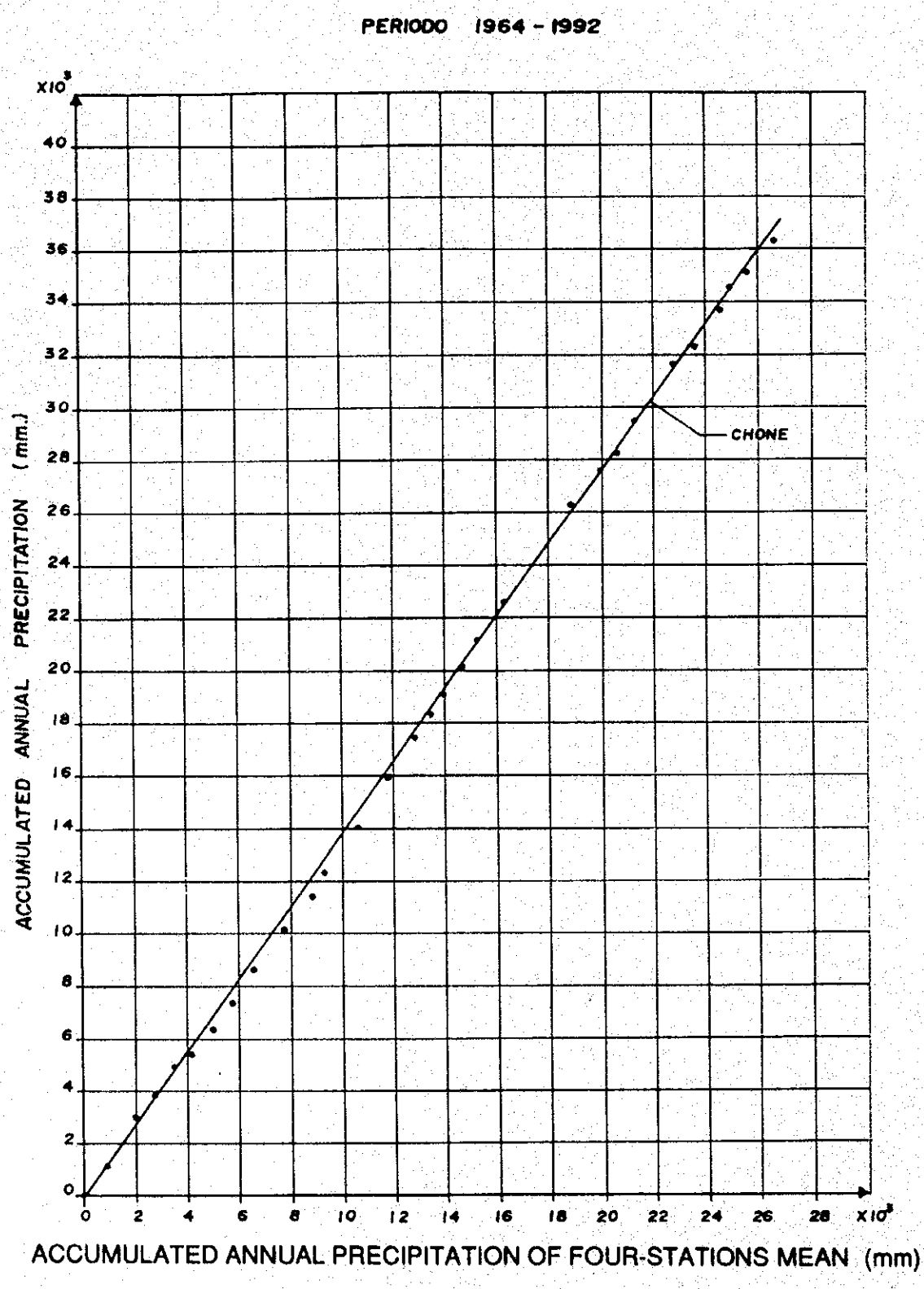
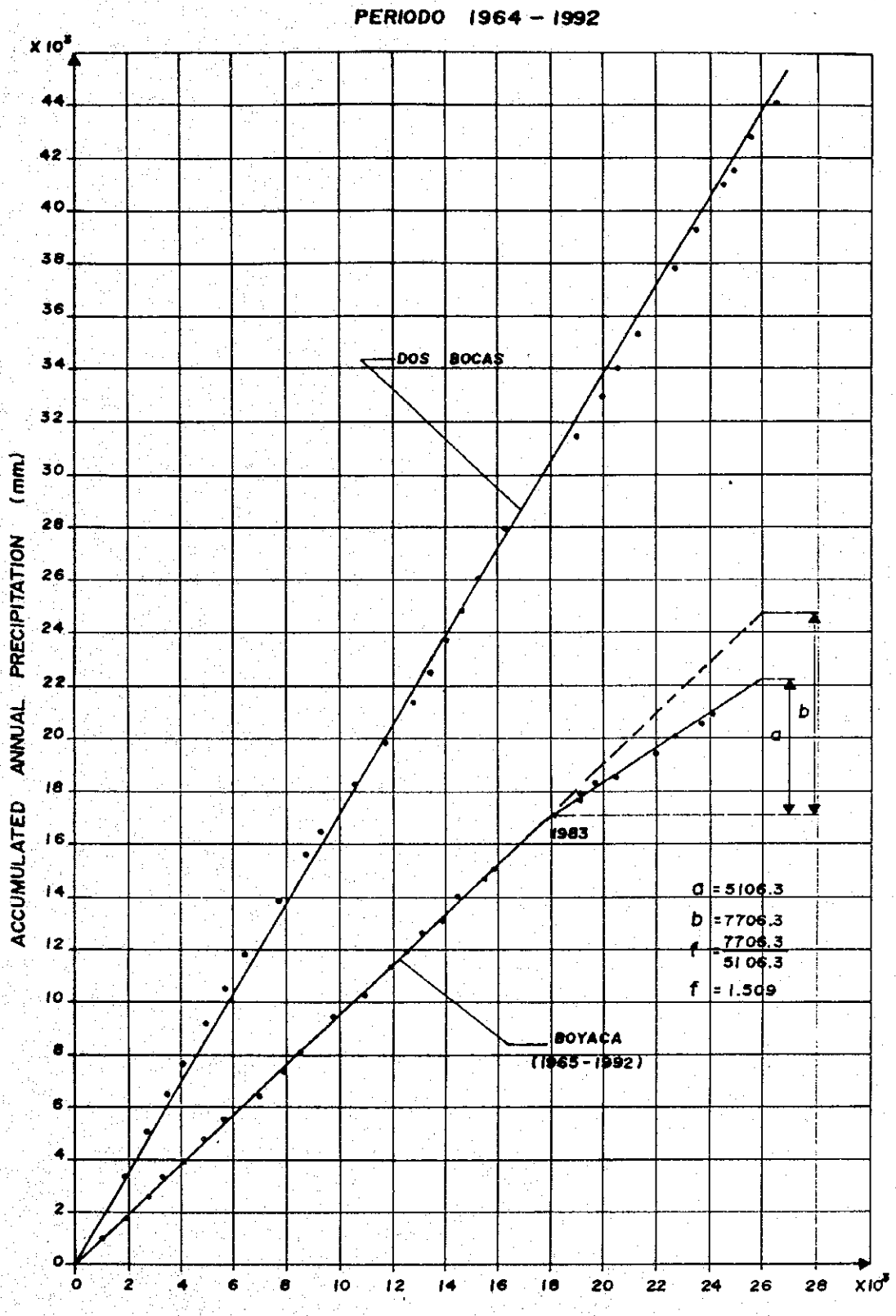
FIGURES

FIGURE 3.1.1



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Double Mass Curve (Chone Station)

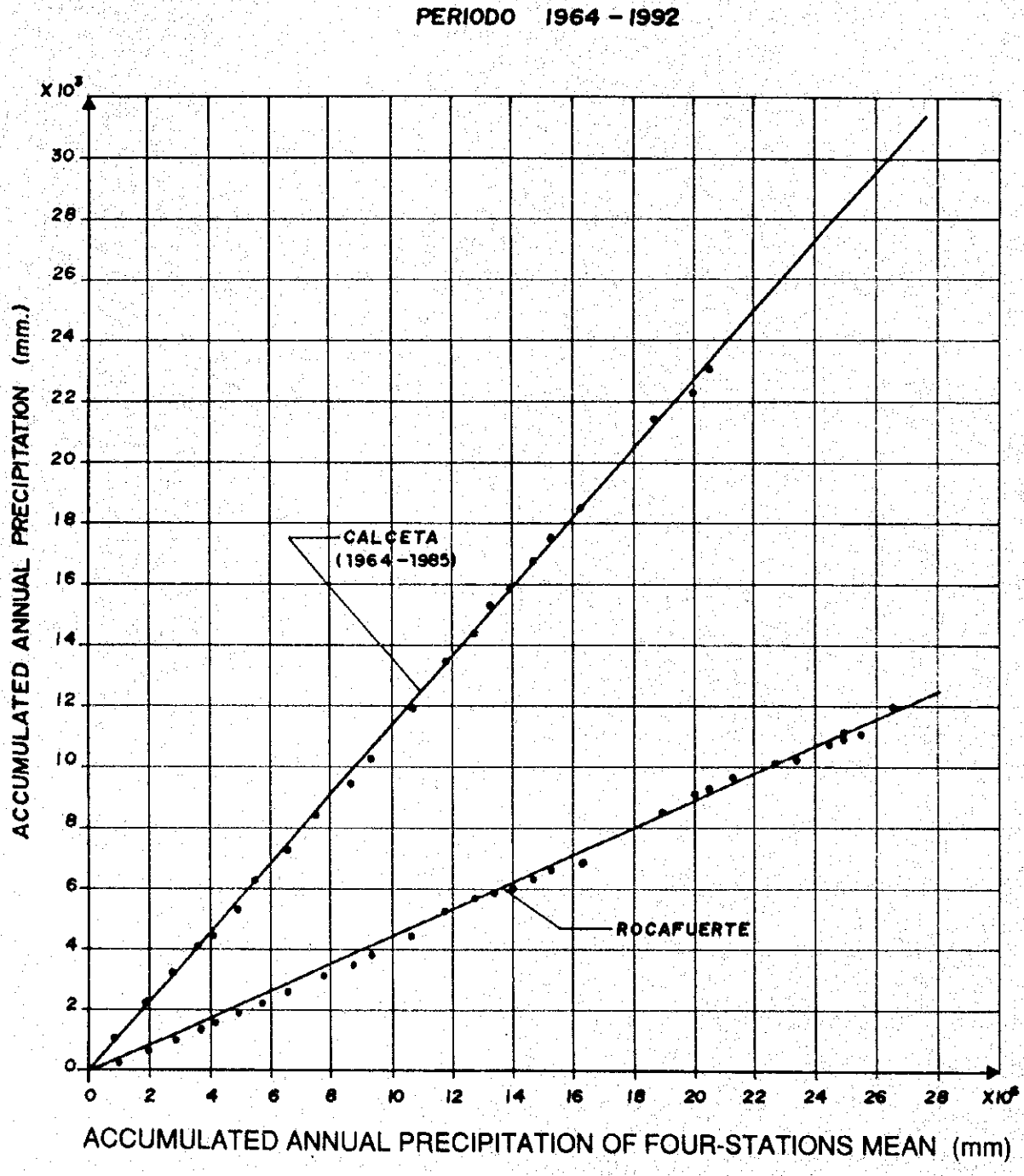
FIGURE 3.1.2



ACCUMULATED ANNUAL PRECIPITATION OF FOUR-STATIONS MEAN (mm)

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Double Mass Curve (Dos Bocas and Boyaca Stations)

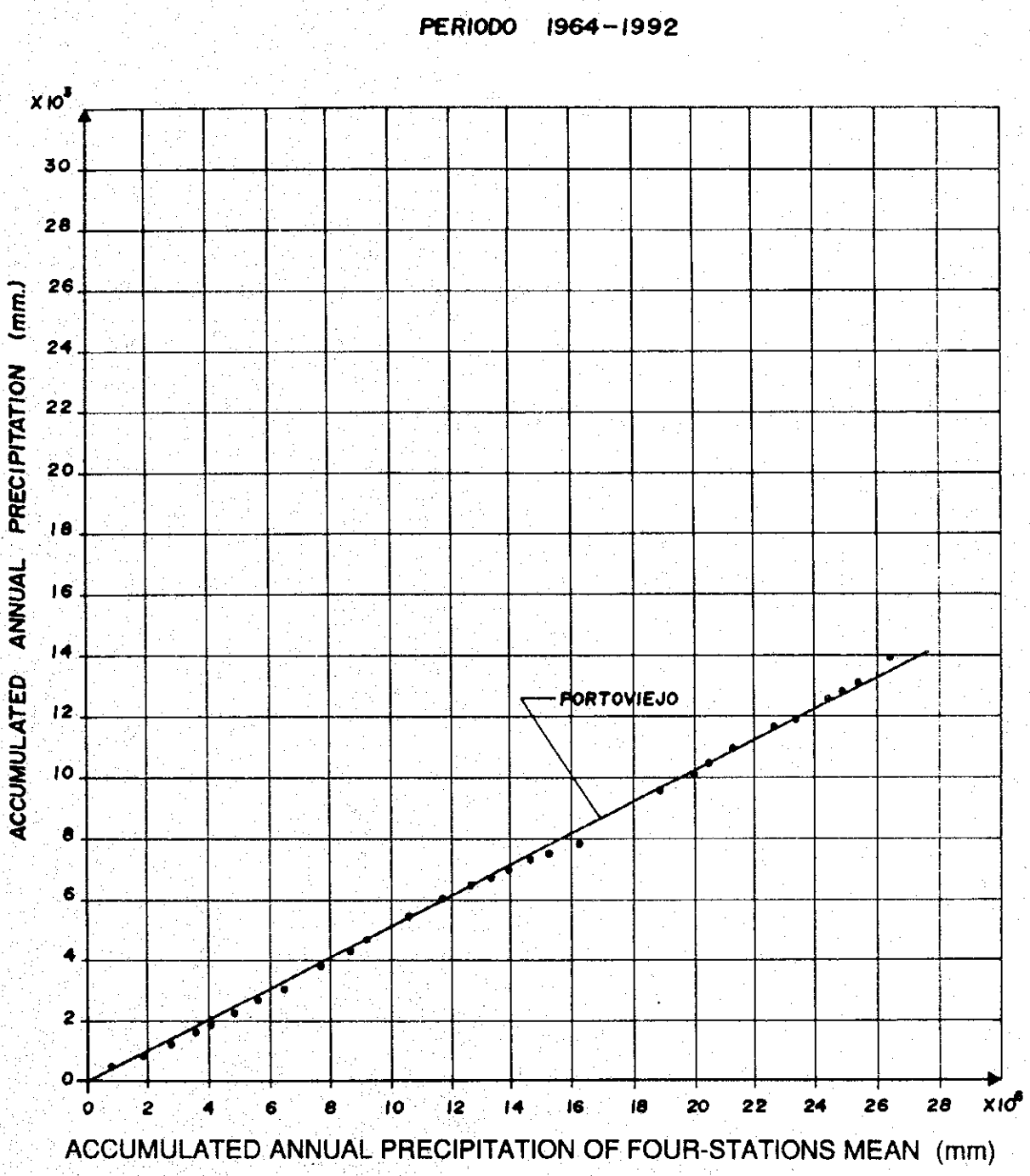
FIGURE 3.1.3



GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

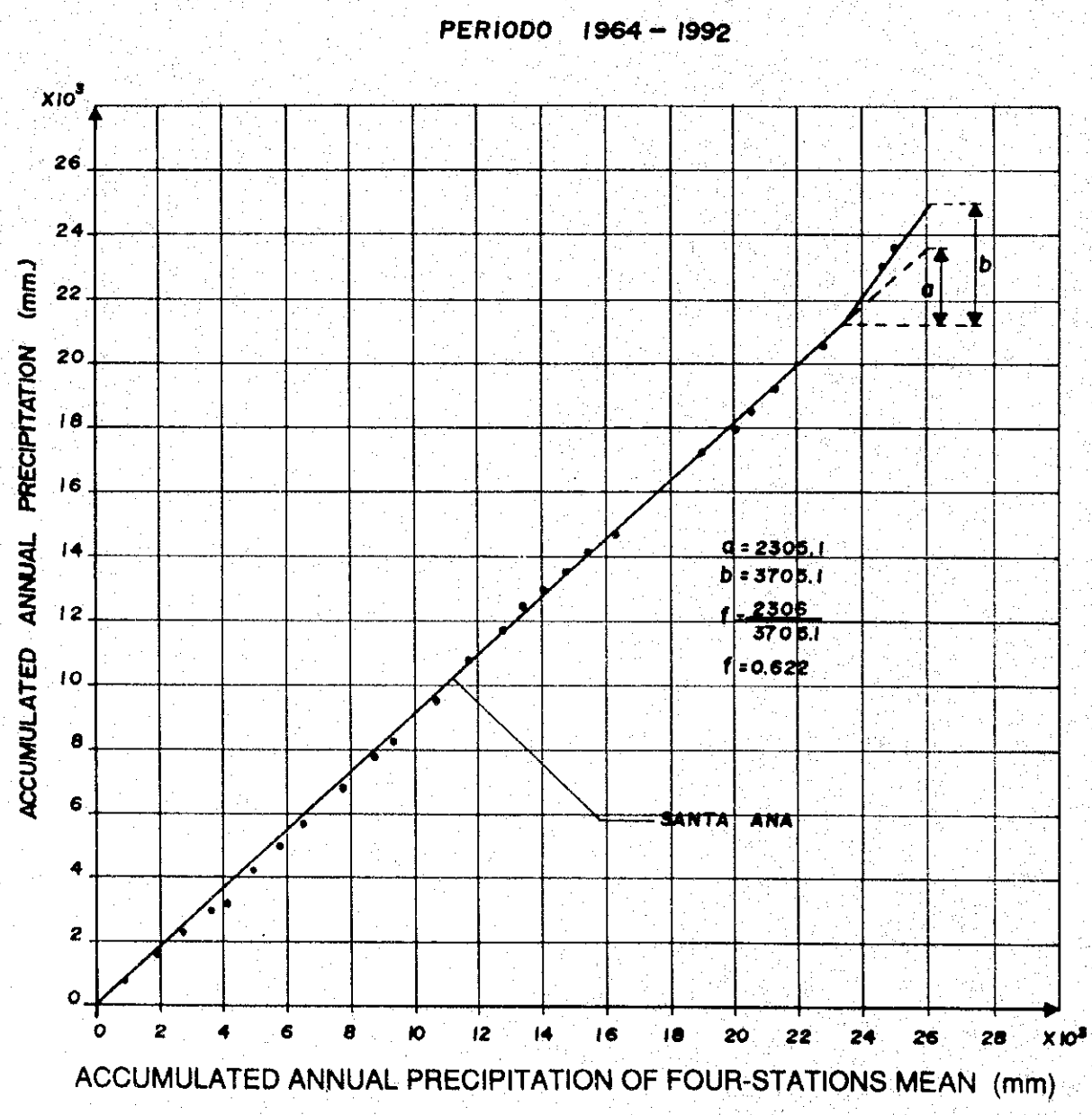
TITLE
Double Mass Curve
(Calceta and Rocafuerte Stations)

