the plantation of oil palm and rubber, due to participation by the land development agencies comprising KESEDAR, FELDA and FELCRA.

Thirty different kinds of soils have been identified in the KESEDAR region. Despite the fact that the impoundment area is generally hilly, the soils which have developed are deep, suggesting that they are essentially old soils which have been little eroded as a result of the excellent ground cover provided by rain forest, and the consequent relatively long periods to mature.

Land use adopted at present can be broadly categorized into four main types viz.:

1. Plantation agriculture
2. Smallholdings
3. Mixed horticulture
4. Forestry

Plantation agriculture is perhaps the most dominant practice in the region and certainly is the most extensive in terms of area. In general, it was observed that oil palm was the main crop planted on level to slightly hilly lands (slope of 12°), while the very hilly areas (12-25° slope) are utilized mainly for rubber, fruit trees and banana cultivation.

Smallholdings are composed of scattered parcels of both legally owned as well as illegally operated holdings. Productivity in these holdings is considered to attain only low yields.

Mixed horticulture is widespread among both land schemes as well as riverine settlers who usually cultivate land around their dwellings with a variety of fruit trees such as durian, cempedak, rambutan, etc.

Forests constitute the remaining areas apart from land schemes and private holdings. The timber industry has contributed to the economy of Kelantan State for more than 30 years. In the case of the Relai and Lebir forest reserves, premium grade timbers have almost all been logged. Kelantan State has been endowed with vast timber resources which have enabled it to become a major supplier of logs to other States for quite sometime. Therefore, it is said that forestry is the dominant industry in Kelantan State.

Logging activities are not concentrated in any single area alone, but rather all over concession areas. Even areas as far south as the border of Taman Negara in the Bukit Batu forest reserve are also being logged. It was observed that logging has been actively pursued along the east banks of the Lebir River all the way to the border of Terengganu.

Information obtained from the State Forestry Department indicates that the Ralai and Lebir forest reserves comprise a total of 102,228 ha out of a grand total of 217,435 ha of forest reserve in Kelantan State (JPNK, 1985). Thus, both these reserves contribute about half of the total forest reserve, hence signifying the importance of the logging industry to the State. Of this total, only about 78,000 ha are considered productive, while the remaining is basically unproductive upland forest (JPNK, 1985). The volume of timber removed has increased from 57,000 m^3 (40,000 tonnes) in 1960 to 307,000 m^3 (215,500 tonnes) in 1971. This exploitation rate has seen steady increases since 1971 as is evident from the data of 1982, whereby 1.1 million m^3 were harvested.

The economic contribution of timber is extremely large, because the data supplied by the State Forestry Department (JPNK, 1985) indicates that a total of 1,432,064 m^3 (about 1,002,400 tonnes) of heavy, medium and light woods were produced by the whole Kelantan State, and the income from timber resources reached over 25 million M$ in 1985. A total of about 9,000 people are engaged in forestry. Therefore, it can be said that forestry has not only made a contribution to productivity, but also contributes to a dynamic economic environment.

The following area of plantation and forest will be inundated by the implementation of this project scheme.

HWL	at 70 m	:	5,472 ha of plantation
			3,428 ha of forest
HWL	at 90 m	:	16,379 ha of plantation
			8,321 ha of forest

The above figures regarding plantations do not include figures on riverine villages (1,669 acres), but do include the losses of the land development area. In addition, 55 acres cultivated by Orang Asli should be considered. Among those developed areas, Lebir -1, 2, 3 and Paloh -3, 4 of KESEDAR and Aring -2, 3, 4, 5, 6 and Aring Timur -1, 2, 3, 4, 5, 6 of FELDA are included.

With a HWL at 70 m, 3,839 ha of KESEDAR plantation and 1,240 ha of FELDA plantation are included out of 5,079 ha respectively. Whereas for a HWL at 90 m, it will be 8,185 ha for KESEDAR and 6,885 ha for FELDA. Inundation areas of FELCRA and ADB Project plantations are 129 ha and 1,180 ha respectively in the case of HWL at 90 m.

The figures on the forest resources include unlogged forest in addition to the logged forest located on both banks of the Lebir River. In the case of HWL of 70 m, 1,599 ha of the logged forest and 1,829 ha of the unlogged forest are included out of 3,428 ha respectively. Whereas for HWL of 90 m, it will be 3,725 ha for the logged forest and 4,596 ha for the unlogged forest.

Since these industries are the main basis of livelihood in the region, many people will be affected by the implementation of the scheme.

Another problem for agriculture will be the measures to be taken for the plantations that remain around the new reservoir. As mentioned before, large quantities of nutrients will be drained naturally into the reservoir as a result of the plantations that remain around the reservoir. Therefore, as stated in Section 11.2., limnological monitoring of water quality should be carried out and careful attention is required for the usage of fertilizers and agricultural chemicals.

Access to the unlogged forest that remains around the catchment area will be another problem for forestry. From the view point of reservoir preservation and protection against erosion, due consideration should be given to keeping the forest as it is, i.e. as a forest reserve. It will be a desirable habitat for animals that inhabit the proposed reservoir area or animals to be relocated as a result of the impoundment.

11.6. Socio-economy

The settlements in the vicinity of the study area are classified into three types:

(1) The riverine settlements found along the Lebir River from Kampung Jeram Panjang near the dam site to Kampung Kuala Aring upstream. These consist of about 20 villages that were identified. These villagers are hereinafter referred to as "riverine settlers".

(2) The government land settlement schemes, that will be inundated by the impoundment, consist of only three KESEDAR schemes at present among those developed, and under such development that accept settlers.

(3) The Orang Asli settlements located in the same vicinity as above.

(1) Riverine Settlers

Of the total of 481 persons which included the 94 heads of household, almost half (205 or 42.6 percent) were absentee members who were not living with their heads of household during the survey. The other 276 (57.4 percent) people were living with their heads of household. The average household size of the riverine settlers was 3 persons when those not living within the study area were not included. However, when they were taken into consideration, the average household size was found to be 5 persons per household. Among those who were living within the riverine villages, 163 (59.1 percent) were male whilst 113 (40.9 percent) were female. Of the 205 household members who lived somewhere else, 85 (41.5 percent) of them were male whilst 120 (58.5 percent) were female. Apparently, those who lived outside the study area are mostly of schooling age and as a result they moved to where educational facilities were definitely better. About 100 persons among those who are living in the study area are involved in self-employment such as rubber tapping, mixed horticulture and animal husbandry, etc. Gainfully employed are 15 persons and self-employment/ gainfully employed are 50 persons.

The economic activities in this area identified during reconnaissance were roughly summarized as below:

(a) Agriculture : hill paddy, orchard, banana, corn, vegetables and rubber;

(b) Paid-Jobs : clearing and working for timber companies;

(c) Forest Produce : Rattan and medicinal herbs; and

(d) Sources outside the study area : contributions, and rental.

The average household income in this area was at $566.67 per month. The mode was $200.00, and the median, $376.67, lower than the mean (average) suggesting that a high percentage of the riverine settlers have a total household income less than average. The present inhabitants residing in the impoundment area have to be resettled to some other places, if a reservoir is to be created by implementing this dam project. Among the riverine settlers, it seemed that only 38.3% were willing to be relocated to another area. The remaining 59.6% affirmatively refused to move out.

(2) KESEDAR Settlers

Three RKT KESEDAR schemes would be affected by the Lebir Dam Project. These are the RKT KESEDAR Chalil (155 settlers), Paloh-3 (286 settlers) and Lebir-1 (135 settlers) with a total of 576 settlers. In terms of housing lots, the three KESEDAR schemes have 300, 398 and 198 lots, respectively. However, the number of housing units completely built by 1986 was 198, 320 and 157 houses, respectively indicating that all the RKT KESEDA schemes were not settled to their full capacity.

Out of 318 KESEDAR settlers' household members, 260 lived in the area of the schemes, whereas there were 58 absentee members. Among those living within the schemes, 52.3% were male and 47.7% were female. For those who lived outside of the schemes, 46.6% were male and 53.4% were female. And among those who live within the schemes, 36 were self-employed, 2 were gainfully employed and 38 were self and gainfully employed. Among KESEDAR settlers, the most significant activity was maintenance work in the agricultural plots within the schemes, and there were 14 (28%) settlers who derived more than 80% of their income from KESEDAR. The second most important activity was paid-jobs (gainful employment). From this source of income, 39 settlers acquired side income to supplement their monthly subsistence. According to KESEDAR, for 1986, the average household income among KESEDAR settlers interviewed was M$246.85 for Paloh-3, M$290.52 for Lebir-1, and M$232.62 for Chalil. This gave a rough average monthly income of about M$252.97 in 1986. In the study conducted by USM in 1987, their average monthly income was of M$317.69.

Chilil and Paloh-3 seemed to be planted dominantly with oil palm, whilst Lebir-1 consisted mainly of rubber. Besides, Lebir-1 was characterized by orchards which occupied a large number of plots of Lebir-1 compared to those of the other schemes.

The implementation of the Lebir Dam Project will necessitate the relocation of KESEDAR settlers as well as the riverine settlers. From the 50 settlers interviewed, only 16% expressed their willingness to be relocated. Those of the unwilling group accordingly accounted for 84%.

(3) Orang Asli

The orang Asli found within the study area are Bateq Negritos.

They may be further classified into dialect groups. Most of them belong to the Bateq De' dialect groups with a few Bateq Teh, Bateq Te' and Mendriq. The Bateq has been described as nomadic hunting and gathering people who subsist mainly on wild tubers, fruits, and small game which they hunt with blowpipes and poisoned darts. They are therefore dependent on the forest for their livelihood. The opening up of forests with logging, and later for government land settlement schemes, threaten their way of life and their very existence. According to JOA Kuala Kerai, there are six penghulus in the three settlement areas, and JOA estimates that the total number of settlers has reached 144 persons at present.

Sungai Linggi settlement was opened in 1969. This is one of the Orang Asli settlement areas developed by JOA to provide a permanent living area for the Orang Asli. The JOA has built a school, a clinic, a madrasah and living quarters for its staff and houses for the Orang Asli. Rubber trees were planted on a plot of 55 acres to provide an alternative source of income in order to encourage the Orang Asli to stay in the area so that they no longer have to be constantly on the move hunting and gathering food or in search of forest products to sell.

Kampung Sedahan is a very recent settlement area. It was chosen and cleared by the Orang Asli who had moved from Kampung Kemara. The settlement is located by a small tributary of the Lebir River covering an area of less than 3 acres. There are 15 houses built closely together in the area.

The houses are more like small huts, but looked more permanent than their traditional "henyak" or temporary wind shelters. Corn, tapioca and a few varieties of vegetables were planted.

The Orang Asli society, like any other traditional ones, must be viewed as a society in transition. Drastic social, cultural and economic changes are taking place within the society. Reactions and willingness to accept changes, however, vary among the individuals. The Bateq Negritos found within the study area are becoming less dependent on the forest to provide food. However, the forest is still important to the Bateq Negritos as a source of income. Although they now have to walk a longer distance deep into the forest, almost to the border to Terengganu, to find them. 'Kayu geharu' is very rare, but fetches a very high price.

(4) Socio-economic impacts

As stated in the Section on Agro-Forestry Resource, the large extent of industrial lands and related facilities forming the basis of the socio-economy in this area will be inundated by the implementation of the Lebir Dam Project Scheme. The following are the statements on the environmental impact excluding Agro-Forestry Resource, which was discussed in the previous Section.

Inhabitants to be affected by the impoundment include approximately 500 members of 100 households of riverine villagers, 3,660 members of 567 households of land development scheme's settlers, and 144 members of the Orang Asli. Among these, it is anticipated that a number of settlers of the land development scheme will increase further in the future if the development is continuously carried out. Eventually, assuming a number of settlers planned by KESEDAR and FELDA from the present plantation area, it will reach 3,840 households in total (see Table 11-4). About 23,040 settlers, a figure which was computed from the average members per household at present, are possibly expected to settle into this area to the maximum extent in the future.

On the other hand, there are public facilities for the people settled in the land development area, that is three mosques, schools and community halls which are regarded to be affected by the impoundment and subject to compensation. Furthermore, a lot of sub-structural facilities such as roads, bridges, etc. for the Kuala Kerai - Gua Musang Highway (5 km), access roads within the plantation areas of

FELDA and KESEDAR, and logging roads for forestry are also affected by the impoundment. These sub-structural facilities are also subject to compensation.

Compensation costs for these facilities are stated in Section 11.13.

Orang Asli and their proposed relocation area are one of the main problems of the socio-economic impact for the Lebir Dam Project. Since their living will be affected by this kind of development, being still based on the forest, it is required to provide their settlement reserves nearby the reservoir and places with an easy access to the forest, so that a new settlement reserve does not affect their traditional way of life. Furthermore, since the new potential resettlement area to be developed by KESEDAR is assumed to be ensured, it is considered that a study on the new land development scheme should be carried out in a practical way to coordinate this with the resettlement.

11.7. Archaeological Observations

Since this area has been developed by FELDA and KESEDAR, no archaeological remains are expected.

The Orang Asli found in the area are the Bateq-Negritos, the nomadic hunting and gathering tribes. Since they move a lot, they are not known to possess any antiquities of any archaeological significance.

References on places of historical interest in Kelantan State indicate that places of archaeological value do not exist within the catchment area of Lebir River.

11.8. Tourism Potential

Kelantan State is located at the north-east part of the Malay Peninsula and is supported mainly by the Agro-Forest industry.

According to the report prepared by TDC (Tourist Development Corporation), the number of tourists reached 224,816 domestic and 29,240 foreign in 1986, and that the average stay of these tourists was 1.6 days for domestic and 1.7 days for foreign tourists respectively.

Access to Taman Negara as a tourism resource is now only available from the Pahang side, but according to TDC, the approach from the Kelantan side is being considered as a conceptional basis under the cooperation of the Wildlife Department.

As facilities for tourists visiting Taman Negara from Pahang side, some observation and fishing lodges for visitors, which is a key station for anglers, have been provided nearby Kuantan and along a tributary of the Tembeling River respectively. An approach to the G. Tahan is available passing through these facilities, and there are narrow paths for jungle trekking along the Tahang and Trengan Rivers.

Although the Lebir Dam Project will have considerable environmental impact on nature and many of the settlement areas within the proposed submerged area, it will create alternative tourism resources, such as water sports facilities, fishing, chalets, picnic areas, etc. so that tourists will make it an important stop-over and/or a convenient linkage for travellers wishing to explore Taman Negara. Hopefully, since this project area is quite ideally located close to the Kuala Kerai - Gua Musang Highway, easy access to the reservoir is expected. Therefore, an approach from the west side, Kuala Kerai - Gua Musang Highway will form a basic concept for tourism development from the Kelantan side.

Establishment of the dam with basic amenities indicated earlier would thus be a strong attraction for travellers to visit the dam and enjoy water related activities, or indulge in the scenic beauty of the forest and the lakeshore, and for those more adventurous, a hike into Taman Negara may be quite fulfilling. To achieve the above purposes, proper monitoring and control should be taken to protect the scenery and water quality of the lake.

Further, the lake created by impoundment will be a convenient linkage for travellers wishing to explore Taman Negara through the Ulu Kelantan trail. This particular route has not established itself as a gateway into the national park because of the difficulty of access. Thus, tourists find it more convenient to travel via Pahang. However, the improvident expansion of facilities should not be taken into consideration. Since Taman Negara is an important reserve where animals can inhabit the area without any danger from the human activities, it will be important to limit the number of tourists and control their movement, to ensure that the beauty of the area and the habitats of the animals are not damaged.

As discussed in the above, the possibility of the dam becoming a local point of interest for tourists by the implementation of this project is very large and extensive. However, an ecosystem in Taman Negara is recommended to be investigated prior to the implementation of the project.

11.9. Mineral Resources

The assessment of the mineral potential of the area for the proposed Lebir Dam Reservoir was carried out mainly based on the presently available geological, geochemical and airborne geophysical data.

The geological features of this area are, that tuffaceous and granite zones are observed along the Lebir River and on the east side respectively, and andesite, argillite and limestone layers can be seen on the western part along the Lebir River. The Lebir fault zone is aligned along the east riverine along the Lebir River stream.

From the geological, geochemical and airborne geophysical investigation, 15 distinct geochemical anomalies were delineated. Two of these are rated at Priority 1, three at Priority 2, two others at Priority 3, and the others at lower ratings. Immediate follow-up investigations for base metals for the two Priority 1 anomalies are recommended, since no mining would be possible after impoundment. A reconnaissance survey, especially for gold, covering the southern part of this area is also recommended, as geologically and structurally the area appears to have good prospects for gold mineralization.

11.10. Impact During Construction

It is anticipated that during construction considerable impact will be felt arising from the dam construction, quarry site working, and the people who engage in the construction work.

Although construction of the dam project interferes with nature and the same measures should be taken basically as mentioned in the previous Section, it is felt that no important and protected animals actually inhabit the area around the proposed dam and quarry sites. However, an alligator, about 1.5 m in length was identified nearby the dam site during the field investigation.

The location of the base camp during construction is not classified at present. However, since this project area is close to Kuala Kerai, one of the largest towns in the region and the small village of Kg. Lalok located at the entrance of the logging road on the east side of Lebir River, no major impact regarding the workers' living quarters is anticipated. In the base camp, sewage will increase in accordance with the increase of service water and foodstuff. Furthermore, in the tropical climate, an increase of disease is anticipated in compliance with studies on sanitation and the environment.

The required measures against such impact are to ensure service water, to install sewage treatment facilities including simple devices and to have periodical medical examinations for all personnel.

It is also considered important to maintain a sanitary environment for the working area for the prevention of disease.

It is anticipated that pollution of the river flow caused by the civil works during construction would affect fisheries and water use downstream.

The above pollution would be caused by turbid water produced by the construction activities and discharged into the river without treatment, and slope erosion resulting from excavation of roads and structures. Therefore, the following protection measures should be adopted during construction.

(1) Protection of the slope excavated (afforestation or shotcrete)
(2) Proper control of the spoil area
(3) Provision of a sedimentation basin for the sand crusher, if necessary.

11.11. Development of Aquaculture Industry

(1) Prospect on the promotion for aquaculture industry

Construction of Lebir Dam and creation of the large man-made lake offers prospects for the development of an aquaculture industry at the reservoir. In the course of this feasibility study, a special study in this field had not been made, but the latest information on development status at the Saguling reservoir (impoundment commenced on February 1985), West Java, Indonesia is presented as a reference for this project.

(2) In the case of the Saguling Project

According to the data obtained by JICA Study Team, the status as of June, 1988 is as follows:

- Saguling Reservoir

Purpose	:	Power generation only
Dam height	:	99 m
HWL	:	EL 643.0 m
LWL	:	EL 623.0 m
Effective water depth	:	20 m
Reservoir area	:	52 km^2
Total storage capacity	:	881 x $10^6 m^3$
Catchment area	:	2,283 km^2
Annual inflow	:	2.5 x $10^9 m^3$
Completion	:	February, 1985

- Present status of aquaculture industry

Method	:	Floating net unit
Size of unit	:	7 m wide x 7 m long x 2 m deep, or 9 m wide x 9 m long x 2.5 m deep
No. of operating units	:	1,400
Fish landing per unit	:	1,300 kg (Net volume of 3 to 3.5 months after deduction of 100 to 300 kg of fry.)
No. of operators	:	Approx. 400
No. of employees	:	Approx. 2,000
Breeding fish species	:	Ikan mas (carp)
Total fish landed per year	:	Approx. 6,000 tonnes
Annual sales	:	Approx. 6 x 10^6 US$

Aquaculture industry using the same type of floating net method is proposed to be developed at the Cirata reservoir completed in September, 1987 located some 40 km downstream of the Saguling dam, and several hundred units are scheduled to start operation by the end of 1988.

The aquaculture industry of Saguling and Cirata is forecast to grow to produce an annual sale of at least 10 to 20 x 10^6 US$ value in the future, since this area has much demand of fish.

Though over 10,000 households must have been relocated for both projects due to the inundation, development of the aquaculture industry contributes largely to the creation of new employment opportunities.

(3) Prospect on Lebir Dam

Since Lebir dam has a similar nature to Saguling in many ways, it is considered to have a large potential for the development of an aquaculture industry if persued seriously. The main points of its potential are as follows.

(a) Annual inflow of the Lebir is 3.5 x $10^9 m^3$ and 40% larger than Saguling.

(b) Water depth of the man-made lake is relatively shallow. (15 m is considered as a proper depth for the floating net method.)

(c) Agricultural plantations are developing and the infrastructure of agricultural management is well established.

(d) It is forecast to have a fish demand of 20,000 tonnes per year, considering a consumption of 20 kg/person/year, since the Kelantan State has a population over one million. Fish production in the Lebir reservoir can occupy a part of this fish demand.

(e) Since the highway network is being extended, a larger potential is expected by extension of the market to other States.

11.12. Impact of Fluctuation of Water Level in the Downstream Area due to the Dam

11.12.1. Estimates of Water Level Fluctuation due to Discharge for Generation

(1) Objective of this Study

The Lebir power plant is proposed to be constructed as a peak power station, operated only for limited hours each day (normally 3 to 6 hours). Large daily water level fluctuations will therefore occur in the downstream area. It is anticipated that the fluctuation will be largest close to the power station, and will diminish with increasing distance downstream.

In relation to this Project, the functioning of a water intake located approximately 90 km downstream of the power station and feeding four irrigation pumping stations at Kemubu, Lemal, Salor and Pasir Mas is of considerable importance.

The object of this Study is to clarify whether the downstream water level fluctuation cuased by the peak generation during the limited hours of each day will adversely affect the reliable delivery of water from the four irrigation pumping stations.