FIGURE 3.1.4



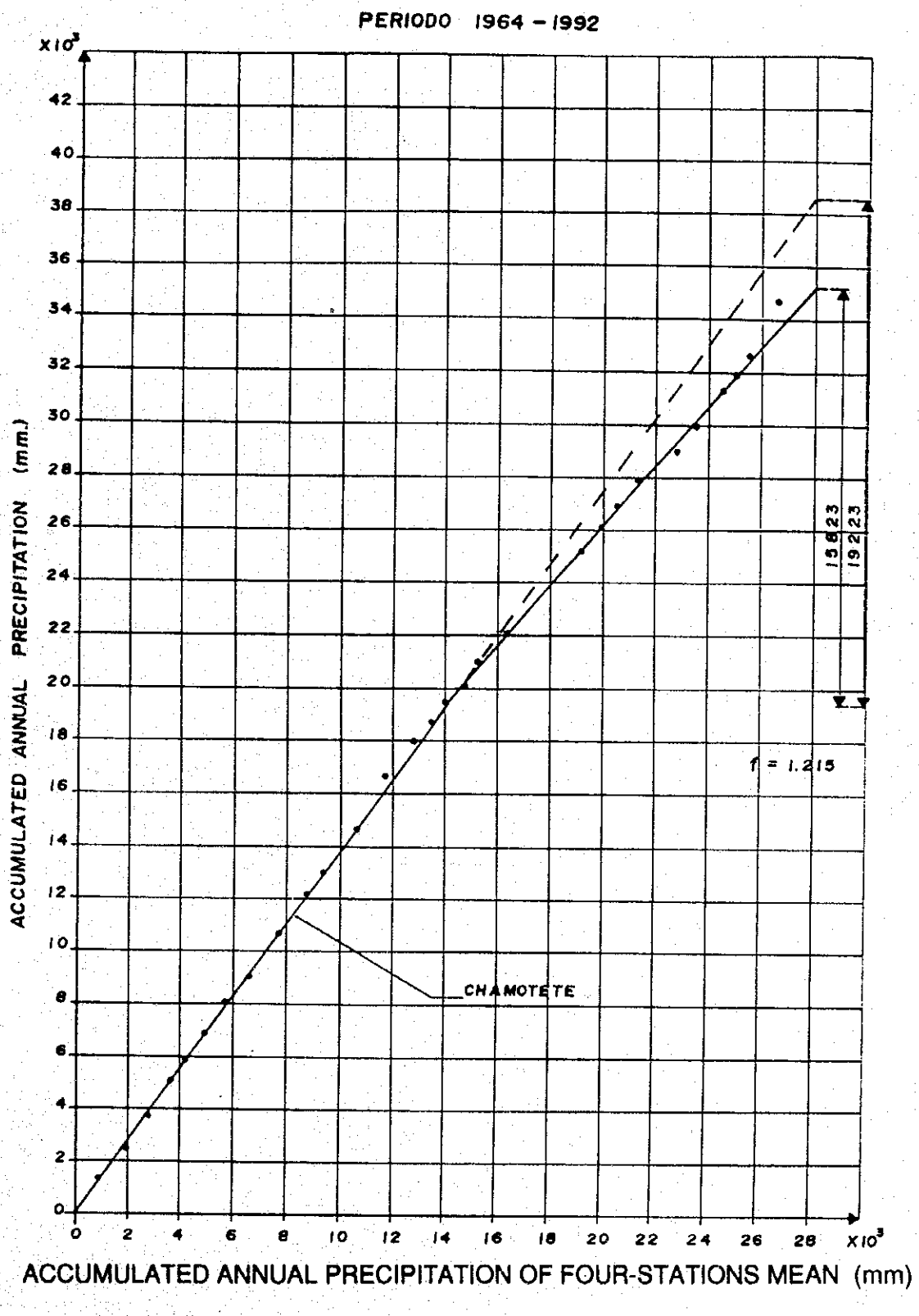
GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Double Mass Curve (Portoviejo Station)

FIGURE 3.1.5



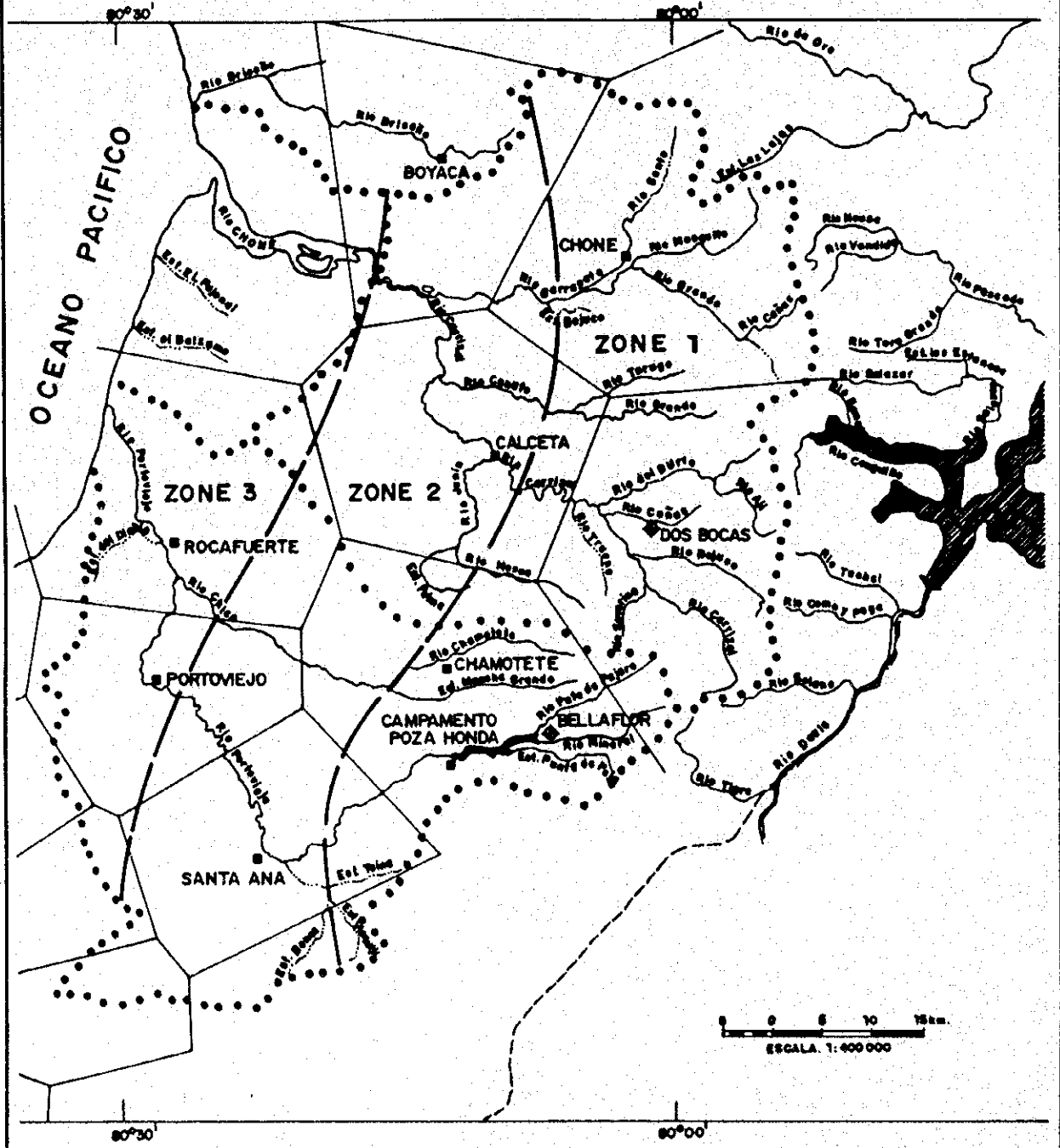
GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Double Mass Curve (Santa Ana Station)

FIGURE 3.1.6



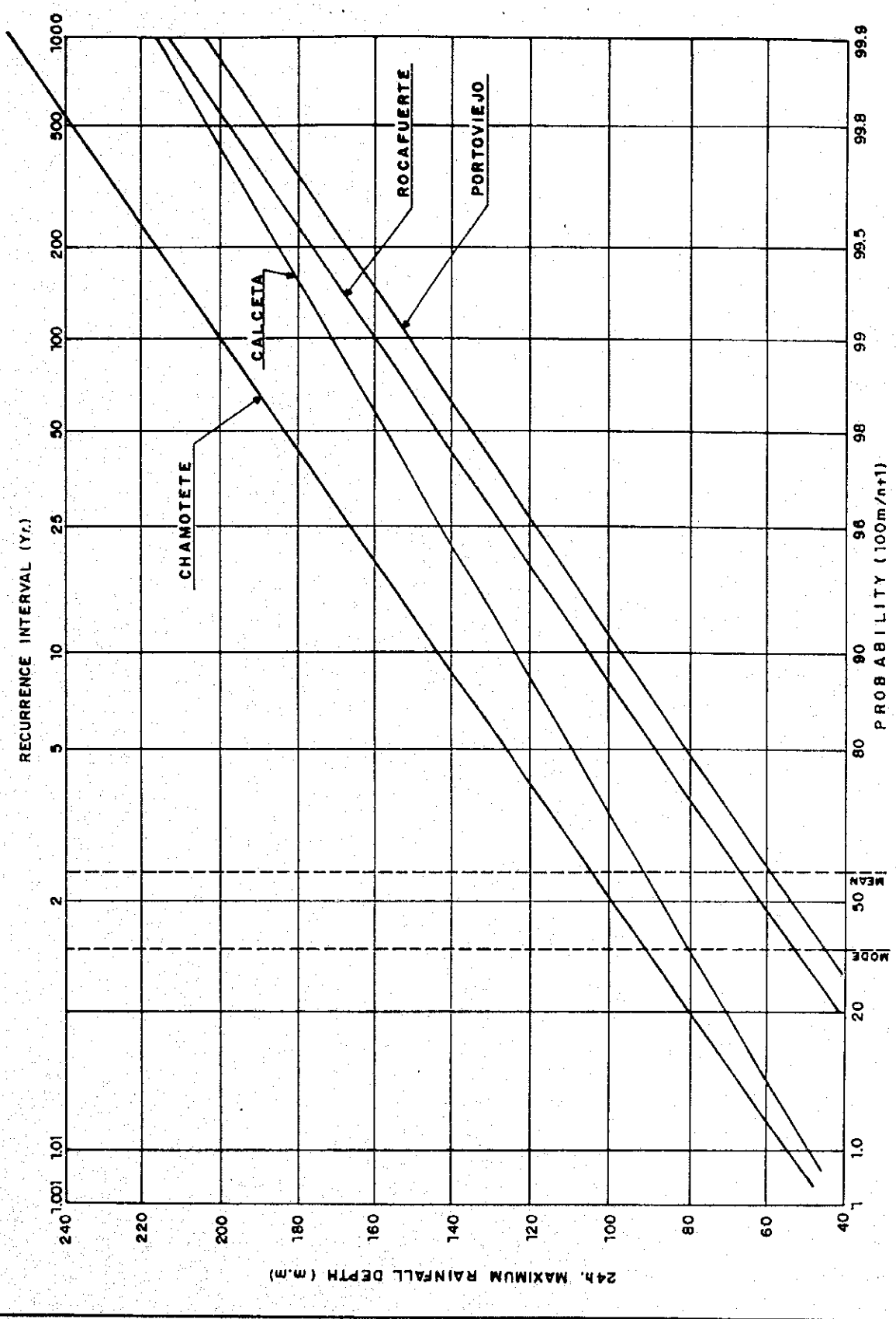
GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Double Mass Curve (Chamotete Station)

FIGURE 4.1.1



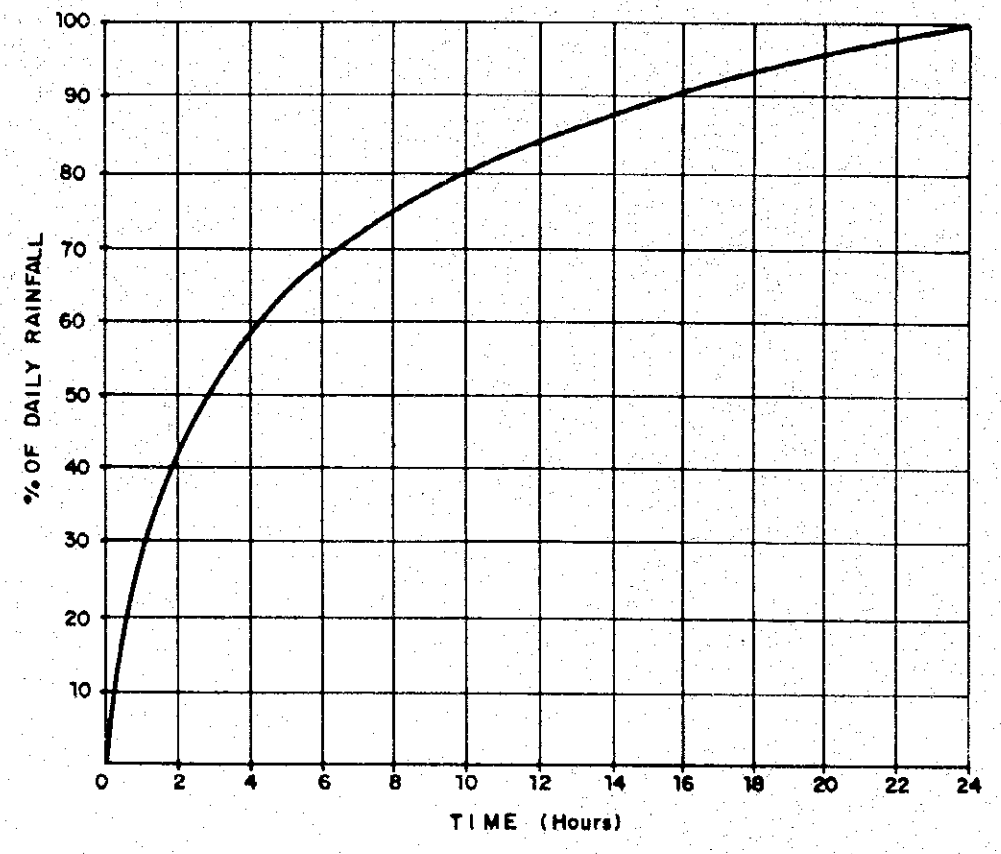
GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Zoning of Rainfall Intensity

FIGURE 4.1.2



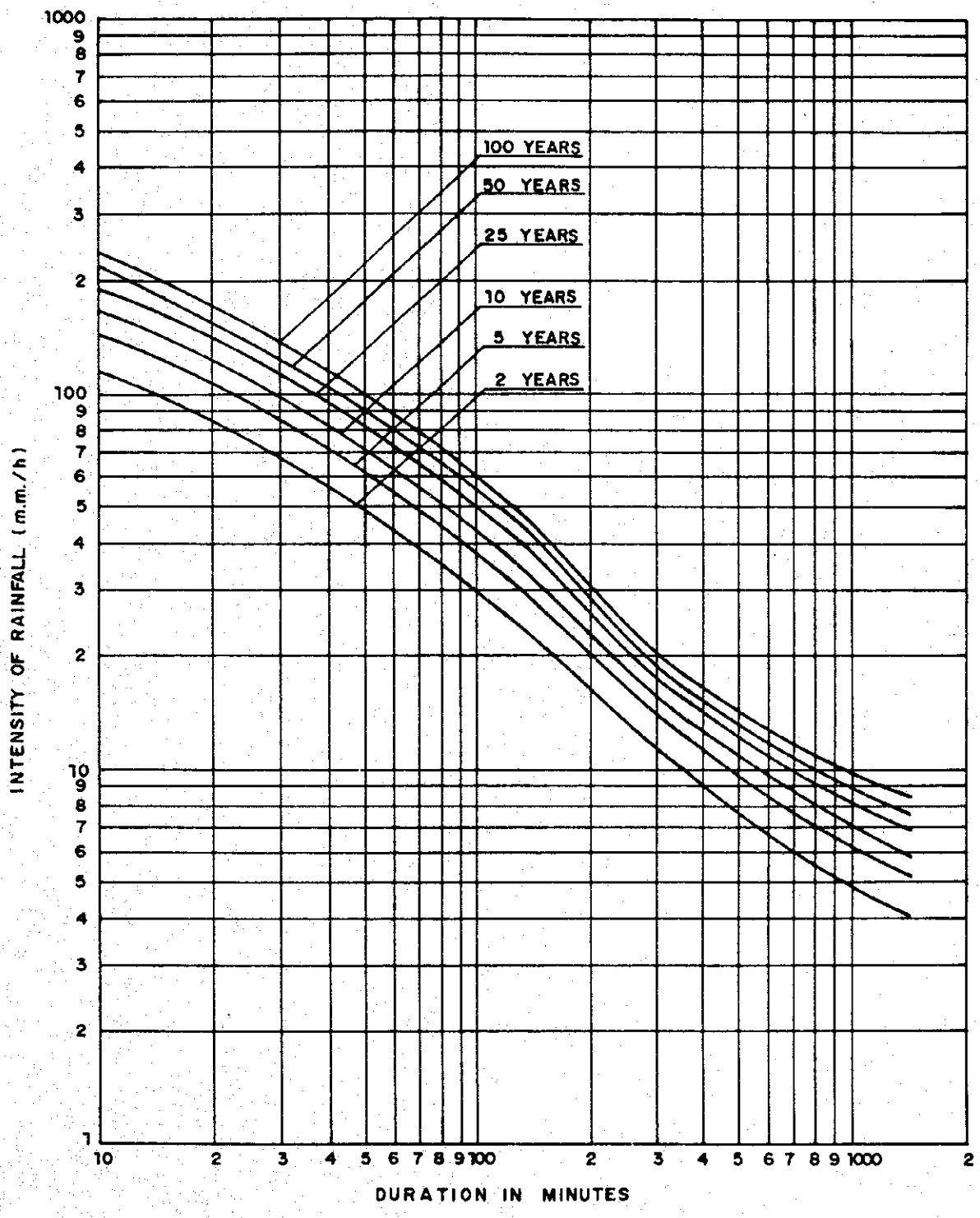
GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Point - Frequency Curves

FIGURE 4.1.3



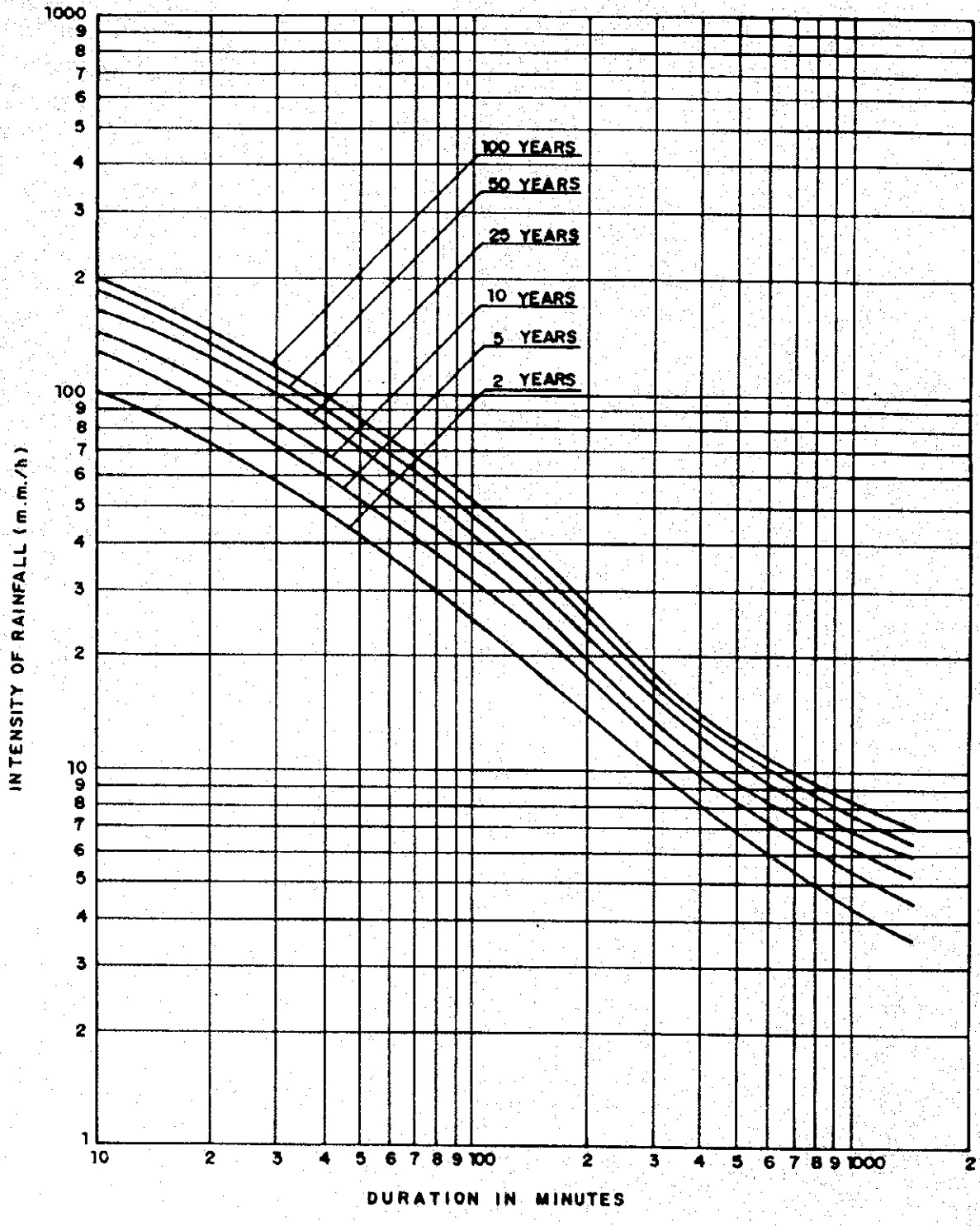
GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Distribution of Daily Rainfall

FIGURE 4.1.4



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Intensity of Rainfall-Duration-Frequency Curves Zone 1

FIGURE 4.1.5



GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)

THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS

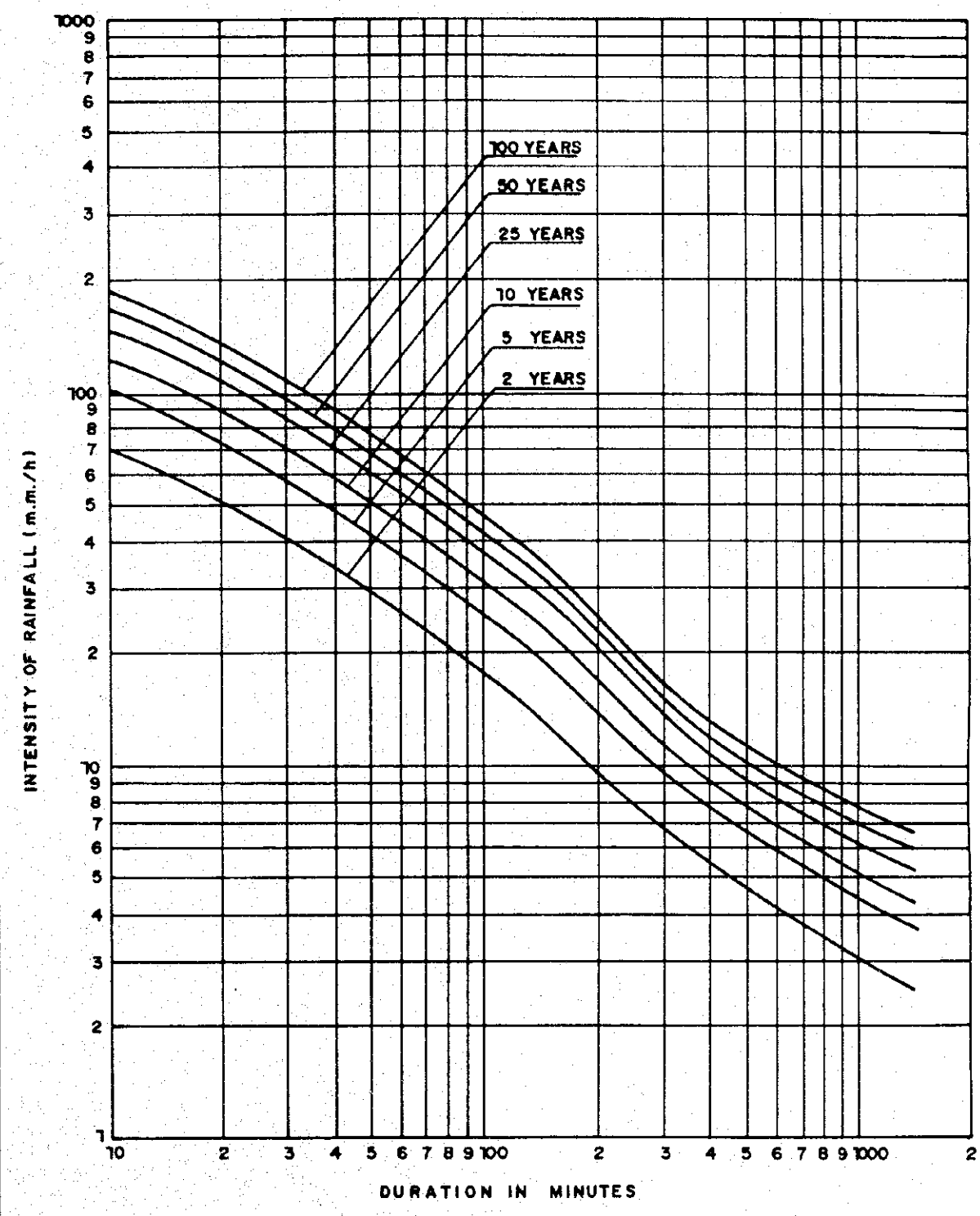
JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE

Intensity of Rainfall-Duration-Frequency Curves

Zone 2

FIGURE 4.1.6



GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)

THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS

JAPAN INTERNATIONAL COOPERATION AGENCY

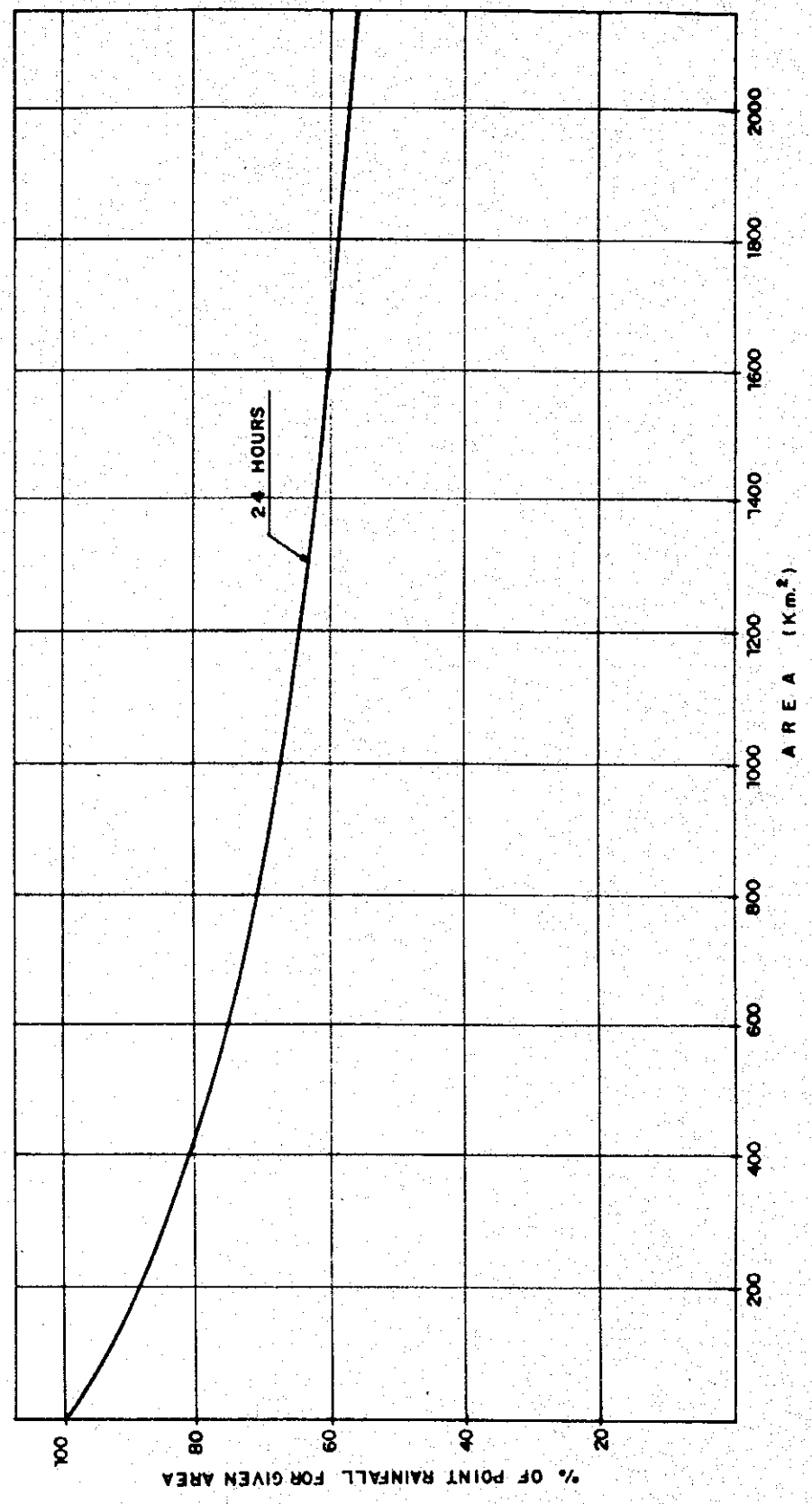
TITLE

Intensity of Rainfall-Duration-Frequency Curves

Zone 3

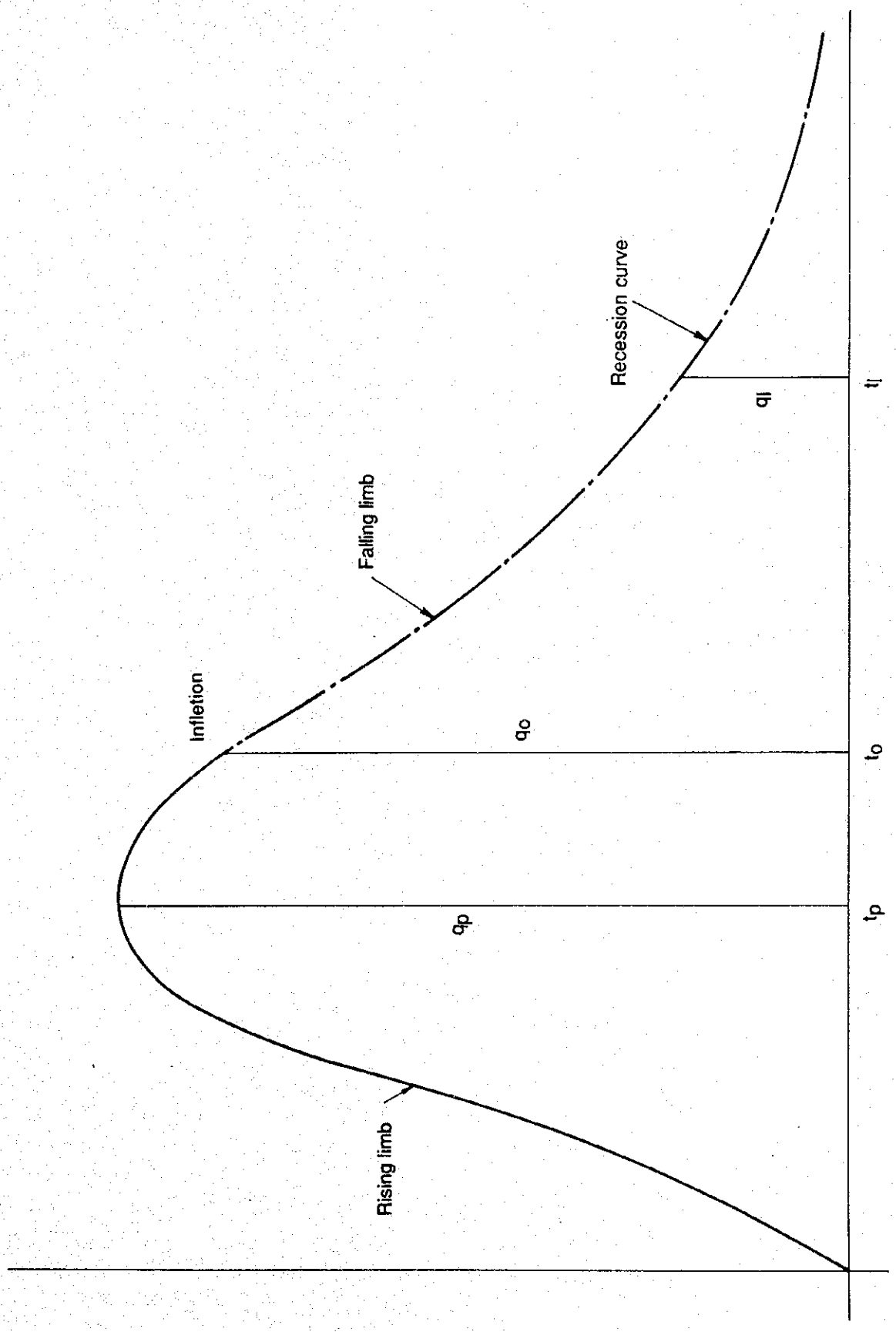
FIGURE 4.1.7

AREAL RAINFALL DISTRIBUTION



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE AREAL RAINFALL DISTRIBUTION