(2) Establishment of Study Cases

In case of the reservoir type peak power station, the plant is operated daily for only 3 to 6 hours but during this period the firm daily discharge (24 x 80 m^3/s) is released downstream. During these periods the rate of discharge can then be 8 to 4 times the firm discharge (80 m^3/s) respectively. As the firm discharge of 80 m^3/s is estimated to be available from the Lebir Dam, the rate of discharge for peak generation is in the range from 320 m^3/s to 640 m^3/s.

Should a smoothing out of downstream water level fluctuation be necessary to ensure reliable draw-off from the river at the irrigation intake, regulating pondage would be necessary at some location in the river between the power station and the intake. As part of the Lebir Dam Project, the necessity of providing such re-regulating storage must be carefully studied. As stated in the another Section, a proposed site for the re-regulating dam was selected at a location just downstream of Tualang Bridge. However, the storage which can be provided for regulation at this location is limited to approximately 1,000,000 m^3. This corresponds to only 0.4 hours reserved capacity in the case of the peak discharge of 640 m^3/s. Although this pondage would provide capacity for only limited regulation of discharge, it has been included in the study cases. In total five cases were studied and each case is evaluated for two conditions of the initial sea water level of the estuary.

Table 11-12-1 shows the content of each case study.

Case 1 - Without the re-regulating pondage.
Steady discharges from the power station of 320 m^3/s for 6 hours.

Case 2 - With re-regulating pondage.

Initial discharge from the power station - 80 m^3/s for 3 hours.

followed by;

Steady discharge from the power station of 320 m^3/s for 5 hours.

Case 3 - Without the re-regulating pondage.

Steady discharge from the power station of 480 m^3/s for 4 hours.

Case 4 - Without the re-regulating pondage.

Steady discharge from the power station of 640 m^3/s for 3 hours.

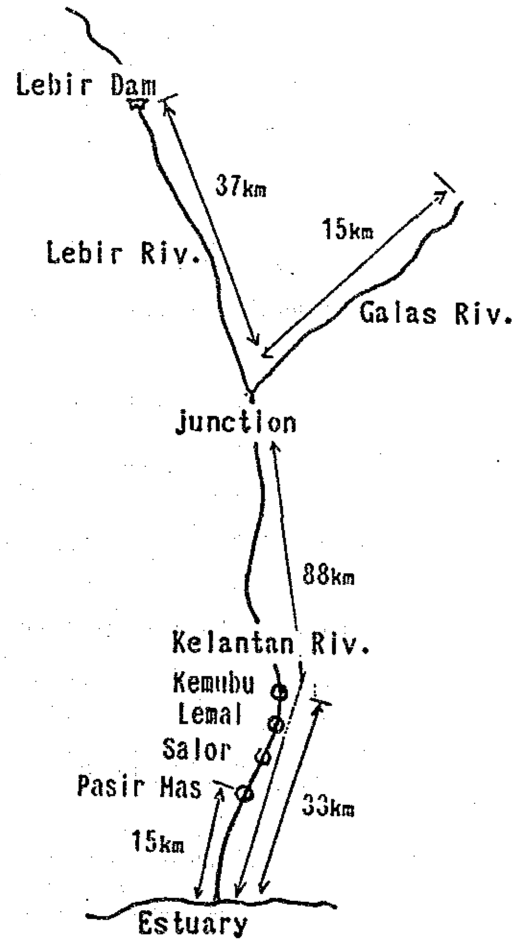
(3) Study Method and Condition

(a) Extent of Unsteady Flow Analysis (Calculation of Water Level Fluctuation)

The river channel consists of the Galas and the Lebir, and after the confluence it is called the Kelantan River. The lengths of each river channel of the Kelantan, and its tributaries the Lebir and the Galas were taken as 88 km, 37 km and 15 km respectively for purpose of analysis.

For convenience of analysis, numbering of the locations was made starting from upstream of the Lebir River through to the estuary of the Kelantan. The cumulative length of river was measured from the estuary toward the upstream reaches. The total length of the Lebir River system is therefore 125 km, and 88 km from the estuary to the confluence.

For measurement purpose the starting point of the Galas river channel was set up at the confluence, 88 km upstream of the estuary of the Kelantan River, and the cumulative distance of river channel has been measured towards the upstream, from the confluence.



(b) Characteristics of River cross-section

The surveyed river cross-sections are in general very complicated in shape and the survey covers some 125 km of the river reaches.

This poses considerable problems in evaluating the equivalent hydraulic trapezoidal or rectangular section suitable for quantitative simulation and accurate estimation of the effects of water level, flow velocity, wave velocity, reserve effect within the river channel and the time elapsed from discharge. The characteristics of these sections, area, hydraulic radius (corresponding to each river depth), have been calculated by the linear approximation method using angular coordinates, allowing a high degree of accuracy to be obtained. Using the measured values the parameters were calculated from the following formulae;

Area of the river section : $A = K \cdot h^m$ (m^2)
Hydraulic radius : $R = C1 + C2 \cdot h$ (m)

The constants were calculated on the basis of unsteady flow calculation of the discharge to be studied, with depth in the range up to 7 m. The average square error of the similar accuracy of the constants is less than 5%. The results are as shown in Table 11-12-1 in Appendix. The deepest river bed height indicated in the tables was adjusted so that the hydraulic radius becomes zero when the depth of the river is also zero.

Most of the adjusted river bed heights are less than 0.5 m. The integer number of river cross-sections such as 1, 2, ... or RS-01, RS-02 ... indicated in the tables are based on the survey result and the values followed by "-" after these integral numbers such as 1-0.5, 1-1, 1-15, ... or RS-01-1, RS-02-1, RS-10-05, RS-10-1, RS-10-15 .... mean that they were determined through linear interpolation. Referring to the Lebir River, 26 sections among the results of the river cross sectional survey carried out from July to October, 1987 were used. For the Galas

River, the values of rectangular section and distances of each section used in Chapter 5 (Run-off Analysis) of this report were adopted as they are, since no survey data is available.

For the Kelantan River, the survey results given in the ENEX Report for KRBS (July 1975) were used.

As understood from these tables, the distances of several kilometers of between sections were thought to be long and not adequate for the unsteady flow calculation. Thus, considering the accuracy of calculation, the distances between sections were reduced to 1 km. The fixed number and river bed height in this case were calculated by alignment proportion. The results are shown in Table 11-12-2 in Appendix.

(c) Roughness coefficient of River Channel

A roughness coefficient of river channel of $n = 0.035$ was equally adopted here because of the gentle river flow.

(d) Condition of Estuary Sea Water Level

A cycle of high and low tide is taken to be 12 hours and varies in sine wave form, because there is only limited data on the fluctuation of sea level at the estuary of the Kelantan River, as follows; H.H.W.L.=5.0 ft = 1.524 m and L.L.W.L.= 2.5 ft = 0.762 m at Port Tumpat.

Therefore, the fluctuation of estuary sea water level (η) can be expressed in the following formula.

$$\eta = 0.381 \cdot \cos(30 \cdot t)^\circ + 1.143 \text{ (m)}$$

where, t = time (hours)

η = 1.524 m in case of t = 0

η = 0.762 m in case of t = 6

(e) Base-flow Discharge

The base-flow discharge of the Galas River was originally estimated to be fixed at Q = 70.86 m^3/s and the condition of the Lebir River was given as a dry bed. However, as it was considered to create problems for unsteady flow analysis against the initial discharge, the base-flow discharge of the Lebir River was fixed at 7.0 m^3/s from the preliminary study result of unsteady flow.

Therefore, the base-flow discharge of the Kelantan River was estimated to be 70.86 m^3/s calculated from the base-flow discharge of the Galas River of 63.86 m^3/s. (70.86 m^3/s corresponds to a 30 year return period of drought.)

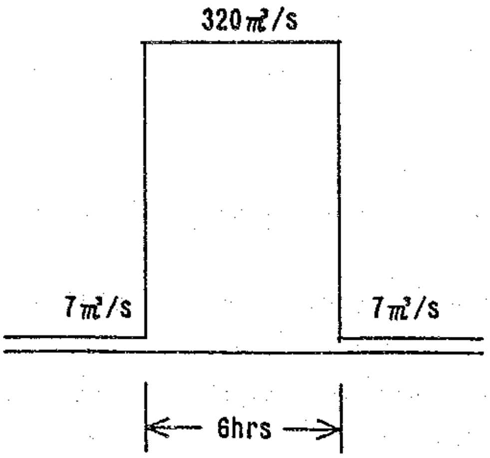
(f) Discharge Patterns of Lebir Power Station

The following three cases show discharge patterns of the Lebir power station considering to discharge during one continuous period each day.

Case 1

Without the re-regulating pondage

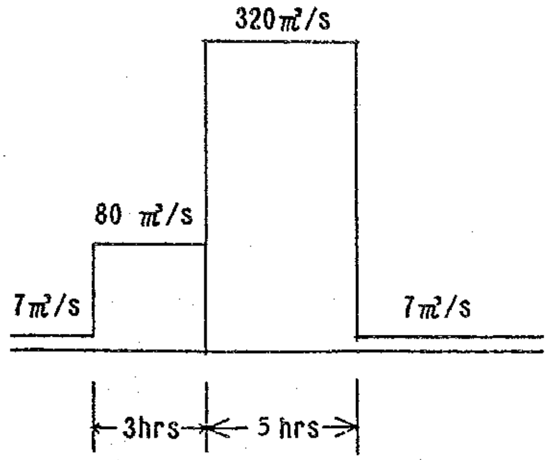
(Qp=320 m^3/s - 6 hrs)



Case 2

With the re-regulating pondage of reserved capacity 1,000,000 m^3

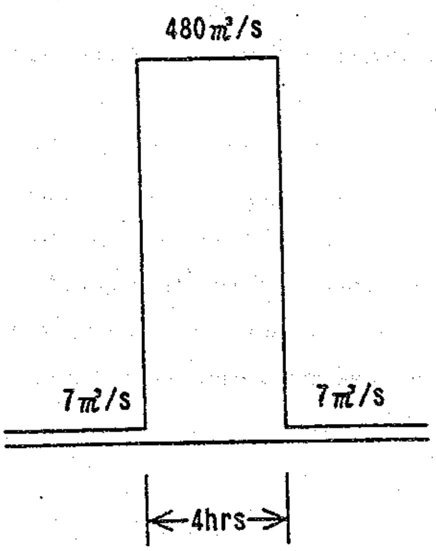
(Q = 80 m^3/s - 3 hrs,
Qp = 320 m^3/s - 5 hrs)



In case with the reregulating pondage, the discharge pattern from the pondage should be shown.

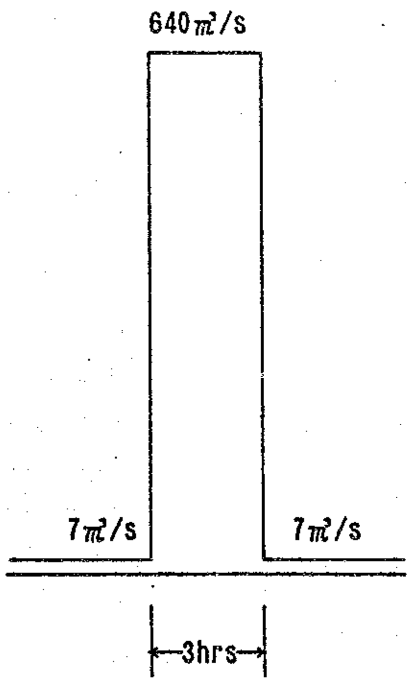
Case 3

(Qp=480 m^3/s - 4 hrs)



Case 4

(Qp=640 m^3/s - 3 hrs)



(4) Results of Study

Fluctuations of the water level in the river and the flow discharge of the 6th and 7th days, when the effect on initial condition of the discharge has disappeared at each downstream pumping station, are shown in Table 11-12-3 in Appendix.

The fluctuations of flow discharge are shown in Fig. 11-12-1.

The results of the study are summarized as follows.

(a) It takes about 20 hours from the start of discharge at the Lebir power station for discharge wave to reach Kemubu pumping station, located at the most upstream. The peak corresponding to the discharge wave comes after about 40 hours.

(b) The tidal effect only reaches as far as the Pasir Mas pumping station, the furthest downstream of the pumping stations (15 km from the estuary). The fluctuation of discharge arising from the tidal effect is relatively small (1.0 m^3/s), and judged as an allowable variation to be ignored. The calculation results show that the other pumping stations located upstream of the Pasir Mas are not affected by tidal effects from the estuary.

(c) In case of the peak discharge for generation of 320 m^3/s without the re-regulating pondage (Case 1), the discharge reaching the downstream pumping stations varies in the range 139 m^3/s to 152 m^3/s. However, since this flow includes a base-flow discharge of 71 m^3/s from the Galas River, it is understood that the discharge from the Lebir power station varies in the range 68 m^3/s to 81 m^3/s after deduction of the base-flow discharge of the Galas River, and is close to the firm discharge. This means that the retained discharge within the river channel between the Lebir dam and the pumping station is enormous in volume because of the long river stretch, the wide river widths and the rather mild river slopes.

(d) Case 2. Adding the re-regulating pondage scheme on Case 1 shows similar results to those for Case 1 and there is no apparent effect of the re-regulating pondage.

(e) In case of the generation discharge of 640 m^3/s without the re-regulating pondage (Case 4), the discharge reaching the downstream pumping stations varies in the range 137 m^3/s to 150 m^3/s, and shows only a difference of about 2 m^3/s from the Case 1 discharges.

(f) Table 11-12-2 shows the results of analysis. (Subject to the time fluctuation of the 7th day discharge which is considered to reach stable conditions)

Table 11-12-2 also shows fluctuation of the water level at the downstream pumping stations. The following are the comparison between the fluctuation of water level and intake condition at each pumping station, and it is understood that these pumping stations do not have any greater affects by the peak discharge for generation of 640 m^3/s of the Lebir power station.

Pumping Station	Range of enough intake	Range of possible intake	Fluctuations of water level when discharging from Lebir P/S
	W.L.+MSL(m)	W.L.+MSL(m)	W.L. (m)
Kemubu	10.4-5.5	5.5-4.9	5.15-5.21
Salor	9.2-2.5	2.5-2.0	3.08-3.12
Lemal	9.1-2.1	2.1-1.6	2.85-2.90
Pasir Mas	9.8-1.8	1.8-1.1	2.32-2.37

(5) Conclusions

The peak discharge for generation from the Lebir power station ranging from 320 m^3/s to 640 m^3/s is moderated to a range 68 m^3/s to 81 m^3/s at the pumping station located about 90 km downstream. Thus, intake conditions at the pumping stations downstream will not be affected by the effect of the Lebir dam. (which was obtained by deducting the base run-off of the Galas River.)

The re-regulating pondage proposed to be constructed at a location about 3.3 km downstream from the power station with a reserved capacity of 1,000,000 m^3, does not have any regulation effect on discharge at the downstream pumping stations.

11.12.2. Water Level in the Downstream Area due to the Spillway Discharge

(1) Objective of this Calculation

This calculation is to indicate comparative fluctuations of water level in the downstream course of the river for cases with and without the dam, on the basis of two probable flood discharges (1/50 and 1/100 return periods).

(2) Method and Condition of Calculations

Water level and discharge at Guillemard Bridge were given as the initial conditions and non-uniformflow calculations were made progressing in a direction backwards upstream. The flow discharges at a certain fixed time vary in accordance with the sections of the river. The following discharges are given in the two reaches of the river;

Case No.	Return Period	Between Lebir Dam and the confluence with the Galas River	Between the confluence with the Galas River and the Guillemard Bridge	
		Discharge (m^3/s)	Discharge (m^3/s)	Water Level (m)
1-1	1/100	3,389	11,675	15.971
1-2	1/100	4,029	12,315	16.200
2-1	1/100	2,745	14,795	17.085
2-2	1/100	3,382	15,435	17.313
3-1	1/ 50	2,947	10,399	15.516
3-2	1/ 50	3,587	11,039	15.744
4-1	1/ 50	2,369	13,279	16.544
4-2	1/ 50	3,009	13,919	16.722
5	1/100	5,951	18,455	18.391
6	1/100	5,823	18,752	18.497
7	1/ 50	5,260	16,569	17.718
8	1/ 50	5,144	16,851	17.819

Note: (a) The discharges of Cases Nos. 1-2, 2-2, 3-2 and 4-2 show values obtained by adding the generation discharge of 640 m^3/s onto each probable discharge.

(b) The water level at Guillemard Bridge is the value calculated backward from the following H to Q curve formula.

For $H \leq 19.99$ m

$$Q = 59.4990H^2 - 885.2066H + 3,405.186 \ (m^3/s)$$

For $H > 19.99$ m

$$Q = 2,801.7458H - 46,521.1898 \ (m^3/s)$$

(c) Roughness coefficient of the river channel was taken as $n = 0.035$.

(d) Cross-section of the river channel

The cross-sectional shape of the river channel was derived from the survey results of July, 1975.

The section area A of flow discharge at each section, and hydraulic radius R were approximated using the following formula and the results of the cross-sectional survey of the river.

$$A = K \cdot hm (m^2)$$

$$R = C1 + C2 \cdot H$$

(3) Calculation Results and Conclusion

The calculation results are summarized in Table 11-12-3. The water level at the Kuala Kerai gauging station rises up to 29.9 m in case of a 100 year return period flood without the dam. However, the rise of water level is reduced to 27 m by the Lebir Dam, and the respective levels for a 50 year return period flood are 29.1 m without the dam and 26.3 m with the dam.

When the discharge at Guillemard Bridge reaches the peak, the contribution of Lebir Dam to the reduction of water level is small. Under these conditions the respective levels are 28.4 m for a 100 year return period flood, and 27.7 m for a 50 year return period flood.

As understood from the above, the water level due to flood discharge from the Lebir River is reduced to 26.3 m at the Kuala Kerai gauging station in case of 50 year return flood. This water level is almost equal to the dangerous flood water level of 25.91 m at this gauging station.

11.12.3. Study on Re-regulating Pondage

(1) If the Lebir Dam proposed in this project is operated with a HWL of EL. 80 m, a daily firm discharge of 80 m^3/s can be obtained by so regulating the flow discharge. However, since an important function of the project is peak power generation, daily operation is at higher rates of discharge, and is limited to 3 to 4 hours. Thus, the Lebir power station discharges 640 m^3/s when operating, giving rise to a possibility of only little flow in the 35 km of river channel between the power station and Kuala Kerai, when the generator is not operated.

According to the information obtained during the course of this feasibility study, pumping of water for irrigation and service water supply etc. (except on a small scale for the water supply of residents) does not take place in the above section of river channel. However, a river condition having no flow in the channel should be avoided. The object of this study is to investigate the effectiveness of re-regulating pondage for maintaining a residual flow in the river.

(2) Catchment area downstream of Lebir Power Station and minimum river flow

The catchment area feeding about 37 km long stretch of river from the power station to the confluence with the Galas River and the minimum river flows are estimated as follows:

	Location	Distance from the dam (km)	Remaining Catchment area (km^2)	Minimum flow in the dry season (Apr.-Sept.) (m^3/s)
1.	Kg. Tualang	3.8	157	0.8
2.	Kg. Durian	9.4	198	1.0
3.	Kg. Temiang	13.2	365	1.9
4.	Manek Urai	17.2	560	2.9
5.	Kg. Pahisek	28.2	644	3.4
6.	Kg. Kandak	35.7	821	4.3

Minimum flows are based on the following references and formulae:

(a) Gauging Station at Tualang 1976-1981 (6 years)

Dry season (Apr.-Sept.)
Monthly Minimum Flow (2 year return) 13 m^3/s

run-off per 1 km^2 = 13/2,480 = $5.2 \times 10^{-3} m^3/s$

(b) Gauging Station at Guillemard 1950-1984 (35 years)

Dry season (Apr.-Sept.)
Monthly Minimum Flow (10 year return) 115 m^3/s

run-off per 1 km^2 = 115/12,100 = $9.5 \times 10^{-3} m^3/s$

Less flow of Case (a) is adopted for assumption.

As understood from the above, the minimum flow in the upper half of the downstream course of the river is only 1 to 2 m^3/s and in the other half is 3 to 4 m^3/s.

Thus, very little flow is anticipated in the dry season.

(3) Proposed site for the re-regulating pondage dam and its size

There are few suitable sites downstream of the power station for the construction of a re-regulating pondage dam. The only prospective site where a rock foundation can be seen is about 300 m downstream of Tualang Bridge. (A floating dam should be considered when further downstream to be sought.)

The river bed elevation of this site is approximately EL.20 m, and the distance from the power station is 3.3 km. The river has a gentle gradient. Therefore, the extent of any re-regulating pondage is very limited if it is designed to avoid back-up of the pondage water level to the tailrace of the power station at EL. 28 m (at the time of peak generation).

Based on the above limitation, the size of the re-regulating pondage is determined as follows.

Type : Concrete weir with open conduit (Natural overflow Type)

Crest elevation of the weir: EL. 25.4 m
Crest length of overflow : 150 m
Capacity of the re-regulating pondage : 870,000 m^3
Foundation of the weir : Rock foundation (EL. 20 m)

(4) Effects of the re-regulating pondage

By construction of the above re-regulating pondage dam, the pondage fills during generating discharge providing a stored capacity of 870,000 m^3, and can release the water to downstream when the power plant is not in operation. The average flow discharge becomes 12 m^3/s and the minimum flow in the natural river channel without the dam can be ensured.

11.12.4. Impact on River Bank Erosion due to Discharge for Generation

(1) Study on Bank Erosion of the Lebir River due to Peak Discharge for Generation

There are some anxieties that bank erosion would be accelerated by construction of the Lebir Dam and power station due to the fluctuating discharge pattern, and especially by the larger discharge during peak generation. The analysis was therefore carried out from two view points.