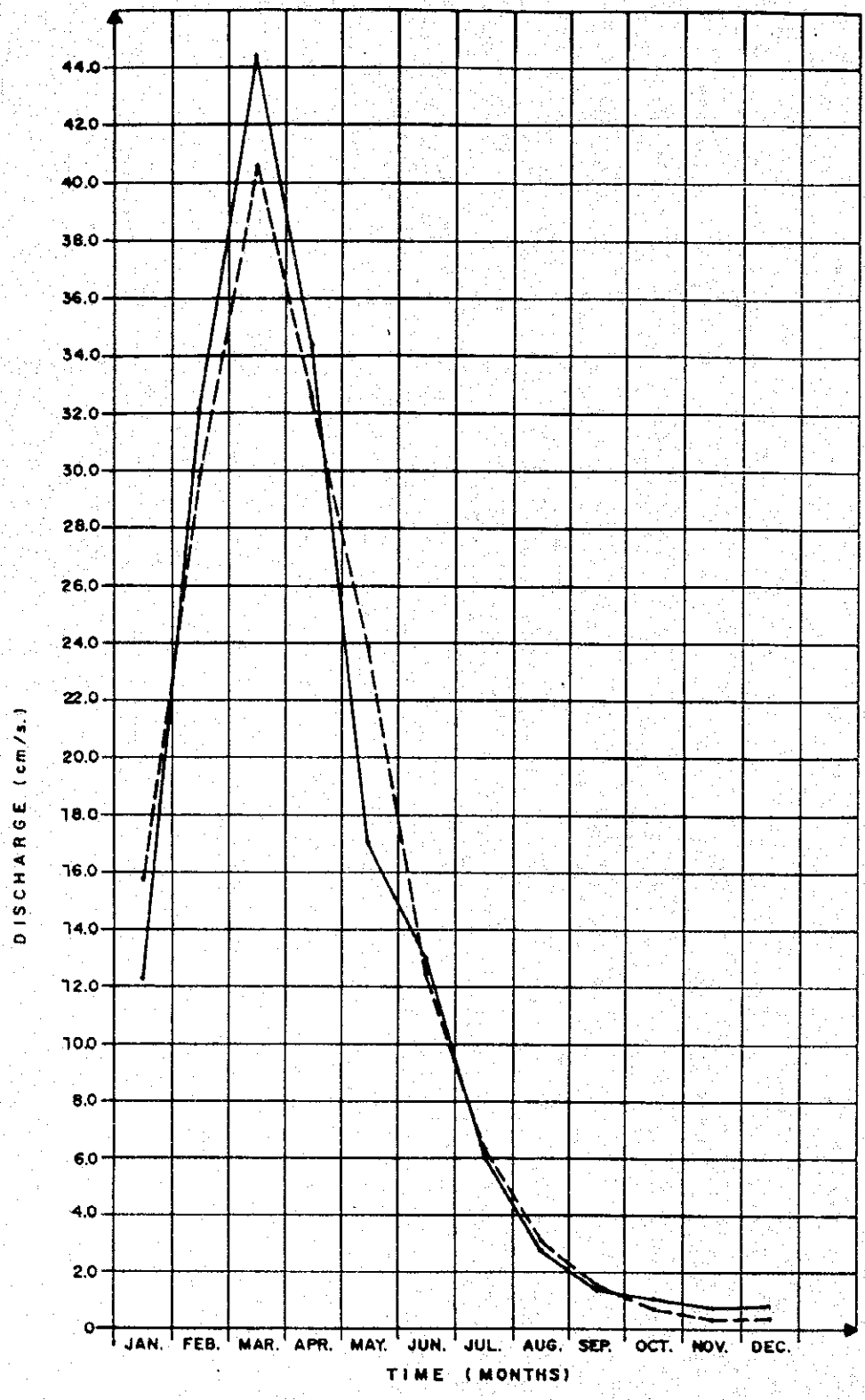
FIGURE 4.2.1



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Theorethical Hydrograph

FIGURE 5.3.1

STATION : CARRIZAL RIVER AT CALCETA

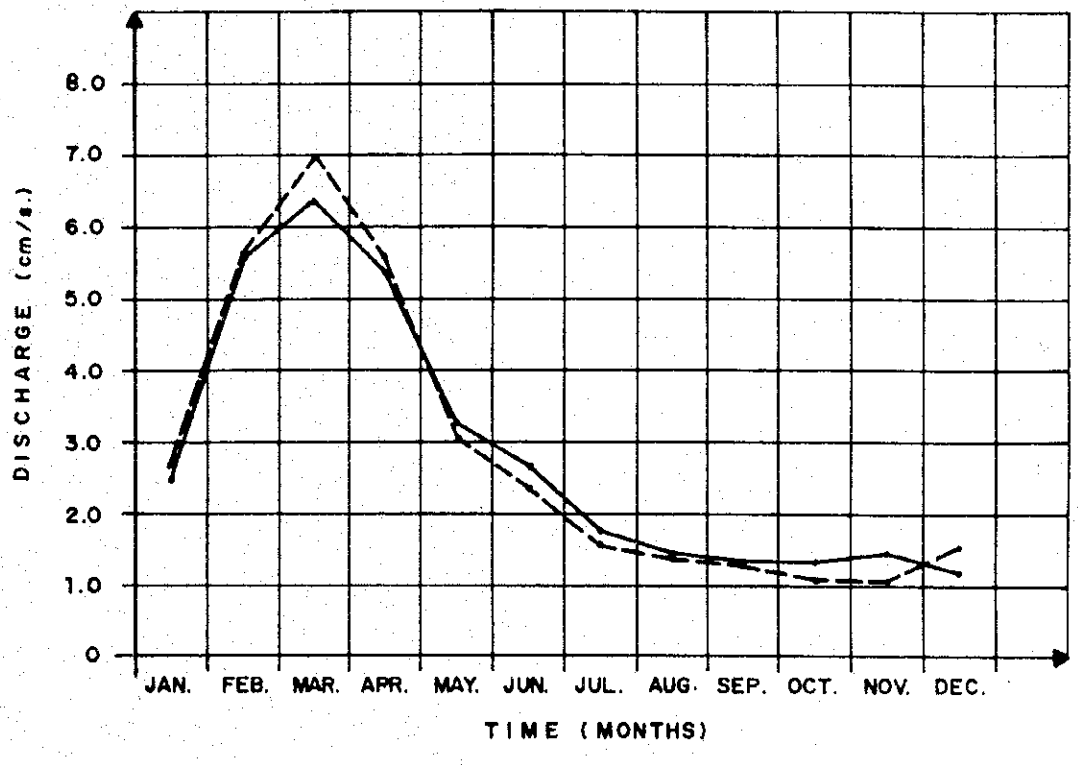


DIFFERENCE = 0.26 %

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fitting of Model at Calceta Station

FIGURE 5.3.2

STATION: CHICO RIVER AT ALAJUELA



——— REGISTERED

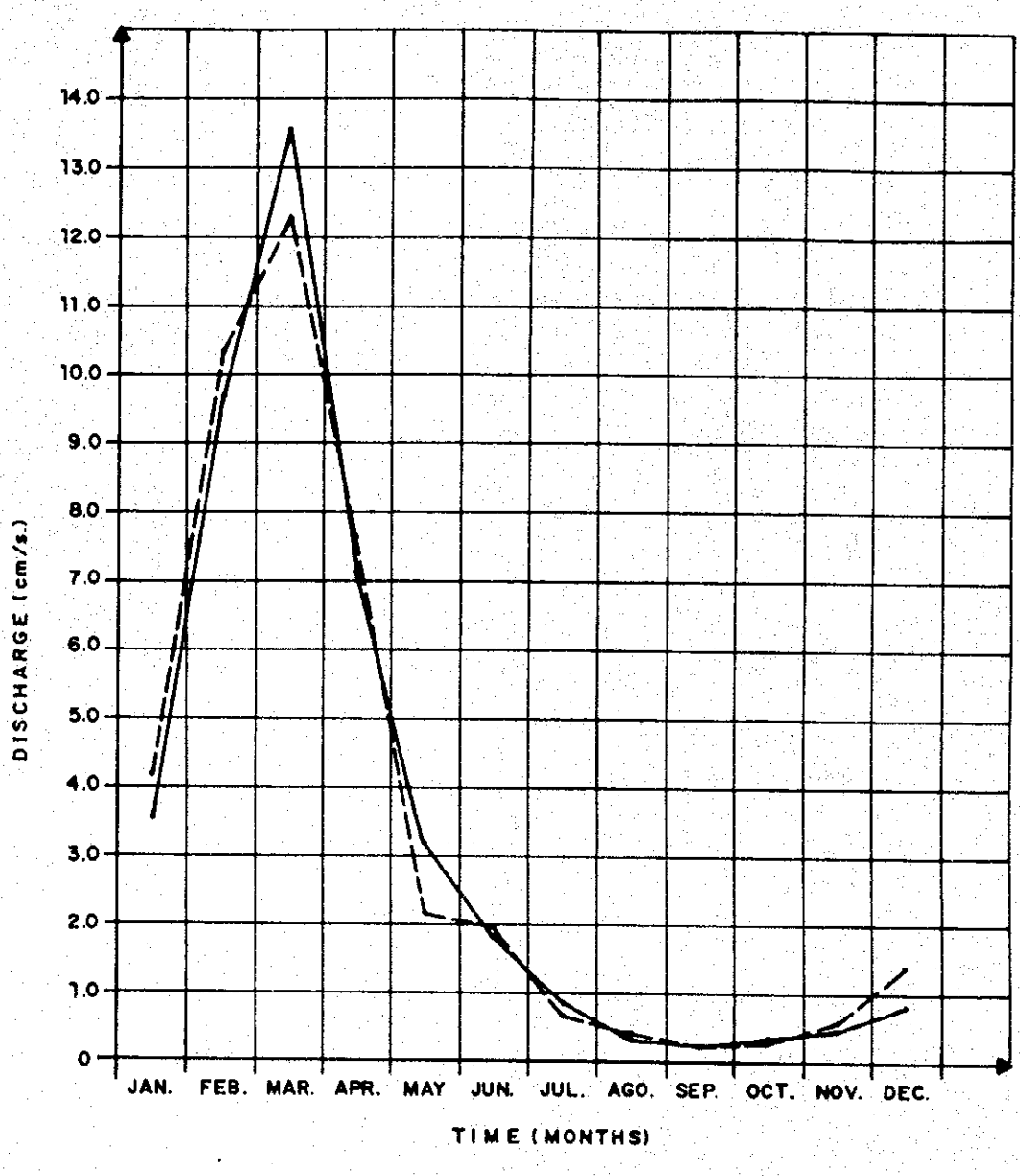
– – – – – SIMULATED

DIFFERENCE = 0.17%

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fitting of Model at Alajuela Station

FIGURE 5.3.3

STATION: GRANDE RIVER AT A.J.MOSQUITO



——— REGISTERED

– – – – – SIMULATED

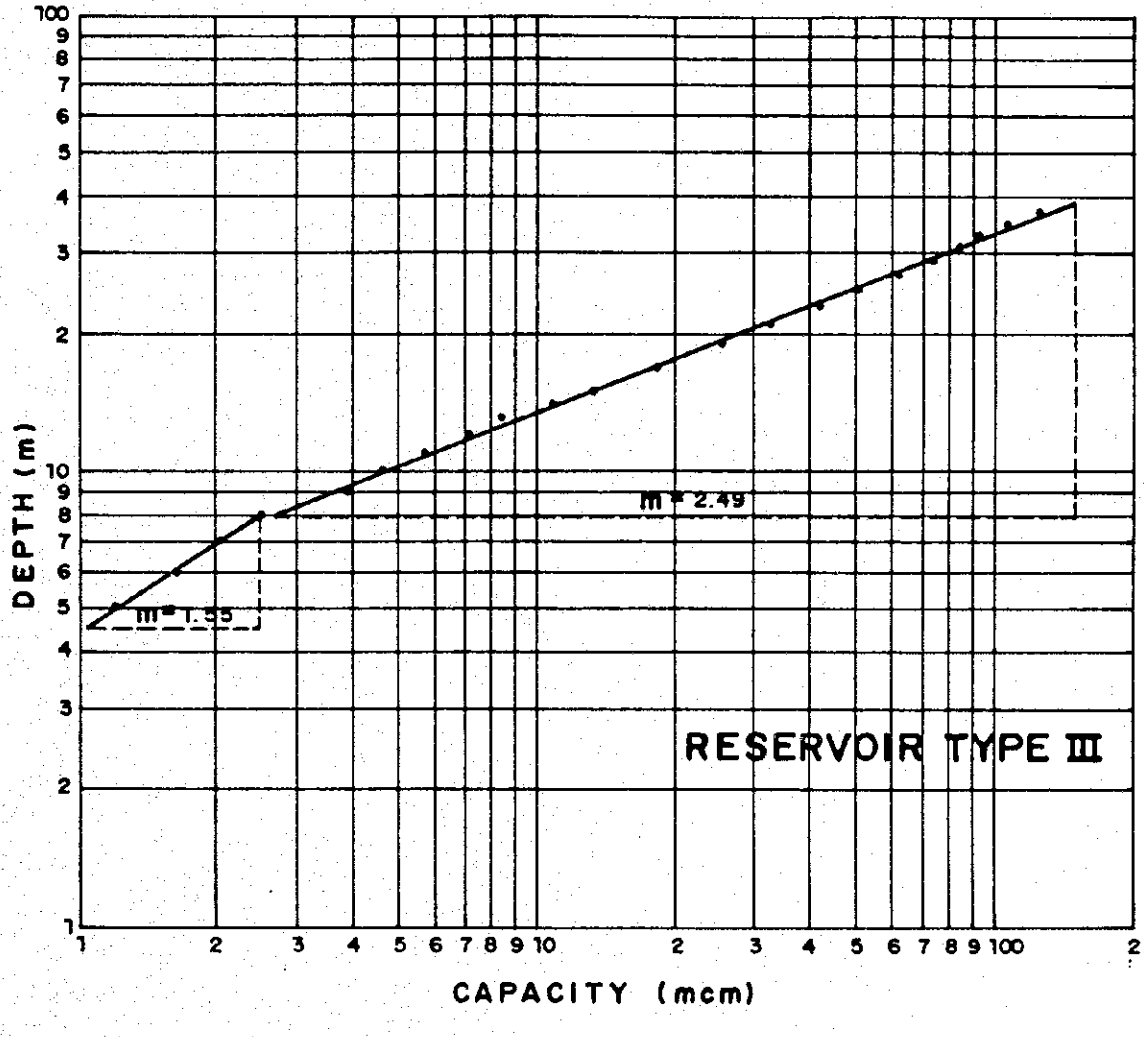
DIFFERENCE = 0.47 %

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fitting of Model at A. J. Mosquito Station