First, how the peak discharge for generation will affect fluctuation of flow discharge, water level and flow velocity at each station on the downstream course of the Lebir River, and whether the fluctuation by peak discharge will accelerate bank erosion or not.

Secondly, by construction of the dam, sediment transport from the upstream course of the river will interrupt and the downstream river channel has a tendency to become a static equilibrium river bed in the course of years.

As a result, the existing river bed may become lower after construction of the dam and the bank erosion be accelerated. Results of these studies are stated below.

(2) Water Level of the Downstream Course of the Lebir River due to Peak Discharge for Generation

(a) Conditions of Calculation

Generation discharge (per day) : 640 m^3/s in 3 hours

Roughness coefficient of river channel: 0.035

River cross section : 26 sections, from the dam site of Kuala Kerai (Result of the survey carried out from July to October, 1987)

(b) Calculation Results

The following list indicates the maximum flow discharge, water depth and flow velocity at typical sections of the downstream course of the Lebir River.

Section	Distance from dam site	Location	Max. Flow Discharge	Max. Water Depth	Max. Flow Velocity
	km		m^3/s	m	m/s
No. 2	0.74		634	7.3	2.1
No. 4	2.64	Tualang	620	5.9	1.8
No. 9	8.46	Kg. Kapangan	533	5.3	1.3
No.19	17.90	Manek Urai	346	4.7	1.2
No.28	28.75	Pahi	234	4.1	1.1
No.36	35.25	Kuala Kerai	198	2.3	1.1

Fluctuations of flow discharge, water depth and flow velocity by time are shown in Table 11-12-4 and Fig. 11-12-4.

(c) Conclusion

After first noting a rise of water level at Section No. 2, 0.74 km downstream of the dam site, it took 2.5 hours to rise from 2.0 m to the maximum water depth of 7.3 m.

The rate of rise is 1.06 m per 0.5 hour. After reaching the maximum level, the water depth drops to 2.4 m after 9 hours. Rate of fall is 0.27 m per 0.5 hours.

At Section No.9, 8.46 km downstream of the dam site, 3 hours are required to reach the maximum water depth of 5.3 m from 1.0 m. (Rate: 0.72 m/0.5 hour)

And after 9 hours the water depth falls to 1.5 m. (Rate: 0.21 m/0.5 hour)

At Section No.19, 17.9 km downstream of the dam site, 4.5 hours are required to reach the maximum water depth of 4.7 m from 1.5m, and after 9 hours the water depth falls to 2.5 m. (Rate: 0.12 m/0.5 hour)

In the case of a rapid fall of water level, there is a tendency for river bank erosion to be accelerated. However, since the rates are about 30 cm and 20 cm per 0.5 hour in the vicinity of the power station and at 8.5 km downstream of the Lebir Dam respectively, only small scale bank erosion is presumed likely, and there is less possibility of large scale bank erosion.

The ratio of tractive force at the river bed ($\tau\ell$) to that at the river bank slope (τs), is calculated by the following formula using the Lane's method.

$$K = \frac{\tau s}{\tau\ell} = \cos\phi\sqrt{1 - \frac{\tan^2\phi}{\tan^2\theta}}$$

where, ϕ : Angle of the horizontal face against the river bank slope

θ : Angle of internal friction of the sediment load in water

Tractive force at each representative section (in case of θ=35°) is as shown in Table 11-12-5.

The following formula was also used:

$$\tau\ell \doteqdot wHI \qquad U^{*}e = \sqrt{\frac{\tau\ell}{\rho}} = \sqrt{gHI}$$

Where, W = Weight per unit volume of the water

H = Water depth

I = Gradient of water surface

(The river bed gradient is adopted because of uniform flows.)

ρ = Density of water

$$dc = \frac{U^{*}c^{2}}{80.9}$$ (cm): Critical movable grain size (The Iwagaki formula is used.)

From the above results, it is understood that bed loads with grain size smaller than 1.8 cm are transported at the river bank of Section No. 2, 0.74 km downstream of the dam site, and those of 0.3 to 0.4 cm are transported at the river banks further downstream of Section No.4 where the river bed gradient becomes rapidly more gentle.

However, after transportation of these bed loads, the river bank surface is covered by bed loads of a large grain size, and what is called an armour coat, is formed. Thus, it is considered that further erosion will not occur. These armour coats are destroyed by larger flood discharge than the generation discharge.

(3) Downstream River Bed Erosion of the Lebir Dam

The flood discharge which governs the static equilibrium of the downstream river channel after construction of the dam, arises from floods of 2 to 4 year return periods (Control Discharge). Therefore, the static equilibrium river bed gradient corresponding to such flood discharge after construction of the dam is first calculated and an approximate level of river bed erosion was estimated.

(a) Basic formula to calculate a static equilibrium river bed.

The flow velocity of the river is as follows according to the Manning Formula:

$$\frac{Vm}{U*} = 7.66 \left(\frac{h}{Ks} \right)^{1/6}$$

where, Vm = Average flow velocity

U* = Friction velocity = $\sqrt{ghIe}$

h = Water depth

Ks = Equivalent roughness

Ie = Energy gradient

Applying dm into Ks (dm = Average grain-size of bed loads),

$$Q = BhVm$$

$$= 7.66 \left(\frac{h}{dm}\right)^{1/6} U^*hB$$

Then, U* is calculated using the following formula:

$$U^* = \frac{Q}{7.66\ hB} \left(\frac{h}{d} \right)^{-1/6} = \frac{Q}{7.66\ B} d^{1/6}\ h^{-7/6}$$

where, $h = U^{*2}/gIe$

$$U^* = \frac{Q}{7.66\ B} dm^{1/6} \left(\frac{U^{*2}}{gIe}\right)^{-7/6}$$

Then, U* is calculated using the following formula:

$$U^* = \left(\frac{Q}{7.66\ B}\right)^{3/10} dm^{1/20} (gIe)^{7/20}$$

where, considering the gravels on river bed is a movable limit,

$$U^* = U^*c$$

U^*c is obtained from the following formula.

$$U^*c^2 = 0.05 \text{ sgdm}$$

where, s = Weight per unit volume of gravels in the water.

Using the above formula, U^* and U^*c are eliminated as follows.

$$(0.05 \text{ sgdm})^{1/2} = \left(\frac{Q}{7.66\ B}\right)^{3/10} dm^{1/20} (gIe)^{7/20}$$

Further, using the above formula, i is calculated as follows, where $Ie = i = -\frac{dz}{dx}$ (Gradient of river bed)

$$\frac{dz}{dx} = \frac{(0.05s)^{10/7} g^{3/7} dm^{9/7}}{\left(\frac{Q}{7.66\ B}\right)^{6/7}}$$

A different expression of the above formula is:

$$Zi + 1 = Zi + \frac{(0.05s)^{10/7} g^{3/7} dm^{9/7}}{\left(\frac{Q}{7.68\ B}\right)^{6/7}} \cdot \Delta x$$

(b) Conditions of Calculation

Calculation was made based on the conditions as follows.

Length of the river channel for calculation:
Approx. 36 km from the Lebir Dam to Kuala Kerai

Elevation of the river bed:

Table 11-12-6 was prepared based on the results of the survey carried out from July to October, 1987, and the elevation of river bed is plotted in Fig. 11-12-5.

The river bed elevation of the downstream end is fixed at Section No. 25.

River width:

To be based on the above survey result, as is also the elevation of the river bed. The average width as shown in Fig. 11-12-5 is used.

Average grain size of the bed load:

Average grain size of the bed materials composing the river bed was determined to be dm=0.01 m from the result of field reconnaissance.

Control discharge:

Judging from the discharge corresponding to a 2 to 4 years return flood after construction of the Lebir Dam, from Fig. 11-12-6, the control discharge forming a static equilibrium river bed is understood to range from 855 m^3/s to 1,240 m^3/s. Thus, discharges are calculated for 3 cases of 855 m^3/s, 1,000 m^3/s and 1,200 m^3/s.

(c) Calculation Results

The equilibrium river bed gradient obtained by calculation is shown in Fig. 11-12-7. As understood from this figure, it is expected to make the existing river bed lower by about 1 to 2 m over a length of approximately 5 km downstream of the dam, and for a further 5 km downstream, river bed erosions of 0.5 to 1 m are expected.

(d) Conclusion

The river bed erosion has a possibility to accelerate a collapse of the river bank, however, it is considered that any overall damage would be small scale because of the limited length of river course affected by the erosion.

11.12.5. Upstream Hydrological Telemetering and Downstream Discharge Warning Systems

(1) Objective of the installation of these systems

For the operation of hydro-power plant, accurate information of the inflow from upstream, and the discharge towards downstream is required for proper management of the facilities. In line with this objective, the installation of the above systems are considered necessary to provide information with the manager and operators of the dam and powerhouse, and to give warning of dangers to persons who may become at risk from flood discharge.

(2) Upstream hydrological telemetering system

This system automatically monitors hydrological phenomena (rainfall and reservoir level) relating to the upstream basin of the dam. The data is transmitted by a telemeter system to the Dam Control Centre.

The operator of dam has available to him, continuously up-dated information of upstream rainfall and reservoir level, so that proper control action can be taken with respect to discharges, and adequate warning of danger can be given to persons who may be at risk downstream.

This system comprises the following:

(a) Hydrological Telemetering System

Automatic rainfall gauging station	:	12 stations
Automatic water level gauging station	:	3 stations
Telemetering system	:	1 unit
Main receiving station	:	1 station at the dam site

(b) Dam Data Management System

Electric calculator	:	1 unit
Reservoir water level gauging station	:	1 station
Auxiliary power source facility	:	1 unit

(3) Downstream discharge warning system

Lebir Power Station is designed as a peak power station, and discharges a very large amount of water when operated (640 m^3/s). At these times flow in the downstream course of the river increases rapidly. The rates of water level rise are 1 m/0.5 hour, 0.7 m/0.5 hour, and 0.35 m/0.5 hour, at 0.7 km, 8.5 km and 18 km downstream of the power station respectively.

Though the flow velocity is relatively slow (1 to 2 m/s), the surge of water could put at risk local residents who commonly use the river as a necessity of their daily lives if not given notice of the discharge.

To keep such risks to a minimum, the warning system will give prior notice of water rises to the downstream residents so that they may move from the river during the time that the discharge warning system is in operation.

The components of the system are as follows:

(a) Downstream discharge warning system

Main sending station: 1 station at the power station
Voice warning broadcasting station : 13 stations
Siren warning broadcasting station : 13 stations

The system is used to give a notice to the downstream residents of spillway discharge, too. Locations of the system are given in Fig.11-12-8.

11.13. Costs for Resettlement and Compensation

11.13.1. Impoundment Area in the Upstream Basin

(1) Area of Impoundment

The area and type of land to be inundated by construction of the Lebir Dam are shown below. The area was measured on the aerophoto map at a scale of 1 : 10,000 which was produced during the previous study in 1979. Reference to the 1:63,360 scale topographical map borrowed from KESEDAR during the survey period of March, 1987 was made.