FIGURE 6.3.1

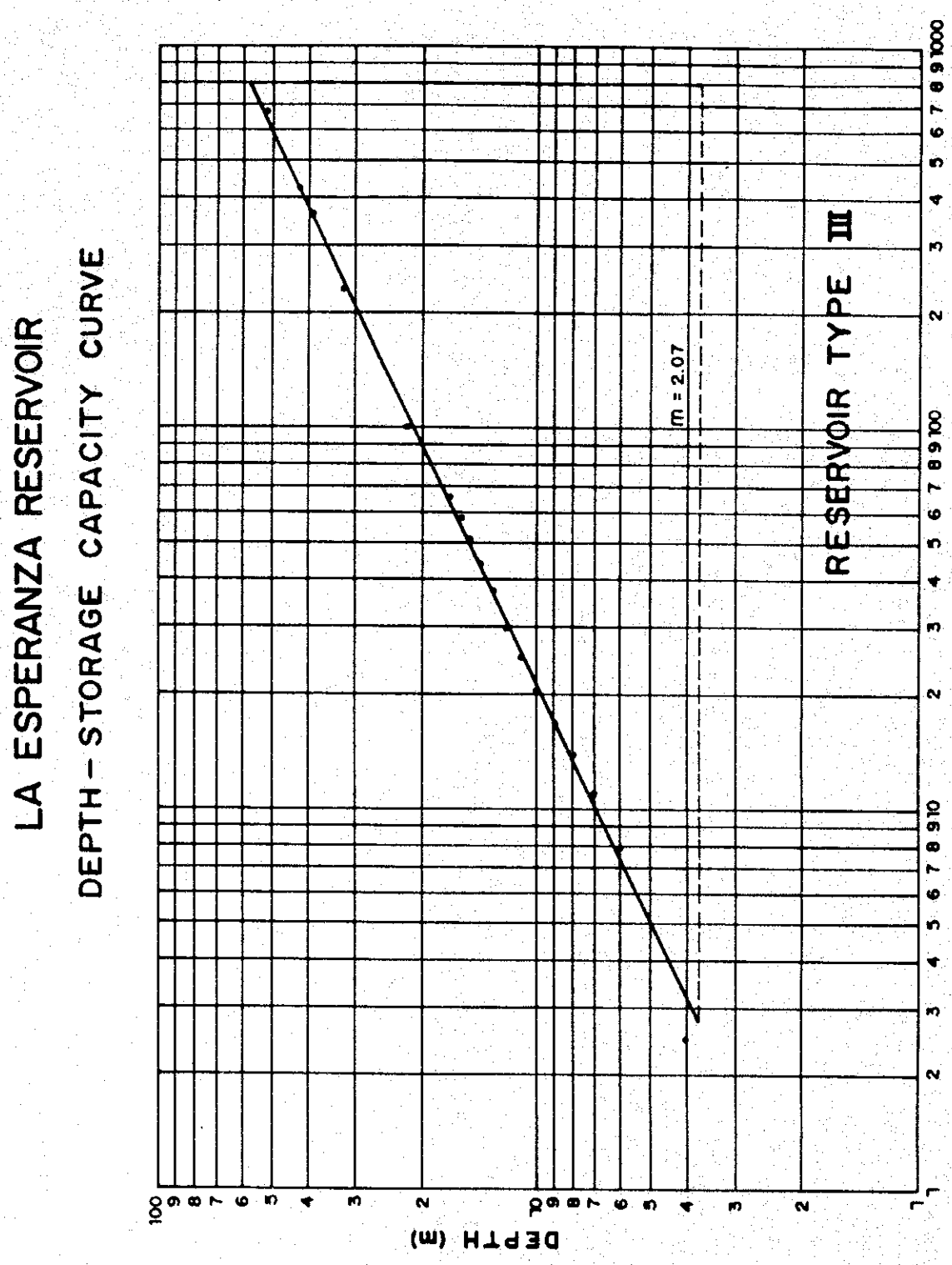
POZA HONDA RESERVOIR

DEPTH - STORAGE CAPACITY CURVE



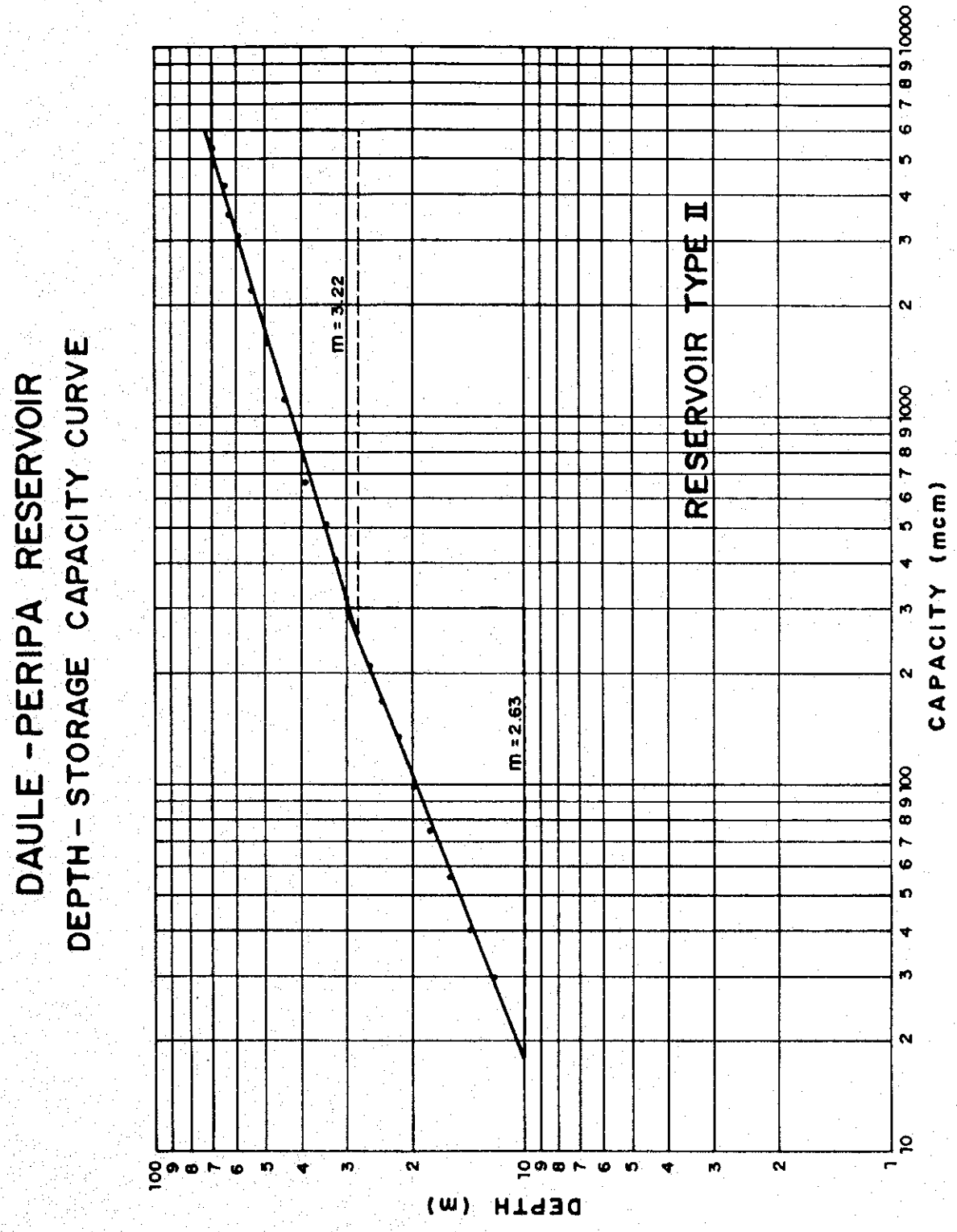
GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Delineation of m for Reservoit Type Classification (Poza Honda Reservoir)

FIGURE 6.3.2



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Delineation of m for Reservoit Type Classification (La Esperanza Reservoir)

FIGURE 6.3.3

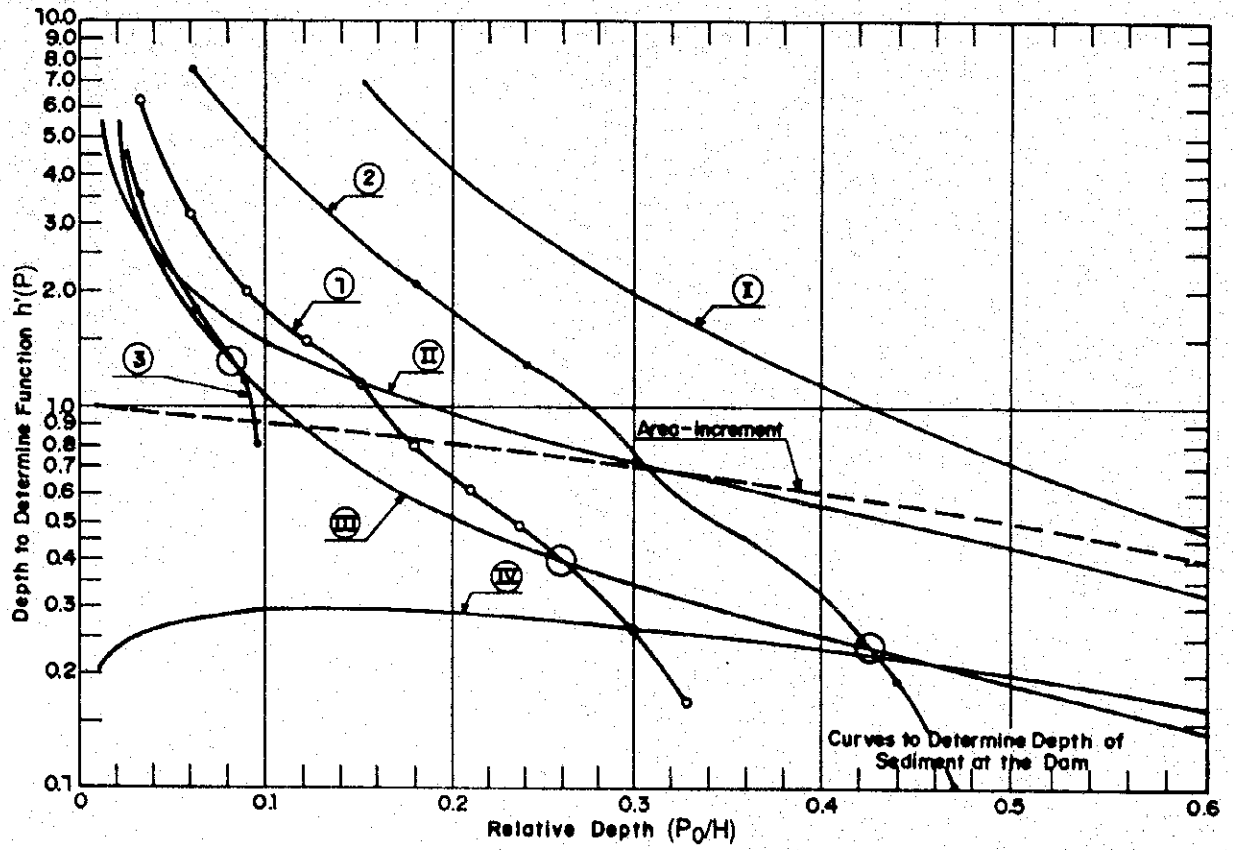


GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Delineation of m for Reservoir Type Classification (Daule-Peripa Reservoir)

FIGURE 6.3.4

POZA HONDA RESERVOIR

(RESERVOIR TYPE III)



P_0 : Sediment Depth

H : Reservoir Depth before Sedimentation

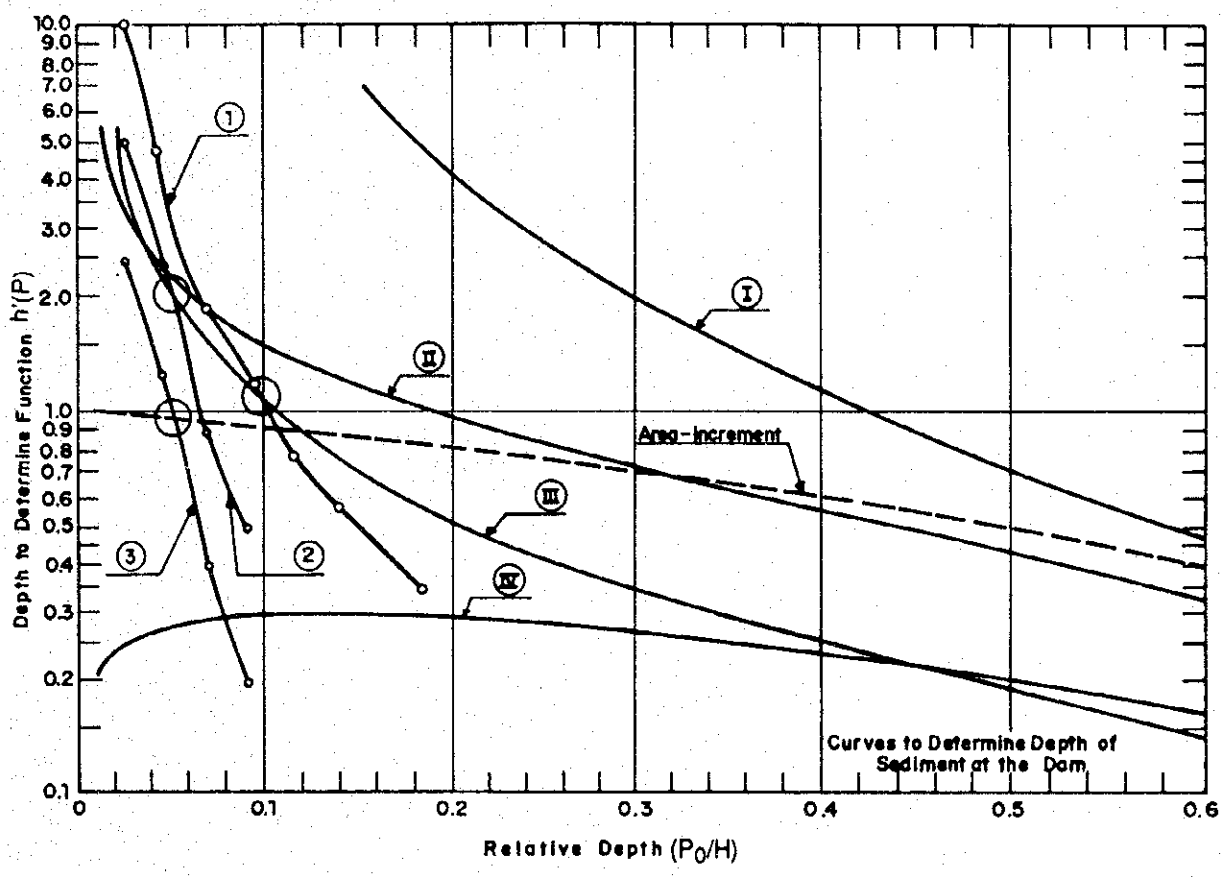
NOTE : 1 (13 MCM)
2 (30 MCM)
3 (7.5 MCM)

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Evaluation of Relative Depth (P=P0/H) Poza Honda Reservoir

FIGURE 6.3.5

LA ESPERANZA RESERVOIR

(RESERVOIR TYPE III)



P_0 : Sediment Depth

H : Reservoir Depth before Sedimentation

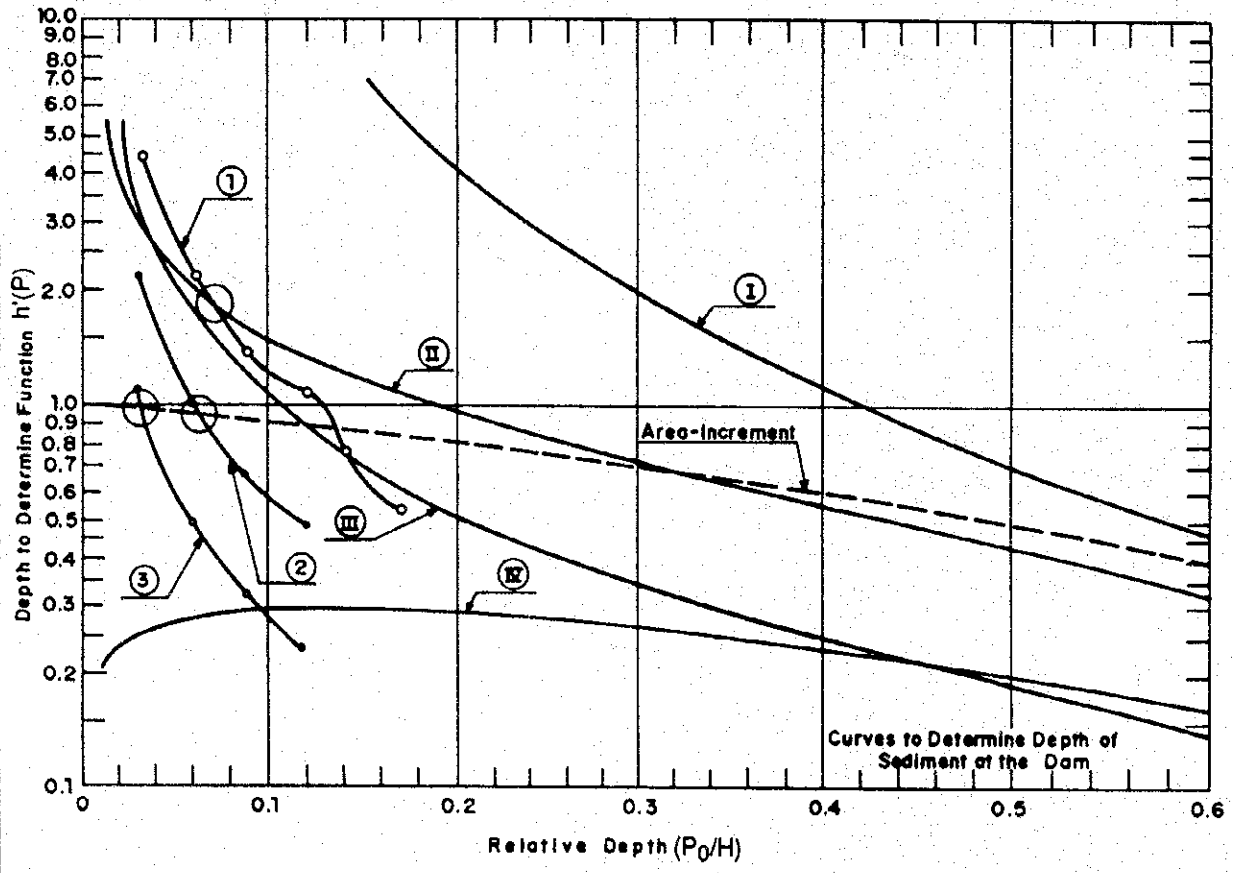
NOTE: 1 (64 MCM)
2 (32 MCM)
3 (16.0MCM)

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Evaluation of Relative Depth ($P=P_0/H$) La Esperanza Reservoir

FIGURE 6.3.6

DAULE - PERIPA RESERVOIR

(RESERVOIR TYPE II)



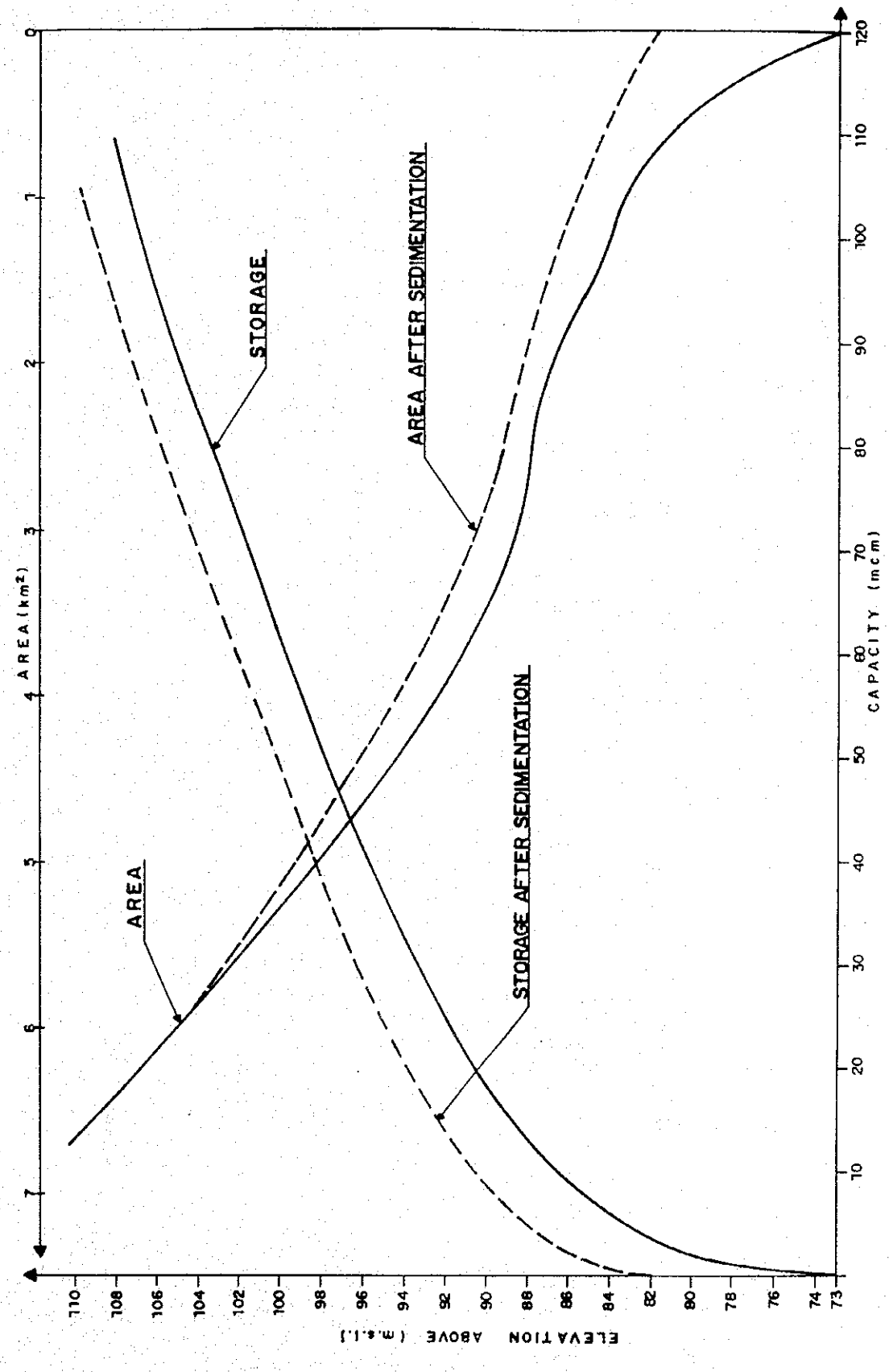
NOTE: 1 (260 MCM)
2 (130 MCM)
3 (65.0 MCM)