Firstly, locations on the topographical map of the agricultural plantations owned by FELDA and KESEDAR were enlarged until they became commensurate with the scale of the aerophoto map, and then by overlapping both maps, land types were assessed. (refer to Figs. 11-13-1, 11-13-2 and 11-13-3). The areas of FELCRA agricultural plantations were measured on the basis of the USM Sub-study Report of December 1987, and the information obtained during the discussions on the Interim Report of February 1988. Also, the information on the ADB Project obtained in February 1988 is taken into account. Areas other than agricultural plantations were assumed to be forest.

Area and Type of Land Inundated

(Unit: ha)

Type of land	WL 60 m	WL 70 m	WL 80 m	WL 90 m
Agricultural plantation	2,656	5,472	9,588	16,379
Forest	1,944	3,428	5,812	8,321
Total	4,600	8,900	15,400	24,700

The ratio of agricultural plantations to forest is approximately 6 : 4. A detailed breakdown is shown in Table 11-13-3.

The following figures are indicated in Page 121, Table 7.3. of the USM Sub-study Report. (extracted to Table 11-13-2)

Summary of Lands Inundated

(Unit: ha)

Type	WL 70 m	WL 90 m
Agricultural plantation	6,571	13,878
Forest	4,670	11,208
Total	11,241	25,086

(2) Inundation Area of Agricultural Plantation

The areas of agricultural plantations owned by FELDA, KESEDAR and the others existing upstream of the proposed dam site, and the inundated area therein are as follows.

Agricultural Plantation and Inundated Areas

(Unit: ha)

Owner	Total Area	Inundated at WL 70 m	Inundated at WL 80 m	Inundated at WL 90 m
KESEDAR	27,626	3,839(13.9%)	5,667(20.5%)	8,185(29.6%)
FELDA	23,965	1,240(5.2%)	3,094(12.9%)	6,885(28.7%)
FELCRA	405	30(7.4%)	77(19.0%)	129(31.9%)
ADB Project	-	363	750	1,180
Total	51,996	5,472(10%)	9,588(18%)	16,379(30%)

Note: Figures in brackets indicate the percentage of total area.

Agricultural plantation areas owned by FELCRA and ADB Project were measured based on the information obtained in February, 1988. (337 ha was counted for FELCRA's area in the USM Sub-study Report.)

The total area of the surveyed agricultural plantations is made up of 27,626 ha in KESADAR and 23,965 ha in FELDA. These figures already include the so-called private area and future extension plans, and are therefore larger than the existing area. The inundated area depends on the water level of the proposed reservoir and the ratio to the total area is about 10% at W.L 70 m, 20% at WL 80 m and 30% at WL 90 m respectively.

Concerning the inundated area of each land scheme, Chalil and Lebir-3 schemes in KESEDAR showed the largest inundation area of more than 90% at WL 90 m, followed by Lebir-1 and Lebir-2 (40 to 50%) and Paloh-3, Paloh-4 and the private area of (10 to 30%).

In FELDA all the schemes except for Aring-1 are affected by impoundment. Aring-6 is inundated by 60% at WL 90 m, followed by Aring-5 and Aring Timur-5, with respective inundation ratios of 50% and 40% and the other schemes with a range of 30 to 10%.

In FELCRA only one scheme on the right bank of the Lebir River is affected by impoundment.

ADB Project is located at the left bank of the Lebir River and among the project areas, the affected areas are Nos. 1989, 1990, 1992, 1993, 1994 and 1995. Table 11-13-1 indicates the detailed figures concerning the inundated area.

The total area of each land scheme in KESEDAR and FELDA and the inundated area therein are illustrated in the USM Sub-study Report (Page 120, Table 7.2) as below:

Agricultural Plantation and Inundated Areas (measured by USM)

(Unit: ha)

Owner	Total Area	Cropped Area	Inundated at WL 70 m	Inundated at WL 90 m
KESEDAR	8,047	7,497	5,023	7,782
FELDA	23,705	22,158	1,548	6,096
Total	31,752	29,655	6,571	13,878

Note: KESEDAR has five (5)plantations consisting of Chalil, Paloh-3, Lebir-1, Lebir-2 and Lebir-3. Figures for each plantation or land scheme are referred to in Table 11-13-2.

(3) Crops in the Agricultural Plantations

Most of the crops produced in the KESEDAR and FELDA owned plantations are rubber and oil palm crops. However, it was impossible to discriminate each cropped acreage on the map, and the only data available was a list of cropped acreage for each plantation. Therefore, there was no way other than to assume each cropped acreage was based on this list. The ratio of cropped acreages of rubber and oil palm for Paloh-1, Paloh-2, Paloh-3, Lebir-1 and Chalil in KESEDAR was 4 to 6 (Refer to Appendix Table 11-1). Meanwhile, the ratio in FELDA was 0.09 : 0.91 (Refer to Appendix Table 11-2).

The above ratios were applied to the measured inundated plantation areas of KESEDAR and FELDA and each cropped acreage inundated was presumed to be as follows:

Each Cropped Acreage by Inundation

(Unit : ha)

Location	Crop	WL 70 m	WL 80 m	WL 90 m
KESEDAR	Rubber	1,536	2,267	3,274
ditto	Oil palm	2,303	3,400	4,911
FELDA	Rubber	115	288	640
ditto	Oil palm	1,125	2,806	6,245
Total	Rubber	1,651	2,555	3,914
	Oil palm	3,428	6,206	11,156

(4) Inundated Area of Forest Reserves

The inundated area of forest reserves due to the impoundment by the Lebir Dam, and the felling status were investigated as below:

Inundated Area of Forest Reserves and Felling Status

(Unit : ha)

Status	Location	Inundated at WL 70 m	Inundated at WL 80 m	Inundated at WL 90 m
Felled	Lebir Right bank	1,599	2,643	3,725
Felled	Lebir Left bank	0	0	0
Felled	Total	1,599	2,643	3,725
Not felled	Lebir Right bank	1,795	3,119	4,524
Not felled	Lebir Left bank	34	50	72
Not felled	Total	1,829	3,169	4,596
Total	Lebir Right bank	3,394	5,762	8,249
Total	Lebir Left bank	34	50	72
Grand Total		3,428	5,812	8,321

The felling status was not measured on the map, but this referred to the ratios of felling for Hutan Simpan Lebir and Hutan Simpan Relai which were seen in the 1987 data of the Agro-forestry Dept. Kota Bharu and the plantation areas of FELCRA and ADB Project were deducted from the forest area. (Refer to Appendix 11-3).

On the other hand, the USM Sub-study Report (Page 258) reported that the inundated area of forest reserve is 4,670 ha at WL 70 m and 11,208 ha at WL 90 m respectively.

(5) Inundated Acreage of Land Except for Plantation

Though JICA Study Team could not survey the area, the USM Sub-study Report gives the following information:

(a) Lebir riverine settlers

Survey result	: 1,669 acres (Page 199)
For compensation	: 2,000 acres (Page 290)

(b) Orang Asli

For compensation	: 55 acres (Pages 229 and 290)

11.13.2. Costs for Resettlement and Compensation

(1) Number of settlers per household

The units of settlers to be relocated due to inundation by the Lebir Dam are reported in the USM Sub-study Report (Page 290), as follows:

Units of Settlers to be Relocated

	Groups	No. of Units		No. of People
(1)	Lebir riverine settlers	100	some	500 persons (Page 150)
(2)	RKT KESEDAR settlers	675	some	4,050 persons
(3)	Orang Asli	-		144 persons

According to the USM Sub-study Report, the above figures represent the updated status of settlers and most of the settlements are situated below the elevation of 70 m, hence the above figures remain unchanged.

Units of settlers per hectare are 0.125 for the rubber plantations and 0.25 for oil palm on average, in KESEDAR and FELDA. If the cropping land was inundated, the settlers would be forced to relocate somewhere else, whether or not their dwelling houses were inundated. Therefore, it is also considered as the base for compensation to assume units of settlers to be relocated based on the cropped acreage inundated. With this method having been applied, units of settlers to be relocated consist of 177% of those reported in the USM Sub-study Report at WL 70 m, and 305% and 569% at WL 80 m and 90 m respectively (Refer to Table 11-13-4). However, these are the maximum figures, including future developments, and will be variable according to the development policy of KESEDAR and FELDA.

(2) Compensation of Cropped Acreage Inundated

The following cropped acreages were considered for inundation compensation in the USM Sub-study Report (Pages 290 and 296).

Cropped Acreage Compensated for Inundation (USM)

(Unit : ha)

	Settlement	WL 70 m	WL 90 m
(a)	Lebir riverine area	809	809
(b)	RKT KESEDAR	3,072	5,666
(c)	FELDA	1,482	7,487
(d)	FELCRA	337	337

Note: Unit in USM Sub-study Report (Ac) was converted to ha.

There is a little difference between the above figures and the inundated area mentioned in the foregoing Section 11.13.1.(2).

On the other hand, JICA Study Team presented its own estimate measured at the stage of Interim Report (February, 1988) on the compensation of cropped acreage inundated against each dam height as set out below. However, the compensated acreage covers islands or peninsula shaped isolated lands within the inundated area, as these areas will be difficult to gain access to and will no longer be available for economic exploitation. For the computation, Table 11-13-5 was used. (Refer to Fig. 11-13-4)

Cropped Acreage Compensated for Inundation estimated by JICA Study Team
(at the stage of Interim Report)

(Unit : ha)

Settlement	WL 70 m	WL 80 m	WL 90 m
(a) KESEDAR	4,472	6,414	10,373
(b) FELDA	1,259	3,256	7,403
Total	5,731	9,670	17,775

The above acreage is further classified based on the method mentioned in Section 11.13.1(3) crop type, as follows:

(Unit : ha)

Crop	WL 70 m	WL 80 m	WL 90 m
(a) Rubber	1,906	2,869	4,837
(b) Oil palm	3,825	6,801	12,938
Total	5,731	9,670	17,775

The details of the calculation are as per Appendix, Table 11-4.

After submission of the Interim Report, a review of the area compensated for inundation was carried out with reference to the following points.

i. To include the submerged area of FELCRA and ADB Project of which the data was obtained in February, 1988.

ii. To measure the submerged area against the design HWL EL 88.1 m selected as the optimum dam scheme.

iii. The submerged area stated in the Interim Report was the maximum extent and included the future development plan of agricultural plantations.

However, the measurement base was given only to the plantation areas to be developed as of 1990. Fig. 11-13-5 was prepared for its measurement.

The following areas compensated for inundation are proposed in this report.