P_0 : Sediment Depth

H : Reservoir Depth before Sedimentation

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Evaluation of Relative Depth ($P=P_0/H$) Daule-Peripa Reservoir

FIGURE 6.3.7



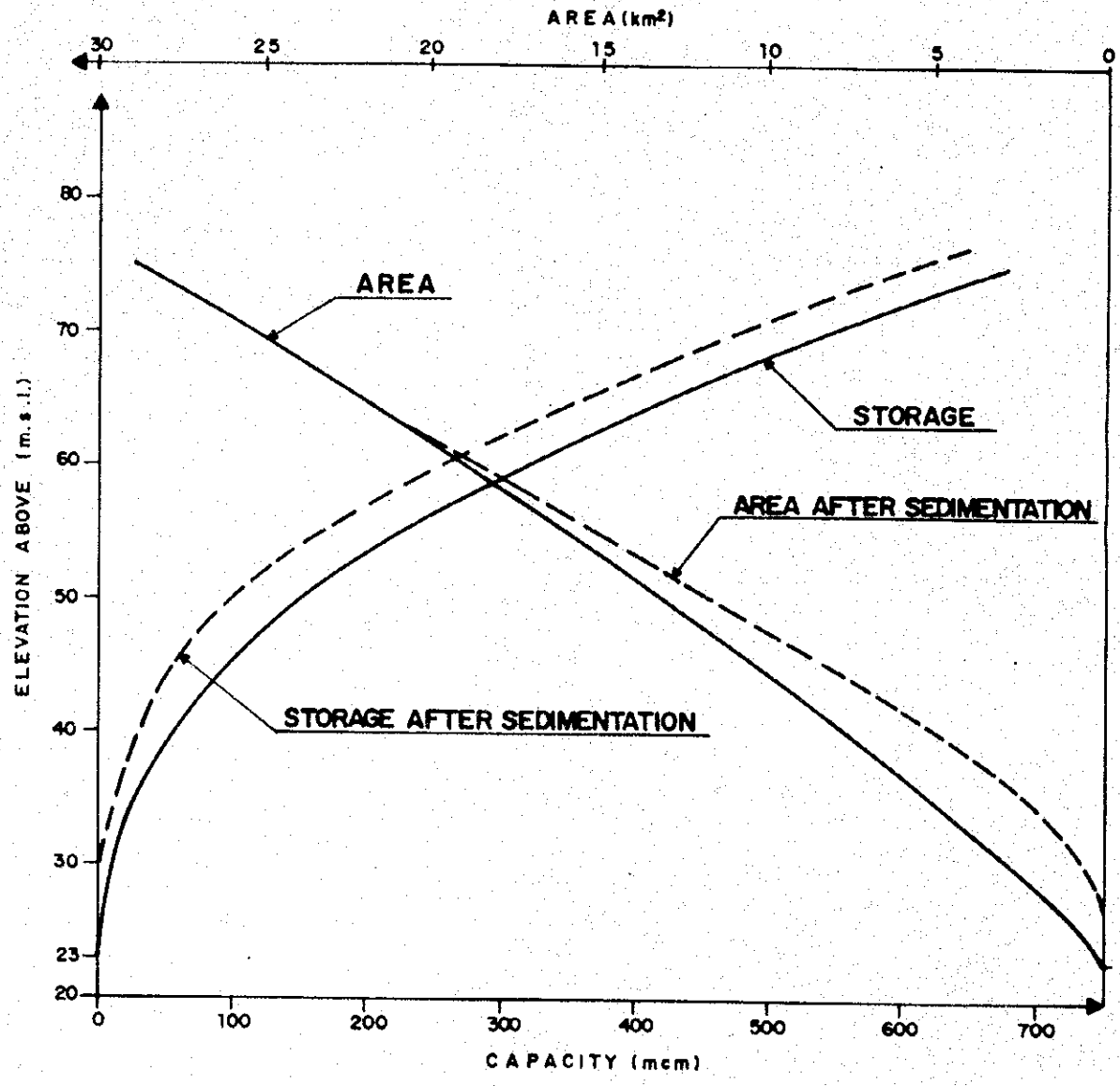
GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE Area - Storage Capacity Curves
Poza Honda Reservoir
(Total Sediment Volume : 13 MCM)

FIGURE 6.3.8

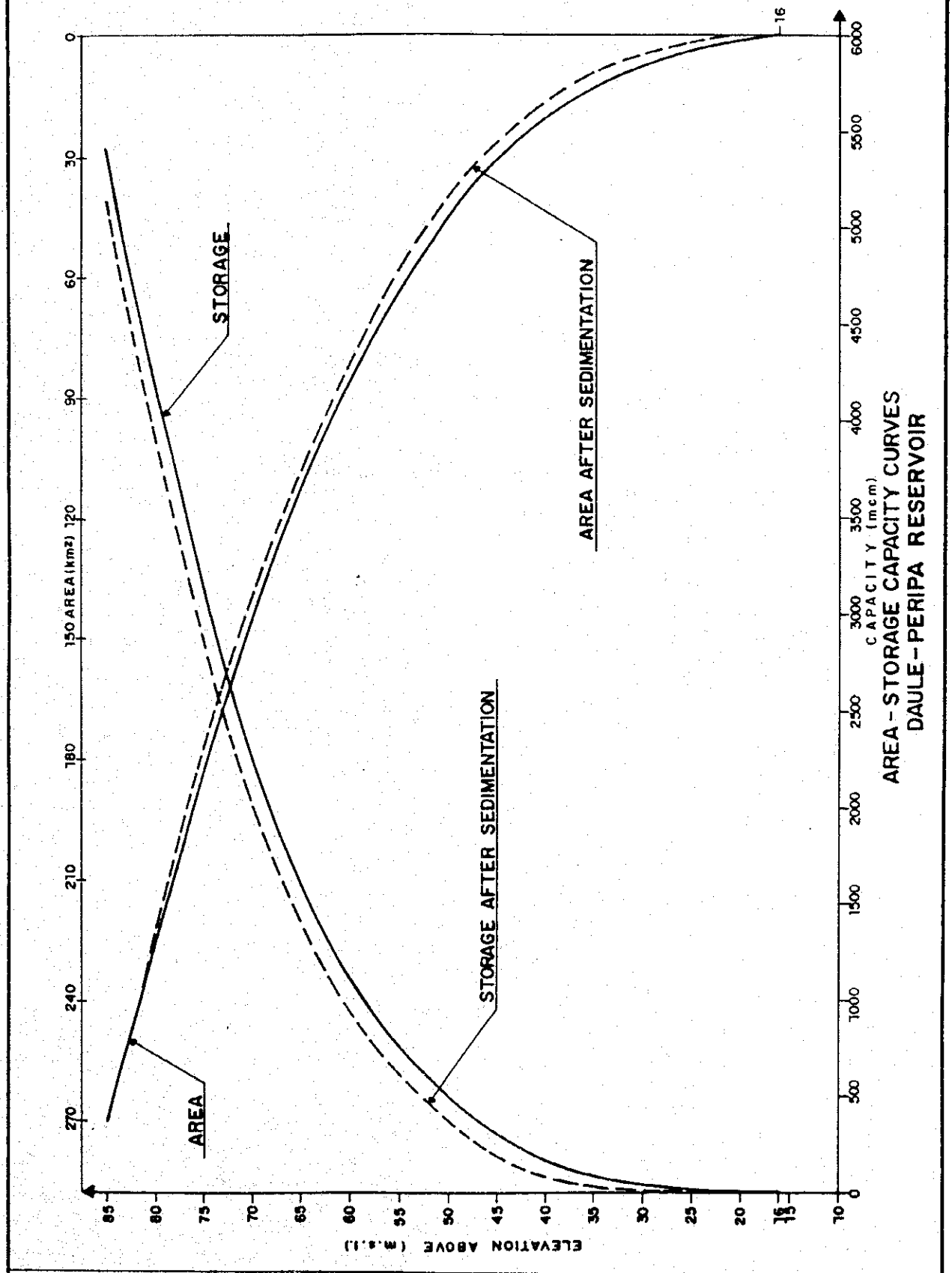
AREA - STORAGE CAPACITY CURVES

LA ESPERANZA RESERVOIR



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Area - Storage Capacity Curves La Esperanza Reservoir (Total Sediment Volume : 64 MCM)

FIGURE 6.3.9



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Area - Storage Capacity Curves Daule-Peripa Reservoir (Total Sediment Volume : 260 MCM)

FIGURE 6.3.10

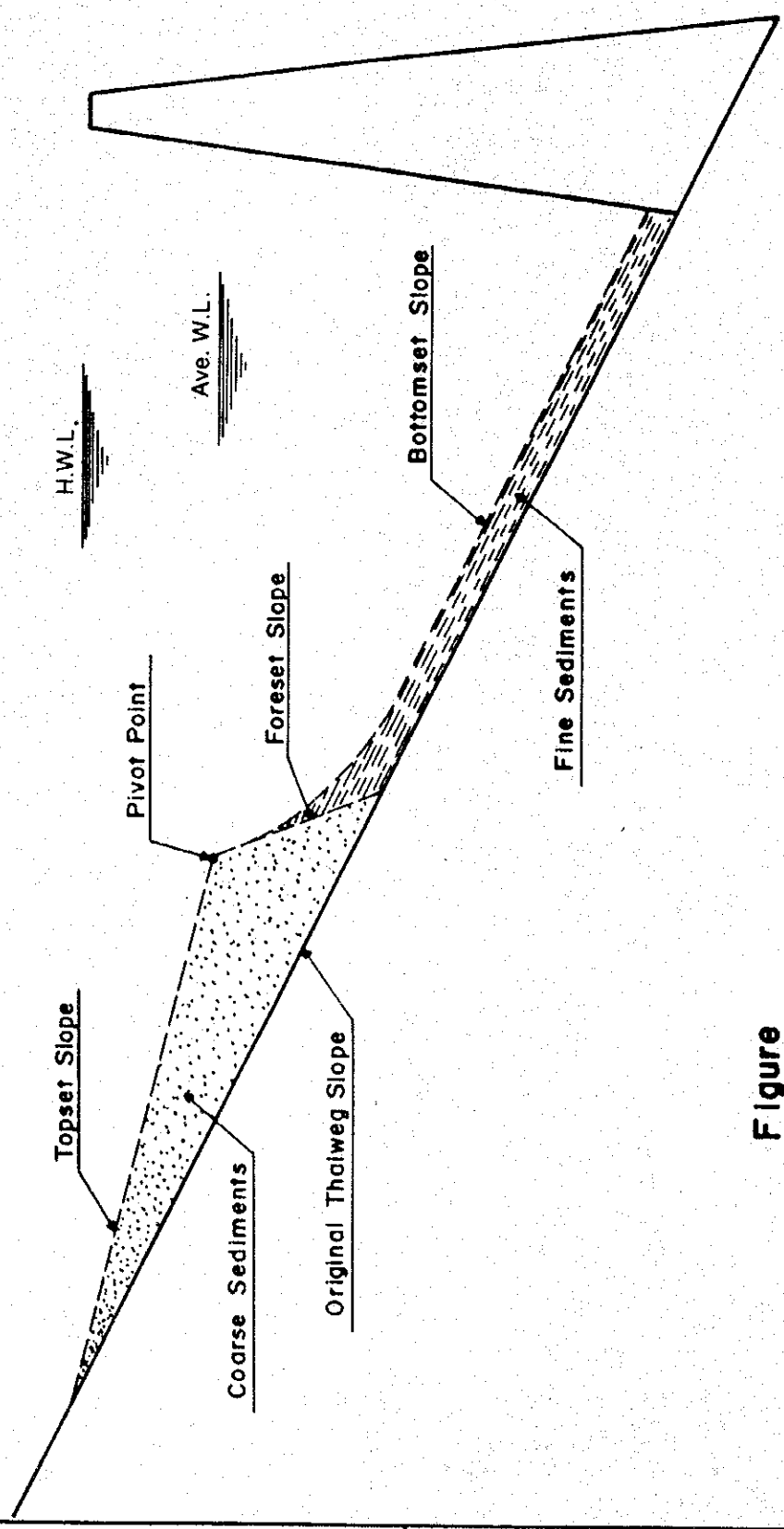
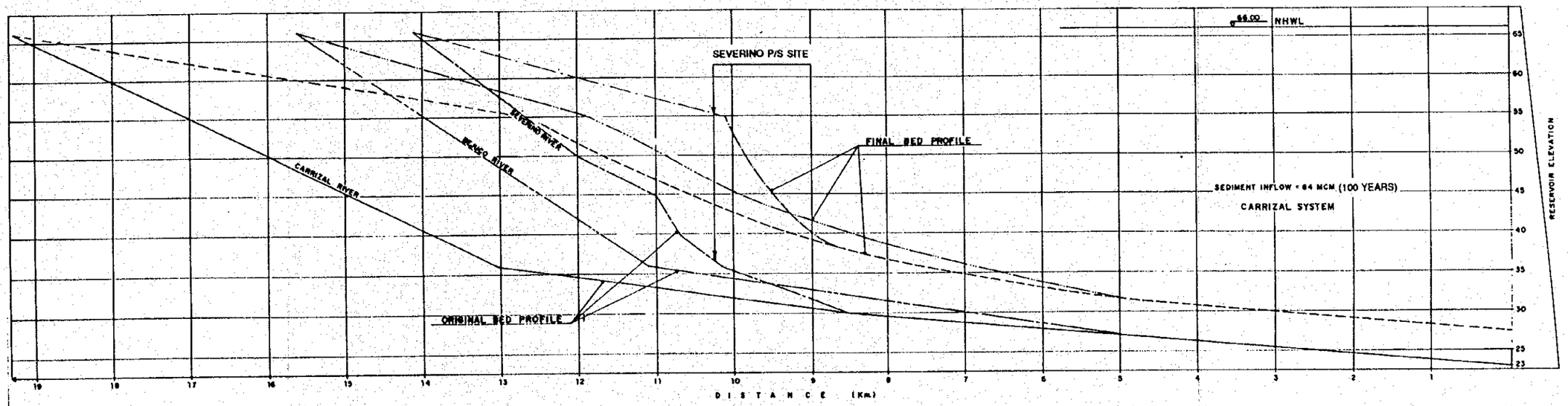


Figure TYPICAL SEDIMENT DEPOSITION PROFILE

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Typical Sediment Deposition Profile

FIGURE 6.3.11

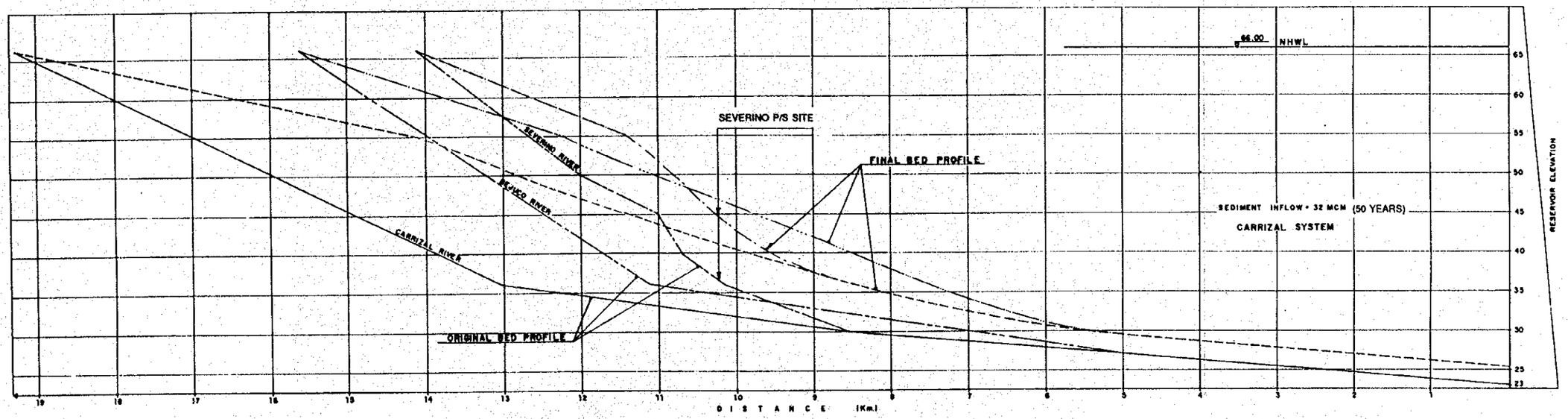
LA ESPERANZA RESERVOIR



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sediment Deposition Profile La Esperanza Reservoir Carrizal River System, Sediment Inflow : 64 MCM

FIGURE 6.3.12

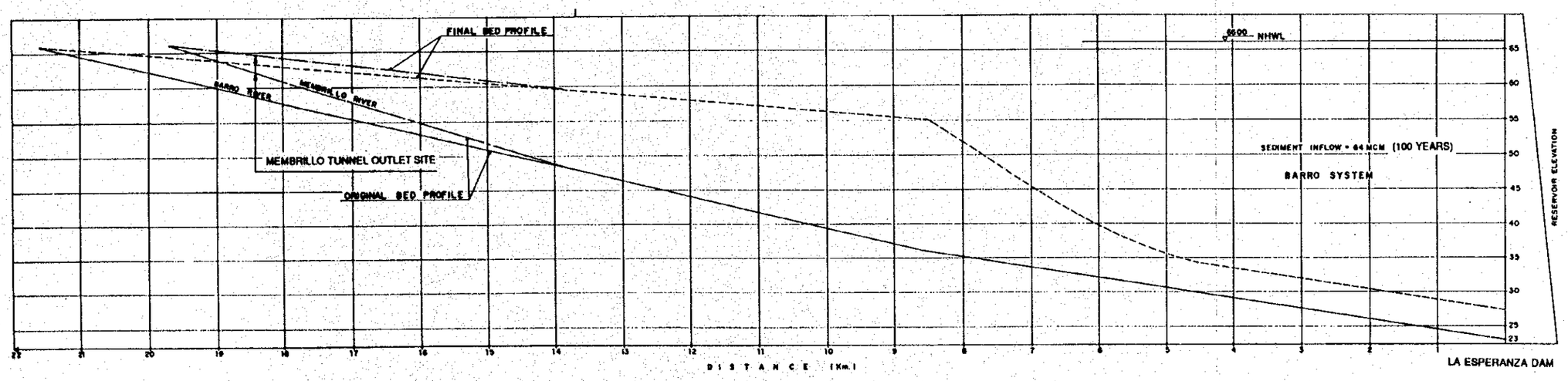
LA ESPERANZA RESERVOIR



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sediment Deposition Profile La Esperanza Reservoir Carrizal River System, Sediment Inflow : 32 MCM

FIGURE 6.3.13

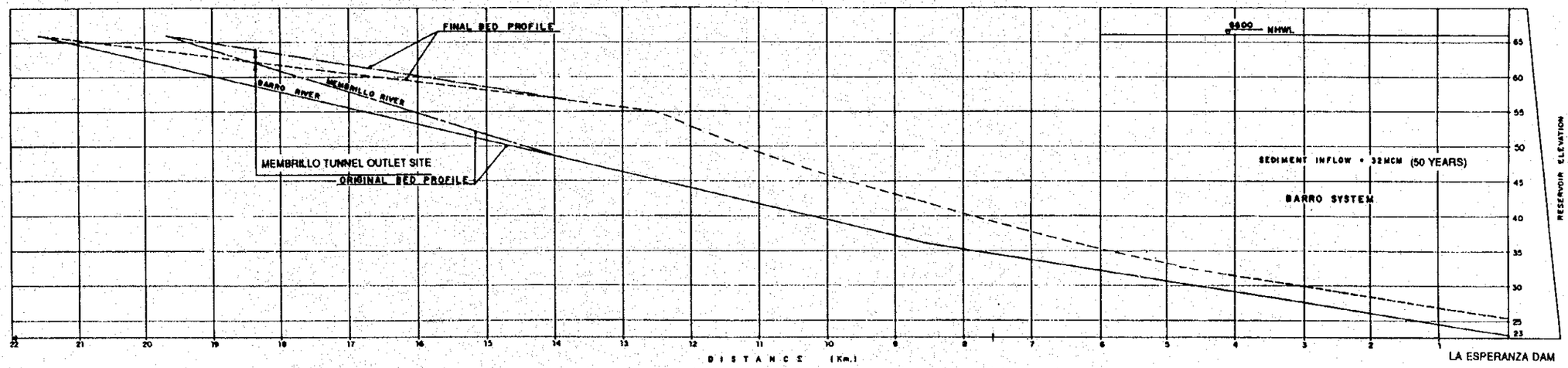
LA ESPERANZA RESERVOIR



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sediment Deposition Profile La Esperanza Reservoir Barrow River System, Sediment Inflow : 64 MCM

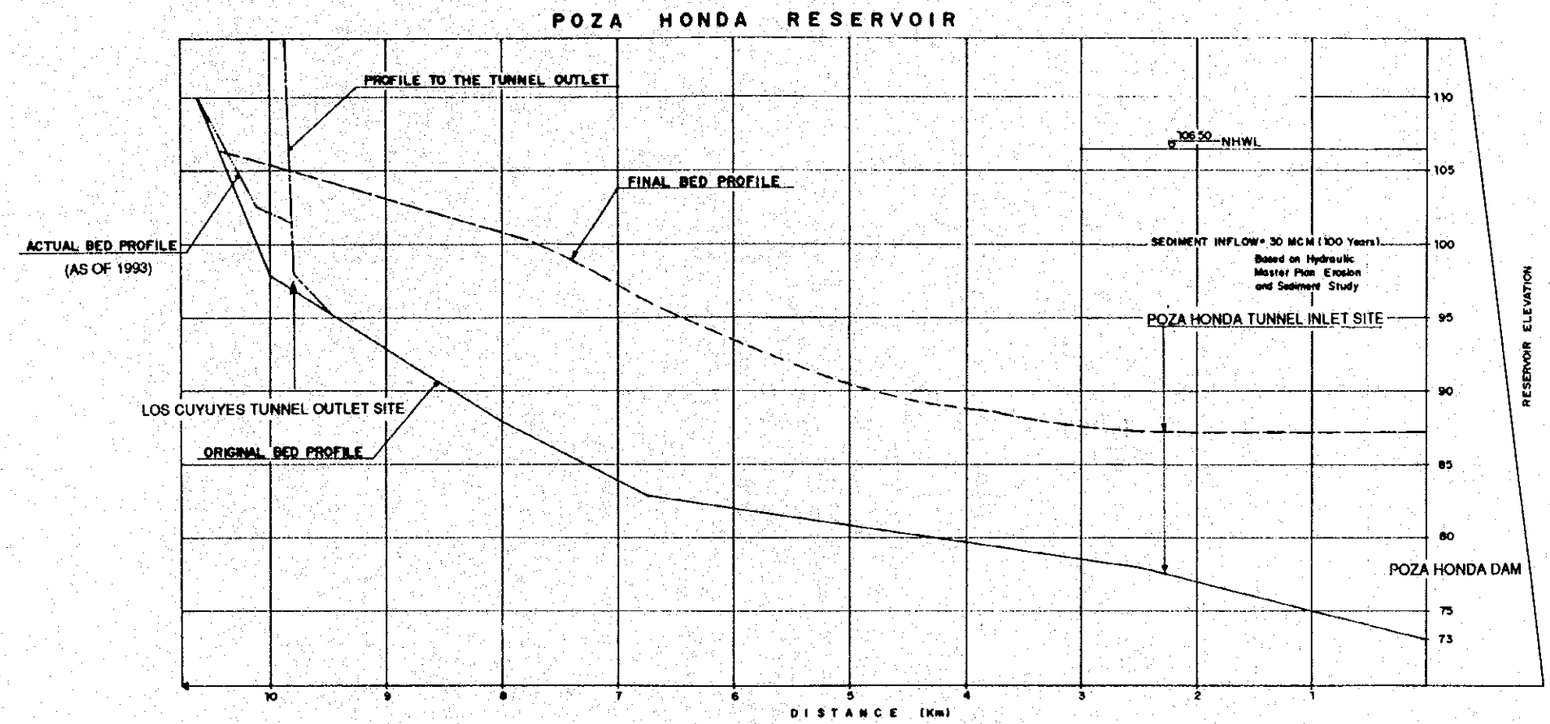
FIGURE 6.3.14

LA ESPERANZA RESERVOIR



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sediment Deposition Profile La Esperanza Reservoir Barrow River System, Sediment Inflow : 32 MCM

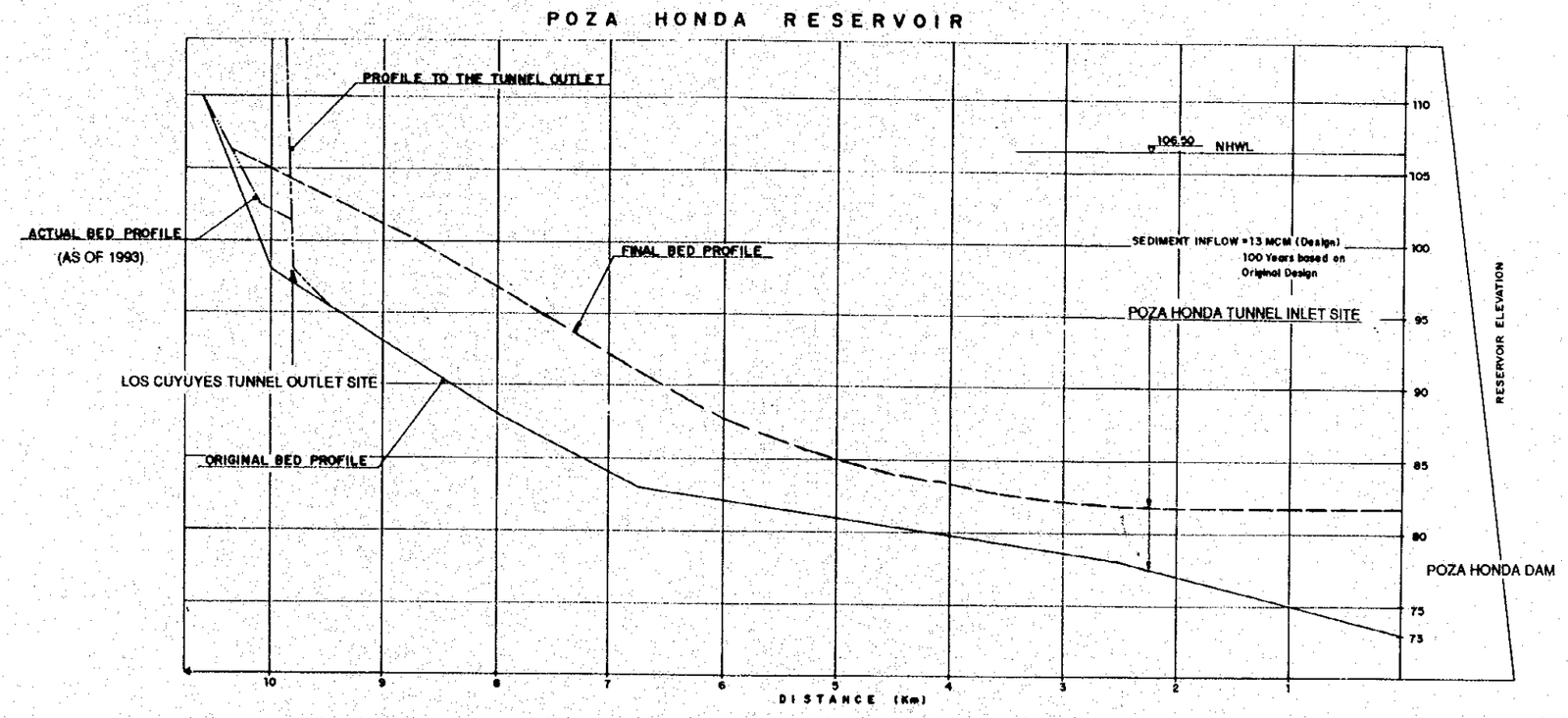
FIGURE 6.3.15



LEGEND

- PATA DE PAJARO RIVER
- FINAL BED PROFILE
- ACTUAL BED PROFILE

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS* JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sediment Deposition Profile Poza Honda Reservoir Sediment Inflow : 30 MCM

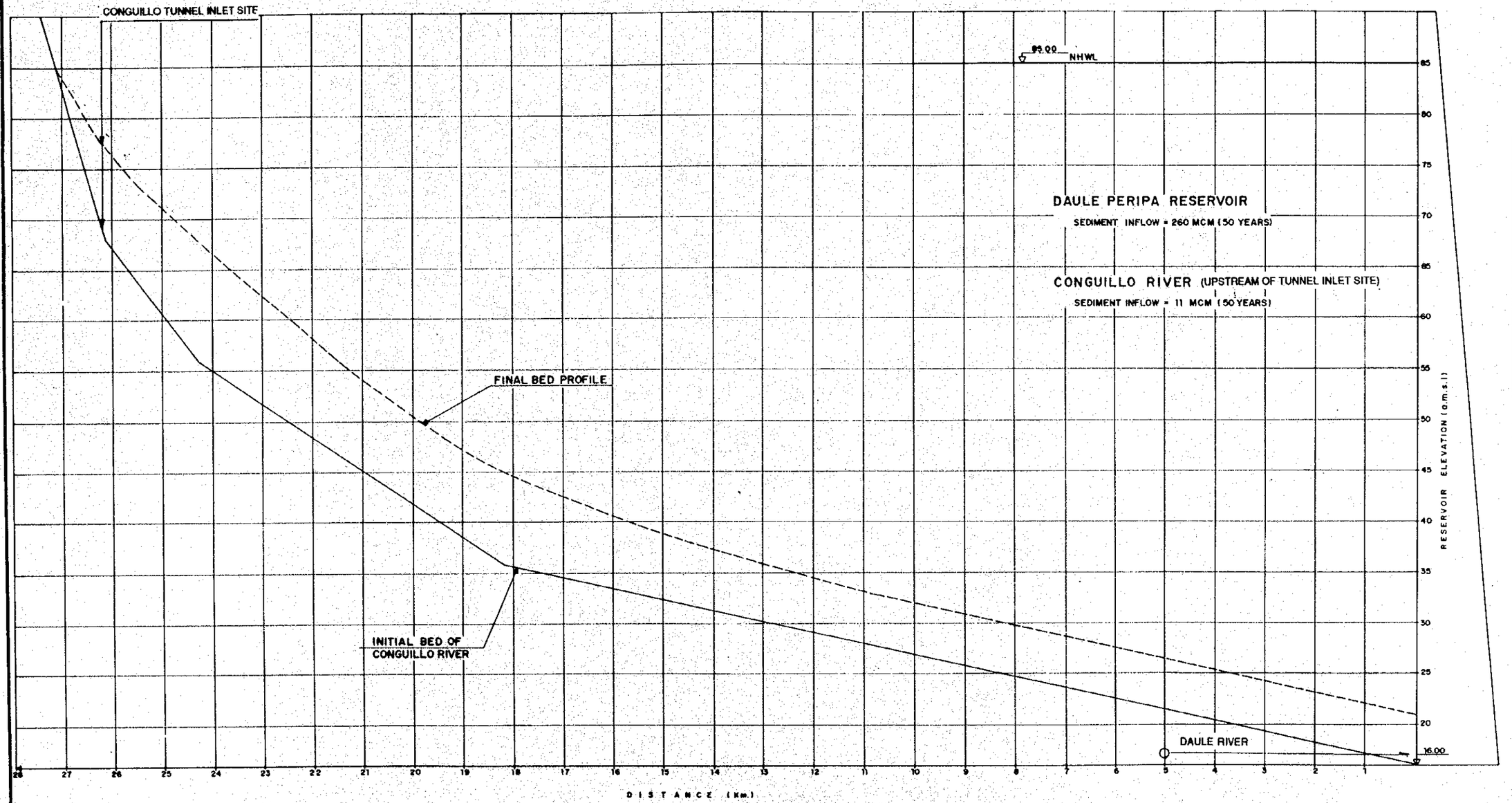


LEGEND

- PATA DE PAJARO RIVER
- FINAL BED PROFILE
- ACTUAL BED PROFILE

GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sediment Deposition Profile Poza Honda Reservoir Sediment Inflow : 13 MCM

FIGURE 6.3.17



GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) ***THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*** JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sediment Deposition Profile Daule-Peripa Reservoir Sediment Inflow : 260 MCM

ANNEX 1

WATER TRANSBASIN PLAN

WATER TRANSBASIN PLAN

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1. INTRODUCTION

The major objective is to review the integrated reservoir operation and water balance study carried out during the feasibility study in order to confirm the proposed water transbasin capacities and inlet and outlet elevations of the proposed three diversion tunnels as well as the elevation at the proposed transbasins. Final elevations to be selected will depend on the estimated reservoir sedimentation levels.

2. ACTUAL OPERATION OF POZA HONDA RESERVOIR

There exists no specific reservoir operation rule for the Poza Honda dam nor for the Santa Ana intake weir. These facilities have been operated to fulfill the minimum requirements conceived in the design and the reservoir water level of Poza Honda has never been below the emergency water level of EL.91.5 m since its completion in 1973 as shown in Fig. 1. The recorded minimum water level was EL.92.97 m with the water volume in the reservoir of 28.42 MCM. Annual maximum and minimum water levels of Poza Honda are shown in Table 1. Fluctuations of reservoir water levels from 1979 to 1993 are shown in Fig.2. The above mentioned data and information suggest that the reservoir has been operated in the following manner.

- Reservoir water level is not allowed to be lower than the emergency level, EL.91.5 m.

- Priority of water release from the dam is;

  (1) Obliged river maintenance flow of 0.25 m^3/s (7.9 MCM/year)
  (2) Domestic water supply
  (3) Irrigation water supply

The river maintenance flow and the domestic water supply should be assured at practically 100% of guarantee, while irrigation water supply depends on water availability.

3. PREVIOUS RESERVOIR OPERATION OF LA ESPERANZA

INTECSA-GEOSISA executed in 1984 a reservoir operation study of La Esperanza with and without transbasin from Daule-Peripa. A simulation study was carry out for the case without transbasin based on two series of synthetic flows and the results are shown in Table 2. Another study with transbasin was made for diversion discharges of 1, 2 and 8 m^3/s to evaluate the available water quantity after regulation by a limited reservoir capacity of La Esperanza. The study, however, was not detailed.

In 1988, the Ecuadorian-Brazilian Consortium made a study on transbasin from Daule-Peripa to La Esperanza at the request of CRM, to evaluate a technical feasibility to make the transbasin level lower from EL.69 m to EL.66 m for transbasin capacities of 6 m^3/s and 12 m^3/s to meet the water demand for irrigation of 20,500 ha. The study concluded that the lower level transbasin would increase the diverted water volume by only 2.5%, but the decision to make the diversion level lower than the originally proposed level of EL.69 m was actually made by CRM mainly to provide more safety. The study results are shown in Table 3.

In 1989, the same consortium, at the request of CRM, revised the diversion tunnel design from Daule-Peripa to La Esperanza to have a capacity of 18 m^3/s, and the reservoir operation study of La Esperanza was repeated for the transbasin level fixed at EL.66 m. The study results, which is given in Table 4, showed that even with increased transbasin capacity of 18 m^3/s, irrigation water supply to 20,500 ha could not be guaranteed by 100%.

In order to meet water demands in Chone and Portoviejo river basins, the same consortium executed in 1985 the reservoir operation study of La Esperanza receiving water from Daule-Peripa with a diversion capacity of 18 m^3/s and supplying water to Poza Honda with a diversion capacity of 12 m^3/s. The study results are shown in Table 5, which indicates that water shortage may take place for 11.25% of the simulation period to meet the demands in the planning year of 2015, due to physical reasons such as the case when water level of Daule-Peripa becomes lower than the intake level of EL.66 m. The water demands for domestic use and irrigation purpose applied in the study are shown in Table 5.