<u>Cropped Acreage Compensated for Inundation in the upstream due to the construction of Lebir Dam</u>

(estimated by JICA Study Team)

Settlement		WL 88.1 m
(a)	KESEDAR	4,935 ha
(b)	FELDA	3,904 ha
(c)	FELCRA	114 ha
(d)	ADB Project	1,047 ha
	Total	10,000 ha

The above acreage is further classified into the area by each crop type, as follows:

Crop	WL 88.1 m
(a) Rubber, etc.	3,100 ha
(b) Oil palm, etc.	6,900 ha
Total	10,000 ha

However, as definite information could not be obtained, for convenience, FELCRA was included in oil palm and ADB Project was included in rubber respectively.

(3) Compensation for Public Facilities

The USM Sub-study Report (Page 290) enumerates the following as public facilities which need compensation:

(a) Social amenities

- Mosque	3
- School	3
- Public hall	3

(b) Road

- Relocation of Kuala Kerai - Gua Musang Highway	5 km
- KESEDAR	100 km
- FELDA	100 km

(c) Bridge

- Aring River
- Lebir River
- Ralai River

(d) Orang Asli settlements 2

According to the result of field survey executed by JICA Study Team in March, 1987, the following roads would be affected by the Lebir Dam Project.

- a 52 km long road under construction by JKR in FELDA complex.

- a 30 km extension road for log transportation on the right bank upstream of the proposed dam site on the Lebir River.

(4) Compensation for Inundation

The USM Sub-study Report (Page 289, APPENDIX 8.1.) enumerates the following items and estimates unit costs for inundation compensation caused by the Lebir Dam Project.

Items and Unit Costs for Compensation
(estimated by USM)

	Items	Estimated Unit Cost (Unit : M$)
(a)	House	
i.	Lebir riverine settlers	2,087/house
ii.	KESEDAR settlers	4,500/house
iii.	Renovation-KESEDAR	368/house
iv.	Staff houses-KESEDAR	20,000/house
(b)	Agricultural Holdings	
i.	Lebir riverine settlers	1,000/ac(2,471/ha)
ii.	RKT KESEDAR	10,000/ac(24,710/ha)
iii.	FELDA	10,000/ac(24,710/ha)
iv.	FELCRA	

(c) Land

i.	KESEDAR	3,000/ac(7,413 ha)
ii.	FELDA	3,000/ac(7.413 ha)
iii.	FELCRA	3,000/ac(7,413 ha)

(d) Social Amenities

i.	Mosque	100,000/unit
ii.	School	100,000/unit
iii.	Public hall	20,000/unit

(e) Transportation of properties 50% of present value

(f) Road

i.	Relocation of Kuala Kerai - Gua Musang Highway	1,000,000/km
ii.	KESEDAR	600/km
iii.	FELDA	600/km

(g) Bridge 150/SQ.FT

(h) Orang Asli

i.	Pasir Linggi	5,000/ac(12,355/ha)
ii.	Kg. Sedahan	L.S. 50,000

(i) Forest Reserve 450/ha

The unit costs for compensation were estimated on the following basis:

Basis for Unit Costs for Compensation
(estimated by USM)

Items		Basis for Estimated Unit Costs
(a) Houses		
i.	Lebir riverine settlers	Average of present value
ii.	KESEDAR settlers	ditto
iii.	Renovation for KESEDAR settlers	ditto
iv.	Houses for KESEDAR settlers	New construction cost
(b) Agricultural Holdings		
i.	Lebir riverine settlers	Double the present cost for opening orchard
ii.	RKT KESEDAR	Oil palm products for 20 years x 1/3 (M$ 150/ton FFB)
iii.	FELDA	ditto
iv.	FELCRA	ditto
(c) Land		
i.	KESEDAR	Development cost of oil palm plantations
ii.	FELDA	ditto
iii.	FELCRA	ditto
(d) Social Amenities		
i.	Mosque	New construction cost
ii.	School	ditto
iii.	Public hall	ditto

(e) Road

i.	Relocation of Kuala Kerai - Gua Musang Highway	Actual construction cost
ii.	KESEDAR	JKR contractor unit price
iii.	FELDA	ditto

(f) Bridge — JKR contractor unit price

(g) Orang Asli

i.	Pasir Linggi	Development cost & compensation for crops
ii.	Kg. Sedahan	Relocation cost estimate

(h) Forest Reserve — Income from felling

Meanwhile, the USM Sub-study Report (Page 294) enumerates M$ 5,000 to 7,000 per acre as the market price of the oil palm land, and an average price of M$ 6,000. Furthermore, the same report (Page 293) proposed an interesting manner of compensation, i.e. no compensation for the agricultural holdings (crops). The JICA Study Team agrees basically with this manner. The differences found between the JICA Study Team and the USM Sub-study Team regarding compensation are as follows:

Cropped Acreage for Compensation		JICA (Interim Report)	USM	JICA (Final Report) at WL 88.1 m
WL 70 m	KESEDAR	4,472 ha	3,072 ha	
	FELDA	1,259 ha	1,482 ha	
	FELCRA	0	337 ha	
	Total	5,731 ha	4,891 ha	
WL 90 m	KESEDAR	10,372 ha	5,666 ha	4,935 ha
	FELDA	7,403 ha	7,487 ha	3,904 ha
	FELCRA	0	337 ha	114 ha
	ADB Project	0	0	1,147 ha
	Total	17,775 ha	13,490 ha	10,000 ha

Unit cost for compensation	JICA	USM
Rubber plantation	MS 5,900/ha	-
Oil palm plantation	MS 7,500/ha	MS 7,413/ha

As for the unit cost for compensation of the cropped acreage, the JICA Study Team adopted an average development cost in KESEDAR and FELDA (Refer to Appendix Tables 11-6 to 9).

Extension of relocation road & nit cost		JICA	USM
WL 70 m	Extension of relocation road	30 km	0
WL 90 m	ditto	75 km	205 km
Road construction cost		M$350,000/km	M$ 600/km

The road construction cost estimated by the JICA Study Team includes the bridges, and is based on 80 % of the following contracts between FELDA and JKR. The reason for this ratio is due to the grading down of relocation road.

Works	Extension (km)	Contract amount (MS$ 10^6)	Price per km (M$ 10^3)
Aring phase - 1	18.5	5.4	292
Lebir (including 2 branch roads)	17.5	10.0	571
Aring phase - 2	15.7	7.0	446
Total	51.7	22.4	433

There are still various arguments on how to decide the unit cost for compensation of the cropped acreage. The JICA Study Team proposes that the plantation development cost should be applied for this purpose as the USM Sub-study Team proposed so. If this idea is to be materialized, a new plantation could be developed in an appropriate site in replacement of the inundated one. The produce from the new plantation will soon reach the same level as before.

On the other hand, another method used to evaluate the compensation cost in view of the produce in the inundated plantation is also considered. For the purpose of reference, the outline is shown as below.

Annual net produce at the plantation

- Rubber	M$ 2,272/ha
- Oil palm	M$ 2,299/ha
Average	M$ 2,285/ha

Convert annual net produce for 20 years to the present value (Assumed discount rate : 10%)	2,285 x 8.51 = M$19,445/ha

It is difficult to evaluate the net produces properly as they are greatly influenced by the crop market conditions. The above figures, therefore, were extracted from the latest farm budget used in KESEDAR and FELDA (Refer to Appendix Tables 11-8 to 11).

The USM Sub-study Report (Page 257) estimates M$ 450 as losses of forest per hectare caused by inundation which were calculated based on the produce of the plantation. With this unit cost, the total loss amount was calculated showing M$ 2.1×10^6 at WL 70 m and M$ 5.0×10^6 at WL 90 m respectively.

The compensation costs estimated by the JICA Study Team and USM Sub-study Team are comparatively listed below:

In case of WL 70 m (at the stage of Interim Report)

(Unit : MS$ 10^3)

	Item	JICA	USM I	USM II
(a)	Houses	4,621	4,621	4,621
(b)	Agricultural holding (crops)	-	106,420	-
(c)	Land development cost	33,933	36,257	36,257
(d)	Social amenities	660	660	660
(e)	Transportation	100	100	100
(f)	Road & bridge	13,500	-	-
(g)	Orang Asli	325	325	325
(h)	Forest reserve	-	2,100	2,100
	Total	53,139	150,483	44,063

In case of WL 90 m (at the stage of Interim Report)

	Item	JICA	USM I	USM II
(a)	Houses	4,621	4,621	4,621
(b)	Agricultural holding (crops)	-	275,899	-
(c)	Land development cost	125,573	100,001	100,001
(d)	Social amenities	660	660	660
(e)	Transportation	100	100	100
(f)	Road & bridge	33,800	9,803	9,803
(g)	Orang Asli	325	325	325
(h)	Forest reserve	-	5,040	5,040
	Total	165,079	396,449	120,550

The above USM I includes compensation for the cropped acreage, but USM II does not include this. The breakdown of compensation costs prepared by the JICA Study Team is shown in Table 11-13-6 (at the stage of Interim Report) and that prepared by the USM Sub-study Team is shown in Table 11-13-7.

After submission of the Interim Report, the compensation costs were reviewed and recalculated. Its result is as shown below.

In case of WL 88.1 m (Optimum plan proposed in the final report)

	Item	Compensation Cost (Unit : M$ 10^3)	Remarks
(a)	Houses	4,621	Quantities and unit rate estimated by USM were adopted. (USM)
(b)	Agricultural holding (crops)	0	*1

(c)	Land development cost	75,000	Quantities and unit rate estimated by JICA were adopted. (JICA)
(d)	Social amenities	660	(USM)
(e)	Transportation	100	(USM)
(f)	Road & Bridge	26,250	(JICA)
(g)	Orang Asli	325	(USM)
(h)	Forest reserve	0	*2
	Total	106,956	

*1 Quantities and unit rate estimated by USM for the Lebir river basin were adopted.
No compensation was considered for plantations assuming that after harvesting an equivalent plantation is provided in the relocation area.

*2 No compensation was considered assuming that the timbers having commercial values are clear felled and transported outside the reservoir area before impoundment. However, when losses of production in future are to be considered and compensated, an amount of some 0.8 million M$ per annum which corresponds to the total yield of 7,900 ha forest areas to be inundated, at the current timber price level, may have to be considered.

Besides, the breakdown of compensation costs proposed as the final report of JICA Study Team is shown in Table 11-13-8.

11.13.3. Candidate Site for Resettlement

In terms of the candidate site for resettlement of the people living in the inundation area, there is no definite site found at present. However, the USM Sub-study Report gives the following suggestions:

(1) Small plots dotted over the southern part of Gua Musang are provided for the Lebir riverine settlers (about 100 households).

(2) Prospects of extension northwards of the existing Ciku plantation are sought for the settlers in the land development area.

It is considered possible to develop rubber plantations on a slope of up to about 30°.

(3) For 144 people of Orang Asli, it is suggested to make them settle by groups near the Malay settlement areas, and it is an adequate policy to make them assimilate little by little to Malay society.

It is also considered possible to support the livelihood of some hundred households if the aquaculture industry using the Lebir reservoir as mentioned in Section 11.11. was developed and operated by the land development authorities.

11.14. Costs for Messures on Environmental Impact

The USM Sub-study Report proposes various measures to cope with the environmental impact caused by the Lebir Dam Project. Based on those proposals and adding some items as deemed necessary, the JICA Study Team estimated the cost required for measures on environmental impact as follows:

Item	Amount (M$ 10^6)
(1) Hydrological telemetering and discharge warming systems	7.93
(2) Relocation of animals	1.52
(3) Felling and clearing within the reservoir	0.792
(4) Construction of fish ladder (tentative plan)	1.407
(5) Construction of re-regulating pondage	1.900
(6) Others (afforestation, water quality monitoring, etc.)	2.0
Total	15.549

The pipe at the bottom of the dam to release the river maintenance water was estimated as a part of the dam's permanent structure.

The basis adopted for computation of each item is explained as follows.

(1) Upstream hydrological telemetering and downstream discharge warning system

Costs of equipment and installation are estimated as follows.

- Hydrological telemetering system (1 Main Receiving Station, 12 Automatic Rainfall. Gauging Stations, 3 Automatic Water Level Gauging Stations and 4 Telemetering Relay Stations)	M$ 2,960,000
- Discharge warning system (1 Main Sending Station, 13 Siren Warning Broadcasting Stations, 13 Voice Warning Broadcasting Stations and 2 Radio Relay Stations)	M$ 4,170,000

- Dam data management system M$ 800,000
  (1 unit of Data Management System, 1 Automatic Reservoir Water Level Gauging Station and 1 unit of Auxiliary Power Source System)

(2) Relocation of animals

Referred to the USM Sub-study Report (Page 83).

(3) Felling and clearing within the reservoir

Assuming that valuable and commercial timbers within the reservoir area are felled and cleared by the Forestry Department of Kelantan, M$330/ha was used in calculation as a cost for clearing the remaining unvaluable trees in some strategic or critical areas selectively covering 2,400 ha out of the total forest area of 7,900 ha.

(4) Construction of fish ladder

Fish ladder with a natural flow waterway type is tentatively proposed to be constructed near the spillway at the left bank of dam, but subject to further detailed investigation of specific migratory species and/or spawning areas. The following are its main features. (Refer to Fig. 11-14-1)

Intake portion	:	Multistage type
Intake range	:	EL.80.0 m - EL.60.0 m
Length	:	200 m
Profile	:	2 m x 2 m
Waterway portion	:	Slope of 10%
Length	:	550 m
Profile	:	2.0 m x 2.5 m

The breakdown of the construction cost is shown in Table 11-14-1.

(5) Construction of re-regulating pondage

A concrete weir of the natural overflow type is proposed to be constructed at about 300 m downstream of the Tualang Bridge in the Lebir River.

Height of weir	:	5.4 m
Crest length	:	150 m
Quantities for construction	:	Excavation 10,000 m^3
		Concrete 10,000 m^3
Construction cost	:	M$ 1,900,000

(6) Others

This item includes the following measures.

(a) Afforestation of the reservoir bank for protecting surface soil against erosion.

(b) Water quality monitoring

(c) Preservation of valuable flora

(d) Monitoring on public health

(e) Education and training on environmental preservation for the people to be involved.

(f) Assistance in preparation for the aquaculture industry, etc.

However, the construction cost of a check dam for protecting against an inflow of silt are not included, because its necessity is not yet confirmed.

The breakdown of foreign and local costs for environmental measures are listed below.

Item	Foreign Cost x 10^6 M$	Local Cost x 10^6 M$
i. Upstream hydrological telemetering and downstream warning systems	7.69	0.24
ii. Relocation of animals	0	1.52
iii. Felling and clearing within the reservoir	0	0.792
iv. Construction of fish ladder	0.7035	0.7035
(5) Construction of re-regulating pondage	0.95	0.95
(6) Others	0	2.0
Total	9.3435 (60 %)	6.2055 (40 %)

During the discussions of the draft final report, a question of abandonment plan of the Lebir dam project, whether considered, was raised by DOE.

The JICA Study Team is of the opinion that no such abandonment of this project can be expected because the life span of a dam is usually very long, even though it is dependent on its silting condition, and the power generation plant will be operated forever at the maximum extent by rehabilitation when required. For this reason, no abandonment plan has been considered for this project.

11.15. Matrix Table on Environmental Impacts for Implementation of the Lebir Dam Project

The relationship between project activities and environmental factors for the implementation of the Lebir Dam Project is as shown in Table 11-15. Analysis using a matrix was first developed in the United States of America for an environmental impact assessment. However, at present, it tends to be used only for the screening of the environmental impact factors, due to many problems involved in the method. For an extract of the environmental impact factors, different points of view arise of each stage of the project, e.g., at feasibility study stage or at detail design stage. At the feasibility stage, particular attention should be given to assessment of the problems of the project area. During the stage of detail design, there are many separate impacts among the factors to be considered, and in an extreme case, even the air pollution caused by the plant operated during construction.

However, since this is a feasibility study, only environmental changes likely to cause large scale impact are dealt with in detail. Others should be studied during the next stage of design.

In assessing environmental impacts, there are often cases when an adequate forecast can not be made due to lack of data, even at the detail design stage. This happens when the required data has to be obtained over a long period of time and monitoring operations have to be set up. Recourse to monitoring must be taken when a large extent of natural environment could be affected by existence of the project and subsequent corrective measures may be needed.

In the Environmental Assessment Handbook of Malaysia, an example of a matrix table for project activities and environmental factors is given. However, this example refers to various project stages and adopts fairly detailed itemizations. Therefore, it is difficult to use for screening to extract the environmental factors. For this reason, several adjustments have been made to simplify the sample table given in the handbook. Twenty six items for the project activities and 40 items for the environmental factors are listed in the matrix table. "O" mark was put in the related items, but in fact these indications have a compound relation.

Items studied in the Environmental Impact Statement (EIS), which was presented previously, mainly dealt with large scale visible impacts in the project area due to the implementation of the project. Though it is anticipated, for example, that air pollution due to the transportation of construction materials by dump trucks and the operation of heavy equipment will be caused, such items are more effectively settled in the project implementation stage. Therefore, EIS excludes studies on these impacts. In general the items studied in EIS are in terms of visible impact, the size of the area affected, forecast of adverse impact on human life, etc. These items are classified into impacts on fauna and flora, water environment, resettlement and public health. (The base line study on the public health is not yet completed.)

11.16. Environmental Monitoring Programme for the Implementation of the Lebir Dam Project

11.16.1. Objective of the Monitoring

A large reservoir area to be created by the dam construction will not only submerge habitats of many fauna and flora, but the newly created water environment will cause changes in water quality due to the retention time provided by the large storage capacity of the reservoir, and to biochemical reactions within it, consequent on the creation of the storage. The mitigative measures to cope with these environmental changes are as set out in other Sections of this report.

Reliable forecasts of the effects of the environmental changes associated with the implementation of the Project cannot be made with accuracy on the basis of present scientific data and information.

In particular, water quality, including the effect on aquatic life caused by creation of the reservoir, and the response to changes in land use in the upstream mountainous area, are uncertain. The adaptability to the new habitat of fauna is also difficult to predict with certainty.

As the water level rises after the commencement of impounding, large quantities of nutrients may be released into the water from the previously cultivated soil areas and submerged vegetation, giving rise to the growth of oxygen consuming organisms. This could result in a steady decline in the oxygen content of the water stored in the lower levels of the reservoir, and high levels of BOD and COD. Excessive release of nutrients could lead to extremely low levels of dissolved oxygen, and cause eutrophication of the impoundment with its associated deterioration in water quality. This situation may however only be temporary once the supply of nutrients from the flooded land has been depleted. Subsequent water quality conditions will depend on measures taken to reduce to inflow of nutrients to the reservoir from the catchment.

The initial problems can also be mitigated by early implementation of the measures within the reservoir, recommended in this report.

However, depending on the water quality and aquatic life, a potential for the development of an aquaculture industry can be expected.

For the future planning of this development, a monitoring programme is necessary to provide better information about present conditions and how these are changed by implementation of the Project.

First, changes in water quality within the river basin and the related behaviour of the aquatic-ecosystem should be studied.

(1) Erosion of land in the catchment area results in siltation of the reservoir and the deposition of other undesirable matter including nutrients. If the area around the reservoir could be kept as forest reserve both these effects would be reduced, and in particular, it would be very beneficial from the point of view of water quality and the control of eutrophication.

(2) The most significant water quality problem within the reservoir is not the temporary deterioration resulting from impounding. The temporary changes of water quality immediately following impounding, arising from the discharge of nutrients remaining in the inundated land, cannot be avoided. However, if the provisions of para (1) above were carried out, nutrients remaining in these areas surrounding the reservoir would be gradually washed out by rainfall and their supply to the reservoir gradually reduced. Action should be taken, to avoid a long term accumulation of nutrients in the reservoir since it could take a long time to dissipate these.

(3) A further source of nutrient supply is from land developments upstream of the reservoir. Inflow and land development should be monitored and studied with the aim of limiting the inflow of nutritious salts.

(4) In the scope of the water quality monitoring, the following items should be included.

(a) To obtain data on present water quality and aquatic life and similar data from the reservoir, including the mechanism of internal production (eutrophication) together with measurement of nutrient inflow to the reservoir.

(b) To simulate the above results using the forecast model of water quality.

(c) To study by sensibility analysis, measures necessary for the improvement of water quality.

The policy on the land development in the future can be established based on the result of the above monitoring, and the necessary information for the aquaculture industry is also provided from these results.

Secondly, the land ecosystem should be carefully studied. As the habitats of much fauna and flora will be inundated. The scope of monitoring should include studies on the relocation of wild animals and the life environment of birds having their habitats within the reservoir area. Although Taman Negara and Terengganu State are considered as the proper sites where the rescued and relocated large mammals can be rehabilitated, monitoring of their living status and numbers is recommended to continue even after their relocation.

A further item relates to mineral resources. Geochemical and geophysical survey data indicated prospects of mining U, Mo, Pb and Zn in the general area in which the reservoir will be sited. The prospects of economic working of deposits were however only assessed as small. Also in our EIS for the Lebir Dam Project a reconnaissance survey for gold was recommended, as the geological structure in the area appears favourable to its presence. If it is intended to follow up the earlier recommendations to obtain better information of what may lie below the reservoir area, this should be done before *impounding of the reservoir. (Refer also to Section* 11.9.).

The above are the main points of monitoring for the natural environment. In addition to this, since the agricultural development and forestry are being carried out actively in the proposed project area, a follow up in the form of monitoring with regard to these industries is inevitably required by the agencies concerned.

Although it is presently considered that no archaeological remains exist in the project area, an immediate follow-up investigation would be required if valuable remains were found at the stage of project implementation.

As indicated above, monitoring followed by environmental assessment covering natural and socio environment, is required to remove present forecasting uncertainties. However, in the execution of this monitoring, the methods should be studied not only by NEB, but also by the various agencies concerned, including Fishery and Wildlife Departments, etc. under the coordination of the Department of Environment, since this is a project of both state and national importance affecting a large land area.