On the other hand, CCAI carried out in 1989 a reservoir operation study of La Esperanza for a simulation period from 1965 to 1982, to supply irrigation water to 21,500 ha with revised water requirement estimated for the Carrizal-Chone project. The study concluded that for a transbasin capacity of 12 m^3/s the number of months when water shortage would happen was 22 (10.2%) for the diversion level of EL.69 m and 17 (7.8%) for EL.66 m, indicating the lower diversion level increased the guarantee by 2.4%.

In Figure 3 is shown for La Esperanza reservoir the area - capacity curves.

4. INTERINSTITUTIONAL AGREEMENT FOR TRANSBASIN FROM DAULE-PERIPA TO LA ESPERANZA

4.1 Declaration of CEDEGE Board of Directors

The Board of Directors of CEDEGE declared in April 1980 that the Manabi province is one of the beneficiaries of the Jaime Roldós Aguilera Multipurpose Project,

Daule-Peripa dam, and be entitled to divert water from the Daule-Peripa dam up to 500 MCM per annum.

4.2 Legislative Law No. 77 of 1981

The Legislative Law No. 77 was published in the Official Register No. 80 on September 15, 1981.

The Law established that water supply to Manabi would be urgent and national priority be given to it including financing. The Law also indicated that the transbasin project to use water of Daule-Peripa should be in accordance with the criteria of CEDEGE and the Municipal Company of Water Supply of Guayaquil (EMAP-G).

4.3 Agreement Among CEDEGE-CRM-INERHI of 1982

An agreement for interinstitutional cooperation was signed on April 30, 1982, among CEDEGE, CRM and INERHI. This document is of much importance from the legal view point in the proposed transbasin scheme being studied by JICA.

In the document, CEDEGE and CRM confirmed the contents of the previous document, recognized the necessity of utilizing water of the Daule and Peripa rivers, which would be stored by the dam constructed by CEDEGE, through realization of a transbasin project, and expressed an intention to allocate an annual volume of water up to 500 MCM for the use in the Manabí province.

The third clause of the document indicated its objectives and in its subclause (c) each one of the parties was requested to take actions for the realization of studies, designs, construction an operation of the Jaime Roldós Aguilera Project and the transbasin project to Manabí.

In the same subclause, on the other hand, INERHI "concedes the right to use required volume of water in accordance with the Law in this regard".

Finally, the agreement mentioned in its subclause (d) for responsibilities that "the operation of the transbasin system to Manabí should be made in a manner as determined by the feasibility study and the definite design for the Daule-Peripa project, guaranteeing domestic water supply to Guayaquil city and following the priorities established by the Water Law and its relevant regulations. The three institutions should coordinate in their respective water use to this effect".

4.4 Agreement of 1986

A new agreement was signed between CRM and CEDEGE on December 8, 1986, containing more concrete clauses about the studies and possible alternatives for water transbasin and its financing.

It is to be noted in this agreement "the use of Daule-Peripa reservoir water" is left to be determined in the next agreement, stating "taking into account the regulations and codes in force for use of water".

4.5 Transbasin Studies for Use of 500 MCM

In accordance with subclause (c) of the third clause of the Agreement for interinstitutional cooperation signed on April 30, 1982, CRM conducted, through contract with specialized consultants, a feasibility study and detailed design of the water transbasin project from Daule to La Esperanza and Poza Honda, and the study report was submitted to CEDEGE.

During the feasibility study phase, various alternatives were studied and the following two alternatives were selected for further comparison study from the technical and economic view points.

- Alternative B, consisting of two sequential transbasins, first from Daule-Peripa to La Esperanza through a tunnel of 8.3 km in length to divert water by gravity and second from La Esperanza to Poza Honda by constructing a pumping station at the La Esperanza reservoir side, penstock line from the pumping station to a stand-pipe and conduction of water by gravity through a pipeline and a tunnel.

- Alternative C, consisting of two independent transbasins, one from Daule-Peripa to La Esperanza through a diversion tunnel by gravity flow, and the other from the Daule river to Poza Honda by means of a pumping station on the right bank of the river, penstock line to a stand-pipe and conduction of water by gravity through a pipeline and a tunnel.

Of these two alternatives, the Alternative C was recommended for preparation of a detailed design, which contained two independent transbasins, one to La Esperanza with a capacity of 6 m^3/s and the other to Poza Honda with a capacity of 12 m^3/s, within a limit of 500 MCM/year. The detailed design was completed in 1987.

In June 1989, CRM, in view of the national priority of the Central Government to construct the La Esperanza dam and the preliminary result of PHIMA, advised CEDEGE that CRM had decided to revise the design of the diversion tunnel to La Esperanza to have a capacity of 18 m^3/s to divert water of maximum 500 MCM/year. Thus, CRM virtually returned to select the Alternative B, consisting of two sequential transbasins.

The revision of the design concluded that the original design of the portal of tunnel was not needed to be modified, and CRM informed it to CEDEGE by the letter No.659 of July 12, 1989. CEDEGE constructed the portal of tunnel accordingly through the Spanish contractor AGROMAN in the dry season of 1989.

Based on the above mentioned background, it may be concluded that CEDEGE allows the transbasin of up to 500 MCM from Daule-Peripa to La Esperanza through the 18 m^3/s diversion tunnel, the portal of which was already constructed by CEDEGE in the Daule-Peripa reservoir.

5. RESERVOIR OPERATION OF DAULE-PERIPA

The Daule-Peripa reservoir will be operated to meet the demands for power (minimum reservoir water level for power generation, EL.65 m), domestic water, irrigation and dilution for irrigation return flow, transbasin to La Esperanza (minimum level of the transbasin, EL.66.6 m) and transbasin to the Santa Elena Peninsula and Macul. The design water levels of the Daule-Peripa reservoir are shown in Fig. 4 and summarized as follows.

Normal High Water Level	EL.85 m
Low Water Level	EL.60 m
Flood Water Level	EL.88 m

At the request of the CRM, CEDEGE conducted a reservoir operation study, generating synthetic flows as inflows to the reservoir, 30 series of 30 years each. In Fig. 5, the results of the reservoir operation study are shown for series No.1, 12 and 18.

5.1 Reservoir Operation Study

A transbasin discharge rating curve is prepared from Daule-Peripa to La Esperanza through the 18 m^3/s diversion tunnel, based upon the hydraulic characteristics of the existing intake, which is dependent on the reservoir water level of Daule-Peripa, as shown in Table 6 and in Fig. 6. The transbasin discharge is 0 m^3/s at the reservoir level EL.66.6 m and is more than 18 m^3/s for reservoir level higher than EL.76.6 m. The reservoir operation study was executed to meet all the demands established by CEDEGE and for three levels of

dilution water requirements, that is to say 1.2, 1.6 and 2.0 times the irrigation water demand including volume to dilute saline return flow of 20% to an acceptable level. In the present study, a dilution level of 1.6 is applied. In Table 7, numbers of months when water shortage takes place are shown out of 360 months (30 years) for one serie as well as the percentage of water shortage months. Water shortage will occur minimum 0.08% for domestic water supply and maximum 9.85% for transbasin to Manabí. The highest probability of water shortage for Manabí transbasin is due to physical limit of inlet level at EL.66.6 m rather than the shortage of reservoir capacity of Daule-Peripa.

In Figure 7 is presented the actual levels corresponding to Daule-Peripa reservoir operation during the period 1987-1993. It is shown clearly that the reservoir fill up completely for the first time in April 1989 and then emptied at the beginning of 1990 in order to proceed with the construction of Conguillo intake for the transbasin to La Esperanza reservoir, after that starts again fill up until reaches the maximum elevation of 86 m, and basically the reservoir has remained quite high because mostly of the hydraulic infrastructure downstream have not yet been constructed in order to fulfill the required water demand.

From the results of the reservoir operation study, duration levels curves were prepared as shown in figures 8, 9, 10, 11 for series 1, 12, 18 and average for 900 years.

5.2 Water Volume to be Transbased to La Esperanza from Daule Peripa Reservoir

Divertable water volumes to La Esperanza are computed as shown in Figs. 12 to 14 for one year, two consecutive years and 3 consecutive years, respectively, as well as level of guarantee. The results are summarized as follows.

(MCM)

Level of guarantee (%)	Divertable water volume		
	One year	Two years	Three years
Maximum volume	568	1,135	1,703
50	568	1,135	1,703
80	555	1,087	1,612
89	500	1,000	1,485
Minimum volume	0	16	407

From the above table, it is understood that water of 537 MCM/year (1,612/3) could be diverted to La Esperanza at 80% guarantee (4 years assured out of 5 years), corresponding as basic years for design to the series 24, year 706, 707 and 708 with the respective divertable water volume of 488, 556 and 568. Technically divertable flows for each month are shown in Table 8, which indicates that during 5 months from December to April, the divertable flow is less than 18 m^3/s. Since the agreement between CEDEGE and CRM limits the diversion water volume only up to 500 MCM/year and the diversion flow up to 18 m^3/s, it is necessary to reduce the diversion water volume from the calculated 537 MCM to 500 MCM intentionally to the best interest of the Manabi province. It is proposed to reduce the diversion flow to La Esperanza in 3 months from January to March when rainfall are maximum and water demands are minimum. The proposed monthly transbasin pattern is shown in Table 8.

6. INTEGRATED RESERVOIR OPERATION OF LA ESPERANZA AND POZA HONDA

6.1 General Concepts of Reservoir Operation

La Esperanza receives natural flows from its own basin and diverted flows from Daule-Peripa. La Esperanza together with the available interbasin flows of the Chone river system should meet water demands for shrimp farming in the Chone estuary (99 MCM/ year), river maintenance (16 MCM/year), water supply to the Chone-La Estancilla water supply system (45 MCM/year), Carrizal-Chone irrigation of 15,000 ha (253 MCM/year), Los Amarillos irrigation of 1,000 ha (19 MCM/year) and Dilution Water equivalent to 20% of the irrigation water requirement.

La Esperanza should also divert water to Poza Honda. Poza Honda receives natural flows from its own basin and diverted flow from La Esperanza. Poza Honda together with the available interbasin flows of the Portoviejo river should meet water demands for water supply to the Poza Honda water supply system except the El Ceibal treatment plant (89 MCM/year), irrigation for Santa Ana system of 3,300 ha (74 MCM/ year), for Pechiche-Pasaje system of 850 ha (20 MCM/year), for Mejía system of 1,250 ha (28 MCM/year), for Ceibal-Guayaba system of 4,650 ha (111 MCM/year) and for Guarango system of 1,500 ha (36 MCM/year), shrimp farming in the Portoviejo estuary (3 MCM/year), river maintenance (8 MCM/year) and Dilution Water equivalent to 20% of the irrigation water requirement.

Poza Honda should also divert water to Mancha Grande of the Chico river basin. The diverted flows together with the available natural flow of the Chico river should meet water supply to El Ceibal treatment plant (63 MCM/year), irrigation for Chico system of

1,700 ha (31 MCM/year) and Dilution Water equivalent to 20% of the irrigation water requirement.

6.2 Basic Conditions for Integrated Reservoir Operation Study

(1) Reservoir Storage Curves

Reservoir storage curves after 50 years sedimentation are used to make the study conservative.

(2) Irrigation Water Requirement

Irrigation water requirement is affected by the effective rainfall. For the study, irrigation water requirement calculated for a drought year with a return period of 5 years is used.

(3) Dilution Water

Dilution water equivalent to 20% of the irrigation water requirement is applied to the study to dilute irrigation return flows.

(4) Use of Interbasin Flows

The interbasin flows, the natural flows from the catchment area downstream of the dam, can be used to meet water demands especially during the rainy season. Use of up to 60% of the interbasin flow is assumed to be allowed.

(5) Water Demand Level

Water demands in the target year of 2020 are used for the study.

(6) Target Reservoir Water Levels

The transbasin from Daule-Peripa to La Esperanza is planned to be made by gravity. Water transbasin is recommended to be continued as far as possible. The design condition to maintain an open free flow in the diversion tunnel will, however, limit a range of the target water level of La Esperanza not more than EL. 63.5 m. Therefore, it is planned to suspend water transbasin from Daule-Peripa when La Esperanza water level is higher than EL. 63.5 m. In other words, a target water level of La Esperanza is fixed at EL. 63.5 m.

The transbasin from La Esperanza to Poza Honda is planned to be made by pumping. Lower target water level of Poza Honda is desirable to save pumping energy cost and to aim at maximum utilization of the own basin flow limiting a spillout volume from Poza Honda to the minimum. However, if the target water level is too low, more frequent water shortage will take place during operation because the reservoir storage capacity cannot be used effectively. A number of trial calculations concluded that the Poza Honda target water level should be EL.102.5 m, 4.0 m below the high water level of Poza Honda.

(7) Intake Level of Severino Pumping Station at La Esperanza

An intake water level of the Severino pumping station for water transbasin from La Esperanza to Poza Honda should be low enough to continue water pumping in low level period of La Esperanza. However, the following two design conditions require to fix the intake level at EL. 47 m, higher than the low water level of La Esperanza by 10 m.

- Anticipated reservoir sedimentation level of EL.45 m at the Severino pumping station site.

- Allowable drawdown of La Esperanza water level during construction of the Severino pumping station, fulfilling the required minimum functions of La Esperanza.

(8) Intake Level of Poza Honda-Mancha Grande Diversion Tunnel

The transbasin from Poza Honda to Mancha Grande is planned to be made by gravity. The topographic conditions at the tunnel outlet limit the lowest intake water level of Poza Honda at EL.94 m.

(9) Diversion Capacity from Daule-Peripa to La Esperanza

The diversion capacity from Daule-Peripa to La Esperanza is fixed to be 18 m^3/s by the interinstitutional agreement between CEDEGE and CRM as discussed in 4 herein.

(10) Diversion Capacity from La Esperanza to Poza Honda

A diversion capacity of 16 m^3/s was proposed in the feasibility study under the following conditions.

- Reservoir storage curves before reservoir sedimentation were used.

- Dilution water requirement to dilute irrigation return flows was not considered.

- Interbasin flows were not taken into account.

The integrated reservoir operation study is repeated based on the conditions described from (1) to (12) hereof for a diversion capacity of 12 m^3/s, 14 m^3/s and 16 m^3/s.

(11) Diversion Capacity from Poza Honda to Mancha Grande

If the natural flow of the Chico river is neglected, water requirements are 1.9 m^3/s to supply the El Ceibal water treatment plant and 2.1 m^3/s to cover peak irrigation water requirement in September for the Chico irrigation system of 1,700 ha including 20% of the dilution water, totaling 4.0 m^3/s. The diversion capacity is, therefore, fixed at 4.0 m^3/s.

(12) Long-term Hydrological Series

Long-term hydrological series were simulated at important points in the Chone-Portoviejo river basins by the Tank Model method on a monthly basis for a period of 20 years from 1971 to 1990, in the feasibility study.

In the detailed design study, the long-term hydrological series are revised by a simulation study using the CIDIAT Model for a period of 29 years from 1964 to 1992. The results are shown in the Interim Report, March 1994. The revised long-term hydrological series are used for the integrated reservoir operation study.

6.3 Integrated Reservoir Operation Study

Based on the conditions described in 6.2, an integrated reservoir operation and water balance study is conducted, for this purpose a computer program was developed and flow diagram is shown in figures 15a, 15b and 15c. All water demands involve in the integrated reservoir study as well as the own basin flow are shown in Figs. 16 and 17. The results are shown in Figs. 18, 19 and 20 for a transbasin capacity of 16 m^3/s from La Esperanza to Poza Honda (Q_{Ep} = 16 m^3/s), in Figs. 21, 22 and 23 for Q_{Ep} = 14 m^3/s, and in Figs.24, 25 and 26 for Q_{Ep} = 12 m^3/s, and are summarized in the following table.

Summary of Integrated Reservoir Operation Study

Description	La Esperanza-Poza Honda Transbasin Capacity (m^3/s) 16	14	12
La Esperanza Reservoir			
Max.water level (EL.m)	66.0	66.0	66.0
Min. water level (EL.m)	39.8	40.4	40.0
Mean water level (50%) (EL.m)	59.9	60.2	60.3
Average water level	58.7	59.1	59.3
Average spillout (MCM/year)	118	115	118
Average evaporation (MCM/year)	21	21	21
Max.transbasin from Daule-Peripa (MCM/year)	500	500	500
Average transbasin from Daule-Peripa (MCM/year)	336	331	328
Max. transbasin to Poza Honda (MCM/year)	380	369	348
Average transbasin to Poza Honda (MCM/year)	213	212	205
Guarantee of water supply to Carrizal-Chone river basin (%)	100(100)	100 (100)	100 (100)
Guarantee of transbasin to Poza Honda (%)	95	96	96
Poza Honda Reservoir			
Max.water level (EL.m)	106.5	106.5	106.5
Min.water level (EL.m)	88.3	88.3	88.3
Mean water level (50%) (EL.m)	103.2	102.2	101.5
Average water level	102.2	101.8	101.3
Average spillout (MCM/year)	53	51	47
Average evaporation (MCM/year)	6	6	6
Max.transbasin from La Esperanza (MCM/year)	380	369	348
Average transbasin from La Esperanza (MCM/year)	213	212	205
Max.transbasin to Mancha Grande (MCM/year)	69	59	55
Average transbasin to Mancha Grande (MCM/year)	33	32	31
Guarantee of water supply to Portoviejo river basin (%)	97(83)	98 (83)	98 (86)
Guarantee of water supply to Chico river basin (%)	96(80)	94 (72)	93 (69)

(Note) Guarantee of water supply is on monthly basis. Figures in parenthesis are guarantee on annual basis which should be larger than 80% (water shortage is allowed once in 5 years). Mean water level is took as corresponding to the 50% in the duration curve.

The transbasin capacities of Q_{Ep}=12 m^3/s and Q_{Ep}=14 m^3/s are not recommendable because the guarantee of water supply to the Chico river basin including water supply to the El Ceibal treatment plant is lower than 80% on an annual basis.

The transbasin capacity from La Esperanza to Poza Honda has been decided to be 16 m^3/s, based on the result of the integrated reservoir operation study and also taking account of the following factors.